Veterinary Fences in the KAZA TFCA: Assessment of Livestock Disease Risks of Potential Removal of Specific Fence Sections, with an Emphasis on the Botswana-Namibia Border

Final Report – July 2024

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EXECUTIVE SUMMARY OF FINDINGS AND RECOMMENDATIONS

Overview

The Republics of Botswana and Namibia are party to the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) for which a treaty was signed by Heads of State in August 2011 (KAZA TFCA Treaty 2011). One of the fundamental tenets of the KAZA Treaty, to promote connectivity to support migratory wildlife species, is discordant with the veterinary cordon fencing across the TFCA that limits wildlife's access to, for example, grazing and water resources, the availability of such resources varying seasonally. In addition, the KAZA Treaty helpfully includes an objective to "promote and facilitate the harmonisation of relevant legislation, policies and approaches in the area of transboundary animal disease prevention, surveillance and control within the KAZA TFCA". Reconciling sectoral land use conflicts is thus integral to the success of this ambitious conservation and development initiative, with more than 70% of land in the TFCA being inhabited by communities living in close proximity to protected areas, with inherent challenges at the interface between wildlife, livestock and people. As the Treaty emphasises, addressing issues at this interface requires a cross-sectoral, integrated and holistic approach.

This report provides an assessment of livestock disease risks under current fencing conditions versus those associated with potential removal of specific sections of veterinary fences, with an emphasis on the Botswana-Namibia border. The work was conducted by a collaborative team representing the Governments of Botswana and Namibia, along with representatives from the Botswana Vaccine Institute, Okavango Research Institute and the broader KAZA Animal Health Sub Working Group. Under the KAZA umbrella and spearheaded by the AHEAD programme (Cornell University), a team of regional experts undertook the work between September 2022 and June 2024.

This report is the second of a three-part project evaluating veterinary fences in Botswana's component of KAZA, some of which border Namibia, and their impact on the overall vision of habitat connectivity implicit for a successful TFCA. The first phase of work, completed in 2022, evaluated the fences based on their impacts on wildlife movements and concluded that removal of sections of several fences would be recommended from a wildlife conservation perspective (Atkinson et al. 2022; see executive summary in Appendix A). The second phase of work (this report) goes on to analyse how the risk of important livestock diseases might change if these sections were removed to promote habitat connectivity across the greater KAZA landscape. A third and final phase, not yet undertaken, would entail consultations with communities that could be impacted, positively or negatively, by the removal of any specific fence or fence section as proposed by the first two phases and associated deliberations. Cumulatively, the three phases of work will provide a science-based product to help inform national, bilateral and KAZA-level planning efforts within the context of regional collaboration and cooperation in the areas of disease risk management, natural resource use and management, and community development.

The outputs of this second phase assessment provide information on the estimated risk of key livestock diseases around selected fences under three scenarios: (i) current conditions where no changes are made, i.e. the status quo, (ii) a specific fence section is removed and (iii) a specific fence section is removed with the addition of targeted risk mitigation (such as application of the Herding for Health model).

The fence sections considered were the eastern section (90 km) of the Zambezi Border fence (east of the Okavango River), the northern section (80 km) of the Northern Buffalo fence and three sections of the Western Border fence along the border with Khaudum National Park and Nyae Nyae Conservancy in Namibia. These fence sections were identified as restricting wildlife movements in Phase 1 of this assessment process and were recommended as high priority for consideration for removal.

Multiple qualitative risk assessments were carried out for the three fences covering three transboundary animal diseases, namely foot and mouth disease (FMD), contagious bovine pleuropneumonia (CBPP) and peste des petits ruminants (PPR). For the Zambezi Border fence (east of the Okavango River) and Western Border fence, nine risk pathways were addressed. These included the risk of South African Territories (SAT) serotypes of FMD to Botswana and to Namibia from cattle, buffalo, or poaching, the risk of FMD serotype O to Botswana from cattle, and the risk of CBPP and PPR from Namibia to Botswana. For the Northern Buffalo fence, where no international borders are involved and cattle are present on only one side of the fence, only two risk pathways were addressed: the risk of SAT serotypes of FMD from buffalo and poaching.

The findings and recommendations are based on analysis of vaccination and surveillance data provided by Botswana DVS and Namibia DVS, observations from a visit to two of the fences, public data from the World Organisation for Animal Health (WOAH), published literature on the diseases of interest, and expert opinions.

Summary of qualitative risk assessment findings

Qualitative estimates of the risks for various diseases at the three fence lines under the status quo, removal of specific sections, and removal of specific sections along with implementation of risk mitigation are summarised in Tables A-C. Although land use and livestock density around each fence contribute to its unique risk profile, there are some commonalities in the risks assessed at each fence. These include:

- **The veterinary fence sections of interest are currently in variable condition, making them semi-permeable under the status quo.** Some fence sections remain upright and fully intact, while others have deteriorated as a result of inadequate resources for maintenance and persistent elephant damage. In some cases, fence sections are completely destroyed or lying on the ground, making it possible for animals to cross.

- **The risks for disease outbreaks remained the same under proposed fence section removals.** Removing fence sections can increase the risk at certain steps in a risk pathway, but in all cases, the probability of disease occurrence and overall risk estimate were the same under both the status quo and proposed removal. In some cases, the probability of disease occurrence decreased with the addition of risk mitigation measures.

- **Effective implementation of risk mitigation can reduce the probability of disease occurrence below the status quo risk.** In some pathways, particularly for the Zambezi Border fence east of the Okavango River, implementing risk mitigation produced a lower estimated probability of disease occurrence than under the fencing status quo scenario. Removal of cattle from Bwabwata National Park lowers the risk of FMD and CBPP to Botswana cattle to negligible by removing the most likely source population. Risks to Namibia would also be reduced by removing the host population nearest to the fence.

- **Removing fence sections impacts risks at some but not all steps in the risk pathway.** Removing a fence section can increase the risk of animal movement across that fence line, depending on the location. Removing a fence section does not impact all of the steps in a risk pathway; for example, the risk of effective contact between livestock within a country or the risk of a free-ranging buffalo being viraemic are not impacted by the presence of fences.

- **Removing fence sections can affect the risk of a pathogen entering a country or zone, but risk mitigation measures can be applied to reduce both the risk of entry and exposure.** Fences may limit the entry of a pathogen into a country, but once a pathogen has entered, border fences will not limit exposure of susceptible animals. Risk mitigation measures, in contrast, may be applied in different ways to limit entry and/or exposure. For instance, removal of cattle from Bwabwata National Park reduces the risk of livestock pathogens entering through the border. Controlled livestock movements under Herding for Health (H4H - a model of strategic active herding and kraaling by skilled herders implementing planned grazing through collective action at village level) reduces the risk of exposure to pathogens outside a herding group.

- **Intentional illegal movement of livestock across international borders remains a major risk for the spread of CBPP and PPR, and to a lesser degree FMD.** Fences have some capacity to control livestock movements but are always susceptible to deliberate destruction, as has been noted in fence patrols and questionnaire responses. As such, fences have limited capacity as a preventive measure against illegal movement of livestock. It would be impossible to maintain constant patrolled surveillance across hundreds of kilometres of fences to prevent all border crossings.

- **The fences have a limited impact on the risk of poaching in general.** The presence or absence of a fence does not necessarily factor strongly into the risk of poaching. Poaching happens regardless of fences and other factors in the poaching scenarios are more strongly tied to the likelihood of disease transmission. There are limited risk mitigation measures to reduce the risks from poaching, other than to increase anti-poaching efforts.

- **The extremely low probability of FMD viraemia in adult buffalo is a critical "risk bottleneck" in the risk pathways for poaching.** Poachers are far more likely to target adult buffalo than juveniles when poaching, and adults are not the demographic in which virus is most likely to be actively circulating. Even if a poacher was grossly contaminated with blood, the blood of an adult buffalo is not likely to contain FMD virus (FMDV), which would still need to be transmitted to cattle via fomites to result in an outbreak. This pathway is therefore unlikely to contribute much to the occurrence of FMD outbreaks, given the negligible likelihood of virus being present in adult buffalo meat or blood.

Table A. Zambezi Border fence (east of Okavango River) risk scenarios summary of findings. Note that for SAT-type FMD outbreaks caused by a strain not covered by the vaccine, the overall risk estimate is moderate.

Zambezi Border fence			
Risk Scenario Disease/Route/Country	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Probability of Occurrence / Risk Estimate		
SAT-FMD/cattle/Botswana	Very low / Low	Very low / Low	Negligible / Low
SAT-FMD/buffalo/Botswana	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/poaching/Botswana	Negligible / Low	Negligible / Low	Negligible / Low
FMD type O/cattle/Botswana	Very low / Moderate	Very low / Moderate	Negligible / Moderate
SAT-FMD/cattle/Namibia	Very low / Low	Very low / Low	Negligible / Low
SAT-FMD/buffalo/Namibia	Very low / Low	Very low / Low	Negligible / Low
SAT-FMD/poaching/Namibia	Negligible / Low	Negligible / Low	Negligible / Low
CBPP/cattle/Botswana	Very low / Moderate	Very low / Moderate	Negligible / Moderate
PPR/small ruminants/Botswana	Very low / Low	Very low / Low	Very low / Low

Table B. Northern Buffalo fence risk scenarios summary of findings. Note that for SAT-type FMD outbreaks caused by a strain not covered by the vaccine, the overall risk estimate is moderate.

Northern Buffalo fence			
Risk Scenario Disease/Route/Country	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Probability of Occurrence / Risk Estimate		
SAT-FMD/buffalo/Botswana	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/poaching/Botswana	Negligible / Low	Negligible / Low	Negligible / Low

Table C. Western Border fence risk scenarios summary of findings. Note that for SAT-type FMD outbreaks caused by a strain not covered by the vaccine, the overall risk estimate is moderate.

Western Border fence			
Risk Scenario Disease/Route/Country	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Probability of Occurrence / Risk Estimate		
SAT-FMD/cattle/Botswana	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/buffalo/Botswana	Negligible / Low	Negligible / Low	Negligible / Low
SAT-FMD/poaching/Botswana	Negligible / Low	Negligible / Low	Negligible / Low
FMD type O/cattle/Botswana	Very low / Moderate	Very low / Moderate	Very low / Moderate
SAT-FMD/cattle/Namibia	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/buffalo/Namibia	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/poaching/Namibia	Negligible / Low	Negligible / Low	Negligible / Low
CBPP/cattle/Botswana	Very low or low / Moderate	Very low or low / Moderate	Very low / Moderate
PPR/small ruminants/Botswana	Very low / Low	Very low / Low	Very low / Low

Fence Section Recommendations

A. Recommendations based on qualitative risk assessment (prior to validation meeting)

Overall, the risk assessment indicated that removing the specific fence sections evaluated would not increase the risk from that of maintaining the status quo. In some cases, the probability of disease occurrence under the fence removal scenario decreased with the addition of risk mitigation measures.

Based on similar risk profiles between the status quo and the fence removal scenarios, the fence sections for which further action is recommended (i.e. Phase 3 community consultations on potential fence section removal) are shown in Figure A and the list of recommendations is delineated in Table D. Figure B shows the fence sections recommended for further action in Phase 3, a smaller subset of all fences / fence sections initially evaluated in Phase 1.

These findings are based on the assessed risks along each fence line, given the disease risk estimates calculated, the presence of livestock and buffalo on both sides of the fence, vaccination status, and the spatial distribution of prior outbreaks and high-risk areas.

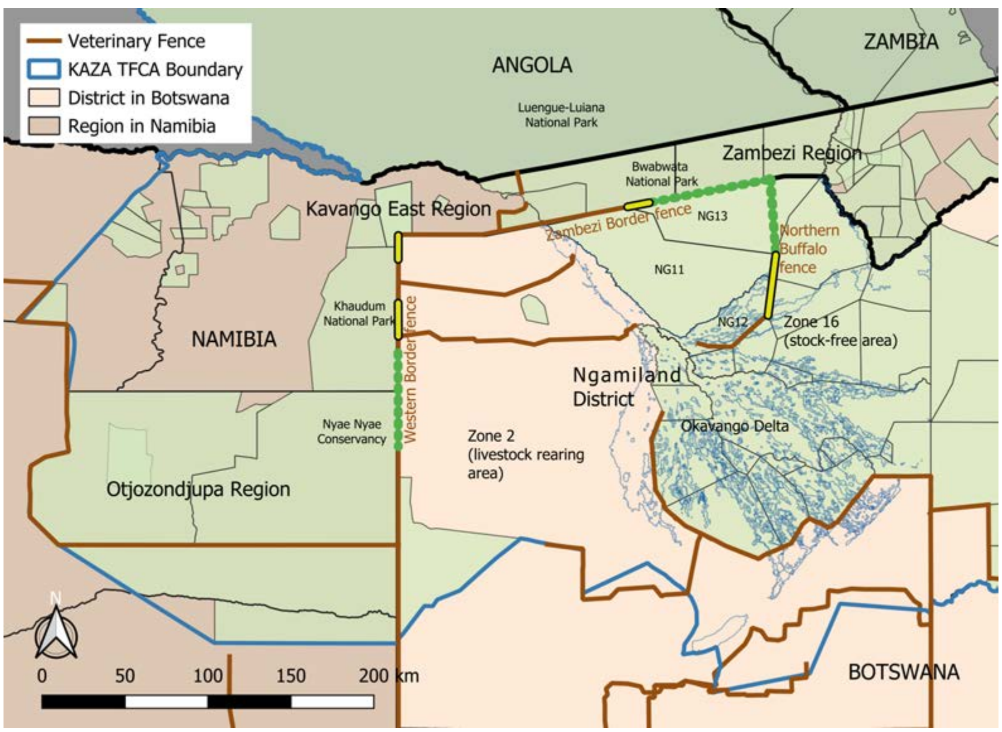

Figure A. Fence sections recommended for Phase 3 community consultations on potential removal (green) or re-evaluation in future (yellow) based on livestock disease risk.

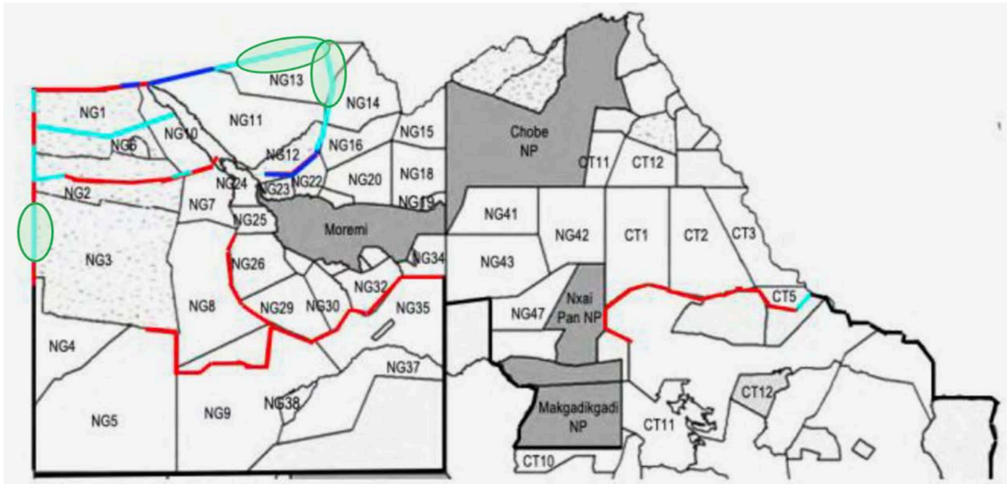

Figure B. Three sections of fences (green ellipses) in northern Botswana initially recommended for Phase 3 review (community consultations on potential removal), which represent a smaller span of fencing than originally identified for potential removal in the Phase 1 report. Phase 1 had evaluated the fences based on their impacts on wildlife movements, as per this map derived from the Phase 1 report's Figure A, wherein dark blue and pale blue had indicated fences that were most negatively impacting wildlife that merited further analysis, a process now beginning to be addressed via this Phase 2 report. Note that the Samochima and Ikoga fences were not evaluated in the Phase 2 analysis, but they are still important to consider due to their impacts on wildlife movements, as per the Phase 1 analysis findings.

Table D. Recommended actions for key fence sections based on livestock disease risk.

Fence	Recommendations
Zambezi Border (east of the Okavango River) - eastern section (90 km) in NG13	**Community consultation (Phase 3) on potential removal of eastern section (75km) in NG13** The greatest overall risks were those from CBPP and FMDV serotype O, given their high consequences. If fence removal with additional risk mitigation was the desired option, the removal of cattle from Bwabwata National Park is the most important of the proposed risk mitigation factors at this fence, because doing so removes the nearest source of transmission of pathogens from Namibia. Removal of these cattle reduces the risk of disease transmission to cattle in Botswana to negligible, and similarly lowers the risk of disease in Namibia if there are no cattle to which to transmit. While both CBPP and FMDV serotype O had a very low probability of occurrence in this area, the high consequences associated with an outbreak of either elevate the risk estimate to moderate. Otherwise, the risks of SAT-type FMD and PPR were considered very low, and when combined with moderate consequences, the overall risk estimate was low. Leaving a section of fence at the western end of NG13 would restrict potential movement of animals from Tovera settlement in Botswana. **Re-evaluate western section in NG13 (15km) after risk mitigation implementation** If cattle were removed from Bwabwata National Park and H4H implementation around Tovera were successful, the remainder of the fence along NG13 could be considered for removal.
Northern Buffalo – northern section (80 km) in NG13,	**Community consultation (Phase 3) on potential removal of northern section (45 km) in NG13** The probability of SAT-type FMD from buffalo or poaching occurring was very low, and the overall risk estimate was low. Although effective contact between buffalo and cattle

NG11 & top of NG12	is believed to be rare, the large number of buffalo in the delta and the density of cattle along the southern part of the Northern Buffalo fence may pose a higher risk than the mostly uninhabited section of NG13. Notably, aerial survey data show that buffalo are already present despite the presence of the fence, but FMD has not been reported in this area of subzone 2a. Farmers in this region have also long been sensitized to the potential disease risk from buffalo and may be more reluctant to have fences around them removed unless results of Phase 1 and Phase 2 can be clearly shared with them. However, there has been a successful H4H pilot running in Eretsha for several years, so the local communities are familiar with this model and its benefits. **Re-evaluate southern section in NG11 & NG12 after risk mitigation implementation** If H4H implementation in the northern delta were successful, the remainder of the fence section along NG11 and NG12 could be considered for removal.
Western Border – sections along northeast Khaudum National Park, north of Ikoga fence, south of Ikoga fence to Dobe	**Community consultation (Phase 3) on potential removal of southernmost (55 km) section bordering Nyae Nyae Conservancy and southern Khaudum National Park** The greatest risk to Botswana along this fence line is an outbreak of CBPP and loss of Botswana's free status. Although considered very low, this risk is perceived to be highest at the more northern sections proposed for removal in the Phase 1 analysis, given their closer proximity to the border with Angola, which is the source of CBPP infections in Namibia, and the lack of recent history of CBPP in Namibia further south. Botswana's surveillance plan identifies specific crushes in the extreme northwest of Ngamiland as high risk for CBPP. The southernmost section proposed for removal in this Phase 2 analysis largely borders Otjozondjupa; there are no high-risk surveillance crushes in this area and CBPP has not been reported this far south. The FMD-free buffalo, limited number of cattle and lack of recent FMD outbreak history on the Namibian side of the fence make the risk of SAT-type FMD to Botswana very low. **Re-evaluate northern sections bordering Khaudum National Park pending continued absence of CBPP cases in Kavango East Region** If CBPP cases in Namibia remain sporadic and Kavango East remains free of cases, the other fence sections bordering central and northern Khaudum National Park could be considered for removal.

While the risk assessment indicated that removing the specific fence sections selected would not increase the risk from that of maintaining the status quo, the risk would be further reduced by implementing certain measures to protect cattle from contact with potential sources of infection. Improving vaccine coverage, particularly for crushpens considered to be at higher risk due to proximity to the border, with post-vaccination monitoring (PVM) to monitor effectiveness, is strongly recommended. The implementation of H4H by cattle owners is aimed at controlling cattle movement, preventing contact with other herds or buffalo, particularly at night, as well as protecting livestock from predation and stock theft, and improving pasture management. It also supports improved vaccine coverage by ensuring that all of the cattle are presented for vaccination and good records are kept.

The assumption is that these measures will be fully implemented, and if this is the case the risk of infection with FMDV as well as certain other diseases should be reduced. Non-compliance with the mitigation measures will reduce their effectiveness and the level of risk will be the same as removing the fences without mitigation measures. Fortunately, the overall risk in these areas is very low, but this should not be a reason for non-compliance with risk mitigation measures that are tailored to improve the general health and wellbeing of livestock and support commodity-based trade (CBT) to enable higher prices for beef.

B. Recommendations based on special considerations identified at validation meeting

In May 2024, a meeting of the core team, the majority being Botswana DVS and Namibia DVS stakeholders, was held in Maun, Botswana to validate the results of the report and allow for bilateral discussions between the Governments of Botswana and Namibia on the fence sections proposed for Phase 3. Group discussions during the validation meeting brought to light several special considerations:

- Although the probability of occurrence for FMD serotype O at the Zambezi Border fence was very low and group discussions noted that FMD serotype O was likely more of a risk to Chobe District than to Ngamiland, based on proximity to Zambia, the moderate overall risk estimate for this disease was an overriding factor in decision making for this fence line.

- Fence patrols that are already in place help with detection of illegal movement of livestock or cattle theft. These patrols should be an explicit part of risk mitigation if fence sections were to be removed. The Botswana Defence Force camp at the junction of the Zambezi Border and Northern Buffalo fences provides some confidence for considering removal of sections of either fence.

- The severity of the consequences of stamping out the 1995 CBPP outbreak in Botswana has resulted in lingering apprehension about the recurrence of the disease in Botswana. Although meat other than lung is still considered safe for trade regardless of CBPP status, trade of live cattle would be affected in the event of an outbreak.

- One important limitation of the analysis was that it did not account for the complete extent of cattle mobility in the region; farmers may move cattle seasonally to different grazing areas. In addition, borehole rights may be owned but not yet developed and could represent future areas of livestock presence not shown on existing maps.

- Although fences do not represent barriers impermeable to all movement, removal of fence sections entirely could facilitate illegal movement of animals and people and possible spread of transboundary animal diseases and poaching. While the attendees agreed that the risk of an FMD outbreak from poaching was minimal, there was concern about poaching of wildlife resources in general, particularly if animals move into areas with higher relative poaching pressure. This could act as a deterrent to animal migration (e.g. if there were significant poaching pressure in Angola, elephants might avoid leaving the eastern panhandle in Botswana to disperse to this area). That said, poaching pressure in northern Botswana itself is not insignificant. In the KAZA context, fence removal decisions would benefit from consultations between, for example, the Animal Health Sub Working Group and the Elephant Sub Working Group.

- Complete data on cattle incursions had not been provided to assist in understanding the risks for the Western Border fence; there was anecdotal knowledge of more cattle movement than what was documented in the report. However, some of these incursions may have occurred further south in areas not proposed for fence section removal.

As a result of the Maun May 2024 validation meeting, the final recommendations are more conservative than the initial suggestions represented in Figure A above that were based purely on the qualitative risk assessment. The final recommendations based on these special considerations and further discussion are presented in Table E, below. The final fence sections recommended for community engagement (Phase 3) on potential removal or re-evaluation in the future are shown in Figure C, below.

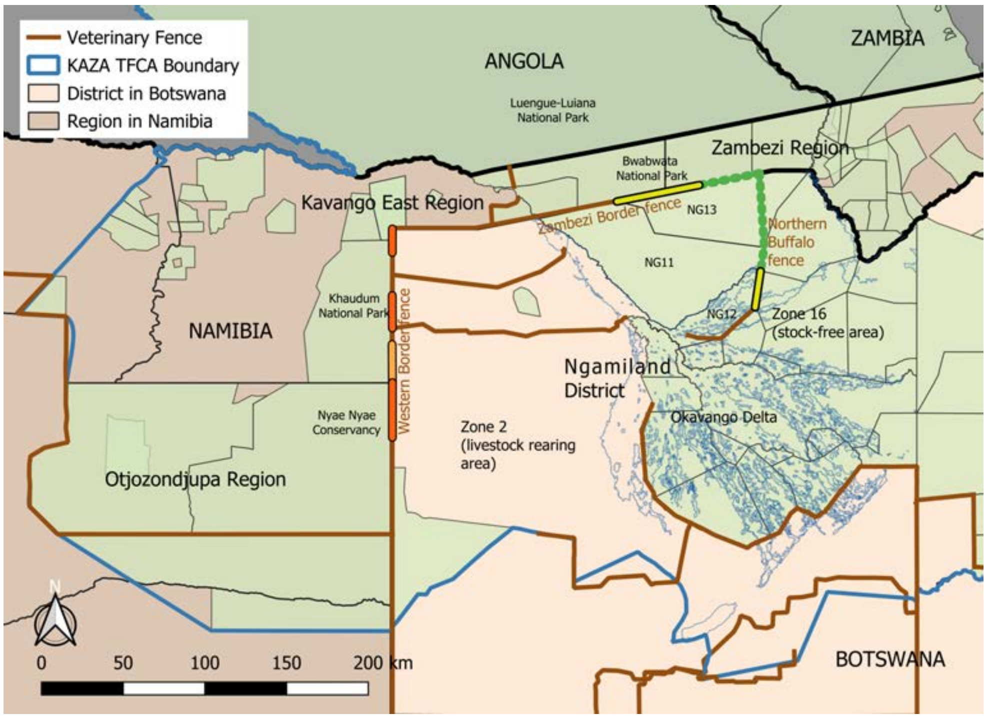

Figure C. Fence sections recommended for Phase 3 community consultations on potential removal (green) with risk mitigation or re-evaluation in future (yellow) based on bilateral consideration. Sections of the Western Border fence (dark and light orange) were not recommended for removal at this time, though one 23 km section (light orange) was highlighted as being a potential candidate in the future pending further information.

Table E. Recommended actions for key fence sections agreed upon during validation meeting.

Fence	Recommendations
Zambezi Border (east of the Okavango River) - eastern section (90 km) in NG13	**Community consultation (Phase 3) on eastern 35 km section, subject to risk mitigation measures** Fence removal would be done in phases, starting with the 35 km easternmost section, furthest from Tovera and Omega settlements. Risk mitigation would involve actions on the part of both Botswana and Namibia. Removal of the cattle from Bwabwata National Park is a key risk mitigation step for fence removal, particularly to minimise the risk of FMD serotype O. Namibia would need to improve the existing 15 km buffalo fence that separates the western multiple use area from the rest of the park and extend the fence westward to run along the Namibia-Angola border to the park boundary at the Okavango River. This would restrict movement of cattle into the park from settlements along the western border of Bwabwata. In Botswana, the farmer at Seshokora crush would also need to be resettled and compensated, to avoid the presence of cattle in NG13, or participate in H4H. **Re-evaluate western section in NG13 (55km) after risk mitigation implementation**

	If cattle were removed from Bwabwata National Park and H4H implementation around Tovera were successful, the remainder of the fence along NG13 could be considered for removal.
Northern Buffalo – northern section (80 km) in NG13, NG11 & top of NG12	**Community consultation (Phase 3) on potential removal of section to Selinda Gate (62 km), subject to risk mitigation measures** The disease risks along the Northern Buffalo fence were perceived to be the most limited, given the fact that it is an internal fence. However, the greatest concern with potential removal of this fence was the risk of increased cattle-buffalo contact in the eastern panhandle. Fence removal would be done in phases, starting with the northernmost 62 km section from Xhoroma to Selinda Gate. Risk mitigation for this fence would involve two related actions. The farmer at Seshokora crush would need to be resettled and compensated, to avoid the presence of cattle in NG13, or participate in H4H. In addition, H4H would need to be implemented at cattleposts in the eastern panhandle. Controlling cattle movement and limiting cattle-buffalo contact under H4H would serve to mitigate the risk of buffalo moving into the area. **Re-evaluate southern section in NG11 & NG12 after risk mitigation implementation** If H4H implementation in the eastern panhandle were successful, the southern sections closer to the cattleposts could be re-evaluated for removal.
Western Border – sections along northeast Khaudum National Park, north of Ikoga fence, south of Ikoga fence to Dobe	**Pause consideration of community consultations until further information gathered and harmonised animal health controls in place** Additional information on cattle incursions was requested to form a more complete picture of the disease risk along this fence, as was other information on elephant migration and human-wildlife conflict. Border security was also noted to be of interest. Given the perceived higher risks, particularly for CBPP, both countries felt there was a need for better harmonised animal health controls throughout KAZA, with specific emphasis on CBPP and PPR, before further consideration of potential removal of parts of this fence in a phased approach. A 23 km section, south of the Ikoga fence, bordering Khaudum National Park, was tentatively identified as a future candidate for consideration, depending on the success of risk mitigation measures elsewhere in Ngamiland.

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ABBREVIATIONS AND ACRONYMS

AHEAD	Animal & Human Health for the Environment And Development (Cornell University)
BAITS	Botswana Animal Identification and Traceability System
BNVL	Botswana National Veterinary Laboratory
BVI	Botswana Vaccine Institute
CBPP	Contagious bovine pleuropneumonia
CBT	Commodity-based trade
Defra	Department for Environment, Food and Rural Affairs
DVS	Department/Directorate of Veterinary Services
DWNP	Department of Wildlife and National Parks
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and mouth disease
FMDV	Foot and mouth disease virus
H4H	Herding for Health
KAZA	Kavango Zambezi Transfrontier Conservation Area
MEFT	Ministry of Environment, Forestry and Tourism
MET	Ministry of Environment and Tourism (now MEFT)
MmmSC	*Mycoplasma mycoides* subsp. *mycoides* small colony variant
NCA	Northern Communal Areas
NSP	Non-structural proteins (of FMDV)
OIE	World Organisation for Animal Health (now WOAH)
ORI	Okavango Research Institute
PPR	Peste des petits ruminants
PVM	Post-vaccination monitoring
PPRV	Peste des petits ruminants virus
SAT	South African Territories (serotypes of FMD viruses)
TFCA	Transfrontier conservation area
VCF	Veterinary Cordon Fence
WAHIS	World Animal Health Information System
WOAH	World Organisation for Animal Health (formerly OIE)

1. INTRODUCTION

1.1 Report overview

The Republics of Botswana and Namibia are party to the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) for which a treaty was signed by Heads of State in August 2011 (KAZA TFCA Treaty 2011). Reconciling land use conflicts is integral to the success of this ambitious conservation and development initiative as more than 70% of land in the TFCA is inhabited by communities living in close proximity to protected areas, with inherent challenges at the interface between wildlife, livestock and people. Addressing issues at this interface requires a cross-sectoral, integrated and holistic approach.

An assessment of livestock disease risks under current fencing conditions versus those associated with potential removal of specific sections of veterinary fences, with an emphasis on the Botswana-Namibia border, was conducted in 2022/23 by a collaborative team representing the Governments of Botswana and Namibia, along with representatives from the Botswana Vaccine Institute, Okavango Research Institute and KAZA Animal Health Sub Working Group.

This report summarises the findings of this assessment, which was the second of a three-part project evaluating veterinary fences in Botswana's component of KAZA, some of which border Namibia, and their impact on the overall vision of habitat connectivity implicit for a successful TFCA. The first phase of work, completed in 2022 with support from the UK Department for Environment, Food and Rural Affairs (Defra) to the KAZA Secretariat, evaluated the fences based on their impacts on wildlife movements and concluded that removal of sections of several fences would be recommended from a wildlife conservation perspective (Atkinson et al. 2022; see executive summary in Appendix A). The second phase of work (this report) goes on to analyse how the risk of important livestock diseases might change if these sections were removed to promote habitat connectivity across the greater KAZA landscape. A third and final phase, not yet undertaken, would entail consultations with communities that could be impacted, positively or negatively, by the removal of any specific fence section as proposed by the first two phases and associated deliberations. Cumulatively, the three phases of work will provide a science-based product to help inform national, bilateral and KAZA-level planning efforts within the context of regional collaboration and cooperation in the areas of disease risk management, natural resource use and management, and community development.

The outputs of this second phase assessment provide information on the estimated risk of key livestock diseases around selected fences under three scenarios: (i) current conditions where no changes are made, i.e. the status quo, (ii) a specific fence section is removed and (iii) a specific fence section is removed with the addition of targeted risk mitigation (such as application of the Herding for Health model).

The fence sections subject to the current analysis are those identified in phase 1 as being a high priority for removal to support wildlife connectivity, as shown in pale blue in Figure 1 (Atkinson et al. 2022). These are the eastern section (90 km) of the Zambezi Border fence (east of the Okavango River), the northern section (80 km) of the Northern Buffalo fence and three sections of the Western Border fence along the border with Khaudum National Park and Nyae Nyae Conservancy in Namibia.

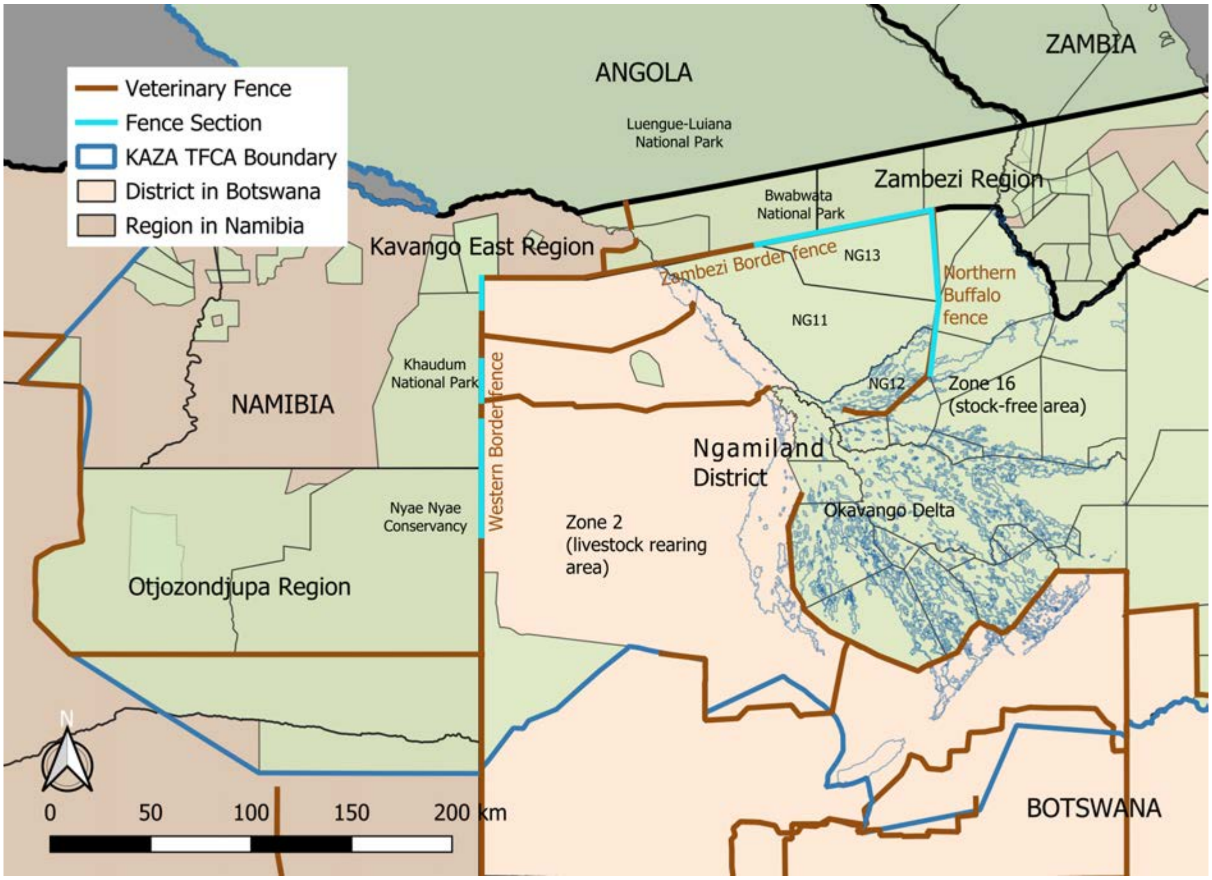

Figure 1. Fence sections recommended as a high priority for removal (pale blue) in Phase 1 report. Note that the Samochima and Ikoga fences were not evaluated in this Phase 2 analysis, but they are still important to consider due to their impacts on wildlife movements, as per the Phase 1 analysis findings.

Two cattle diseases were selected as highest priority for the livestock disease risk assessment: foot and mouth disease (FMD) and contagious bovine pleuropneumonia (CBPP). The report covers the multiple risk assessments that were completed for each of the three fences. These include the risk of South African Territories (SAT) serotypes of FMD to Botswana and to Namibia from cattle, buffalo, or poaching, the risk of FMD serotype O to Botswana from cattle, and the risk of CBPP from Namibia to Botswana. Later discussions with government veterinarians also identified the risk of peste des petits ruminants (PPR) as a concern with potentially removing fences. Given the late inclusion of PPR, the fact that it has never been identified in Namibia and its low probable relevance given that there has been no evidence to date of sustained circulation in wildlife in Africa, this disease is discussed more briefly in the report.

1.2 Background

Fencing has historically been used throughout southern Africa to separate livestock and wildlife, often for the purpose of limiting contact between cattle and buffalo to prevent the spread of FMD viruses (FMDV). This is because international trade standards set by the World Organisation for Animal Health (WOAH) have until recently required cloven-hoofed animals and commodities to originate from geographic areas free of FMD – an unachievable target in areas with buffalo. In recent years, non-geographic international trade standards have been developed and are increasingly being adopted, most notably commodity-based trade (CBT) of beef, which include the management of FMD risk along beef value chains (SADC and AHEAD 2021). The availability of non-geographic trade standards and innovations such as CBT, when applied to beef, offer alternatives to the traditional geographic-based approach to FMD risk management that has been so reliant on fences (Atkinson et al. 2019). Importantly, this creates an unprecedented opportunity to mitigate conflict between two traditionally opposing land uses – wildlife and livestock – in landscapes such as KAZA.

In 2019, the KAZA Heads of State acknowledged the importance of connectivity across the TFCA for the conservation and management of the TFCA's elephant population (KAZA TFCA Secretariat 2019). Fences represent significant barriers to this connectivity by inhibiting wildlife movements and have been recognised as such in various KAZA strategic documents such as the Master Integrated Development Plan (KAZA TFCA Secretariat 2015).

In 2020, the KAZA Secretariat received support from Defra to conduct phase 1 of the veterinary fencing assessment in Botswana's portion of KAZA, focused on fencing's impacts on wildlife movements (Atkinson et al. 2022). Ngamiland contains numerous fences along its borders and throughout its interior. These fences have been erected over time in response to various disease outbreaks, but they have not been as effective as might be desired. For instance, the construction of fences during the 1995 CBPP outbreak was not enough to control the outbreak at the time, and ultimately the entire cattle population in Ngamiland was depopulated. Similarly, although fences have been constructed to separate buffalo in the Okavango Delta from cattle and ostensibly prevent FMD, the region has had an increasing number of outbreaks in the last 15 years. Maintenance of such an extensive fencing system in the face of vandalism, ongoing damage by elephants and periodic flooding is difficult to say the least, and hugely taxing from a financial and human resource perspective (Atkinson et al. 2019). As a result, many sections of veterinary fences are now in a dilapidated state, leaving the integrity of these fences for achieving separation of cattle and buffalo populations inadequate at best.

The current fencing system has severe environmental consequences. The Phase 1 report found that these fences restrict wildlife movement in KAZA's Khaudum-Ngamiland and Kwando River Wildlife Dispersal Areas (Atkinson et al. 2022), and recommendations were made for the removal of several fence sections (Figure 2). Of these, three were marked as high priority and were approved for this Phase 2 disease risk assessment by Botswana's National Committee on Cordon Fences. The findings of the Phase 1 report are supported by a recent policy brief produced by the KAZA Elephant Sub Working Group, which reached similar conclusions. The policy brief specifically identifies Botswana's Northern Buffalo fence, the Botswana-Namibia Zambezi Border fence, and the Botswana-Namibia Western Border fence as "substantially constraining elephant movements" based on >3.9 million GPS observations from collared elephants, with a recommendation to remove or realign fences (KAZA TFCA Secretariat 2023).

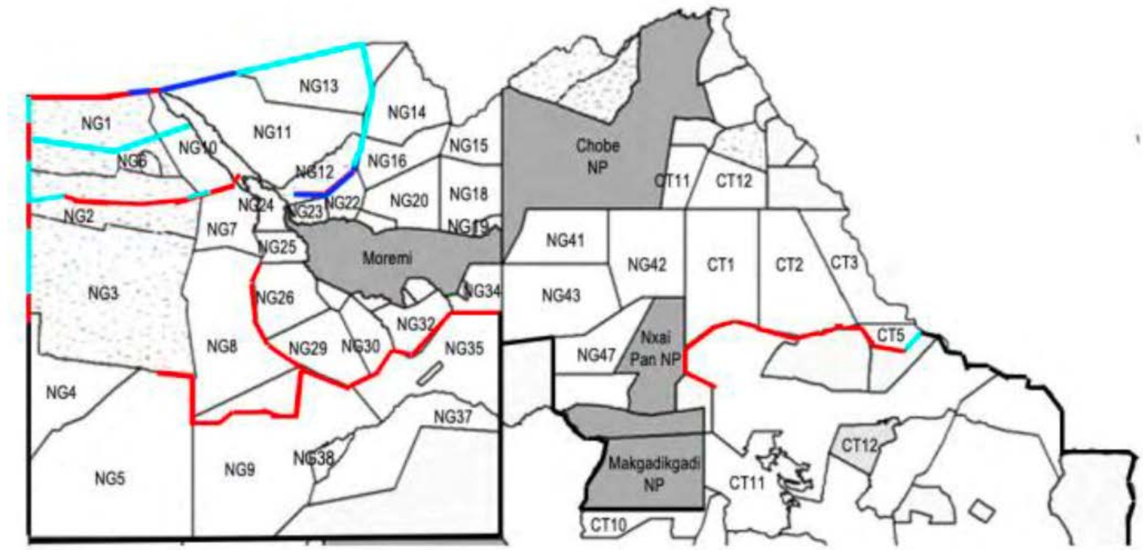

Figure 2. Botswana fence sections recommended for removal in Phase 1 (pale blue) or removal pending further evaluation (dark blue). Additional fences surveyed (red) and other major fences (black) are indicated. Source: Atkinson et al. 2022.

The Government of Botswana has removed selected fences in the past, including the Setata fence and Nxai Pan Buffalo fence (Ferguson and Hanks 2010). This Phase 2 report serves to provide a science-based analysis of how the risk of important livestock diseases might change compared to the status quo (fences in their current condition) if specific sections of the above mentioned three fences were removed to promote connectivity across the greater KAZA landscape, along with a third scenario involving fence section removal plus implementation of a tailored risk mitigation strategy which could include managed herding and kraaling along with CBT, which requires risk mitigation throughout the value chain.

1.3 Focus area and fences of interest

This report focuses on the central portion of KAZA, within Botswana and Namibia, where the three veterinary fences identified as being most problematic to wildlife movements and thus habitat connectivity are located (see Figure 1). Specifically:

- **Zambezi Border fence (east of the Okavango River)**. The 133 km fence runs east-west between Botswana and Namibia from the eastern banks of the Okavango River to the intersection with the Northern Buffalo fence. The easternmost (approx. 90 km) section, bordering Botswana's land use zone NG13 and Namibia's Bwabwata National Park, was proposed for removal in the Phase 1 analysis (as shown in light blue in Figure 2 above). The earliest parts of the fence were erected in the 1970s. Additional fencing was erected following the 1995 CBPP outbreak to prevent movement of cattle across the Botswana-Namibia border.

- **Northern Buffalo fence**. The fence extends 129 km south beginning at the Zambezi Border fence junction and terminating at the Okavango Delta and is located entirely within Botswana. The northernmost (90 km) section, bordering Botswana's land use zones NG13, NG11 and part of NG12, was proposed for removal in the Phase 1 analysis, as shown in light blue in Figure 2. The fence's construction began in 1991 as a physical barrier between buffalo in the Okavango Delta and cattle reared outside the delta to prevent transmission of FMDV.

- **Western Border fence**. The 300 km fence runs north-south between Botswana and Namibia, although the southern half (south of Dobe border post) extends outside of KAZA's boundaries. The three sections proposed for removal in the Phase 1 analysis all lie within KAZA's boundaries and include (i) the first ~15 km section [from the north] adjacent to Khaudum National Park, (ii) a ~20km section immediately north of the Ikoga fence junction and (iii) a ~60 km section to the north of Dobe (shown in light blue in Figure 2 above). The fence was initially constructed as an international border fence in 1954 to inhibit cross-border movement of pastoralists and cattle theft, not for separation of cattle from buffalo. A second fence was erected by Botswana in 1997 following a CBPP outbreak in Ngamiland to control cattle movements. Today, the fence line has components on both the Botswana and Namibia sides which are maintained by each country separately.

1.4 Diseases of interest

FMD is a reportable disease and one of the most economically important livestock diseases in the world (Knight-Jones and Rushton 2013). There are seven different serotypes of FMDV: one lineage comprising serotypes O, A, C, and Asia-1, and the other lineage comprising the SAT serotypes, namely SAT-1, SAT-2, and SAT-3 (Knowles and Samuel 2003; Vosloo and Thomson 2017). SAT-type FMDV is endemic in the region and is maintained by a wildlife reservoir, the African buffalo (*Syncerus caffer*). Other species such as kudu (*Tragelaphus strepsiceros*) and impala (*Aepyceros melampus*) may become infected but do not appear to play a significant role in the maintenance or transmission of FMDV.

FMDV serotype O has only recently appeared in the region. It is of particular interest because it results in higher morbidity and mortality than SAT-type FMD and spreads rapidly among cattle, in which it is believed to have evolved with no involvement of a wildlife host. Serotype O is also of interest because historically southern African countries have only vaccinated against endemic SAT-type FMDV. Vaccination does not offer cross-protection among serotypes, therefore cattle receiving the trivalent SAT-1, SAT-2, SAT-3 vaccine remain unprotected against serotype O.

CBPP is another economically important disease of cattle in southern Africa. It is caused by *Mycoplasma mycoides* subsp. *mycoides* small-colony type (Spickler et al. 2010a), and there is no evidence of infection in African buffalo or other wildlife species. Controlling cattle movements is the most fundamental factor for control of CBPP (C. Marobela-Raborokgwe, personal communication), along with surveillance and vaccination.

PPR is a disease of sheep and goats and is often fatal, particularly in naïve populations. PPR is not endemic to southern Africa but appears to be spreading widely in Africa and Asia. A relative of rinderpest, PPR is caused by a single serotype of PPR virus (PPRV) and is preventable by a vaccine which confers life-long immunity. PPR does not have a carrier state and there are no known wildlife reservoirs, although seropositivity or very occasional clinical cases have been reported in a number of wild ruminant species in Africa due to spillover from sheep or goats, while some larger outbreaks in wildlife have been reported in Asia (Njeumi et al. 2020). WOAH and the Food and Agricultural Organization of the United Nations (FAO) have prioritised PPR as an active target for global elimination by 2030 through an eradication strategy similar to that employed for rinderpest (World Organisation for Animal Health 2015; Njeumi et al. 2020).

1.5 Country disease status

This report focuses on fences within Botswana or on Botswana-Namibia borders, and therefore each country's status on control of the diseases named above is relevant. The diseases status of neighbouring countries is also relevant to consider; specifically, Angola and Zambia have been identified by Botswana and Namibia DVS based on their proximity. No detailed information on cattle numbers or disease control activities was collected from the competent authorities in either country, but some information from public records and information provided at regional meetings is provided below to help inform the level of risks from these countries. Cattle observed during the dry season in parts of Angola, Botswana, Namibia, Zambia and Zimbabwe under the 2022 KAZA Elephant Survey are shown in Figure 3.

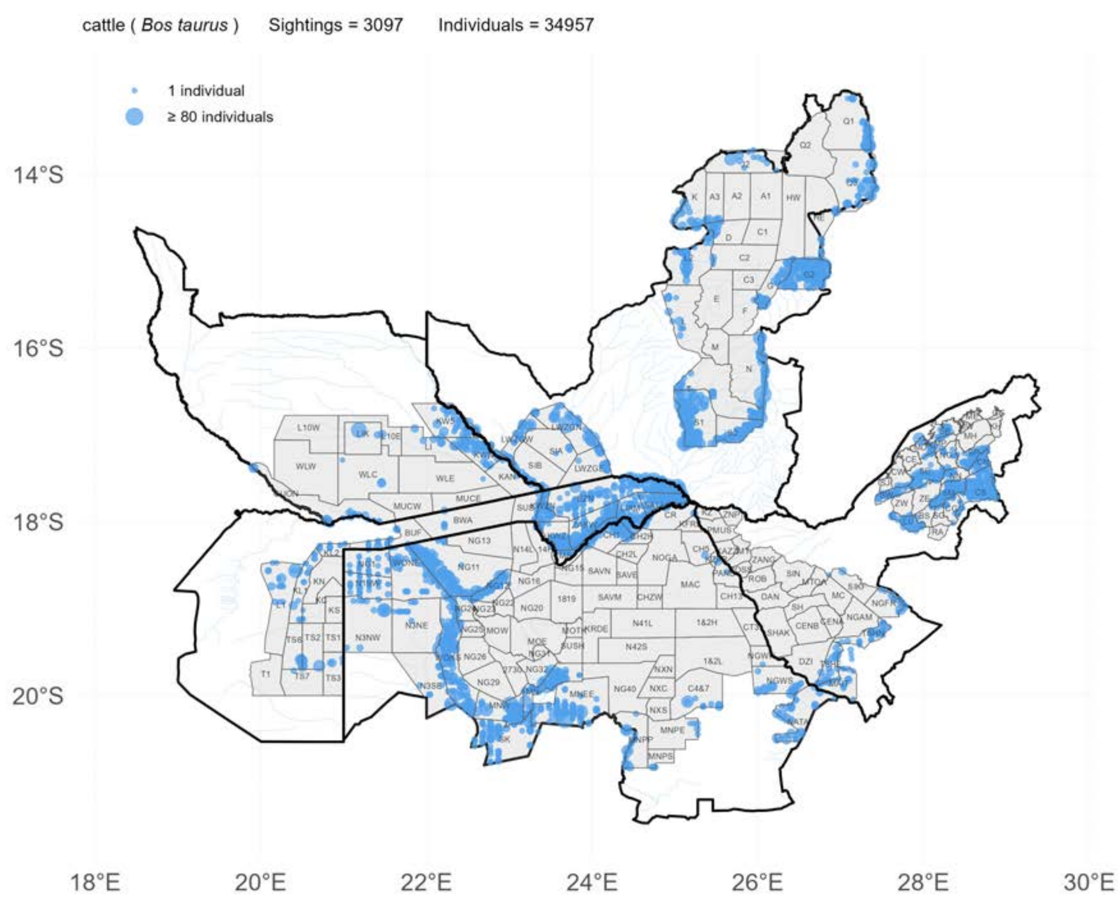

Figure 3: Map of cattle observed during the 2022 KAZA Elephant Survey. Source: KAZA Elephant Survey Report Volume I (Bussière and Potgieter 2023a).

Botswana has a WOAH-endorsed official FMD control programme and is divided into a number of veterinary zones containing livestock of different FMD status. The FMD-free zones are located in the south while the areas surrounding the Okavango Delta, namely Ngamiland (North West District) and Chobe District, are considered FMD infected zones (or red zones) that have no official WOAH status, although vaccination is practised here. Botswana also maintains additional disease control subzones in the north (Figure 4). Zone 2 covers much of Ngamiland and is divided into 6 subzones, 2a–2f, where livestock rearing is practised. Zone 16, which includes the Okavango Delta eastwards towards Chobe District (zone 1), is considered a stock-free area due to the presence of buffalo. Botswana has an objective of achieving FMD-free without vaccination status for subzones 2e and 2f by 2024, and FMD-free with vaccination status for 2a–2d by 2025.

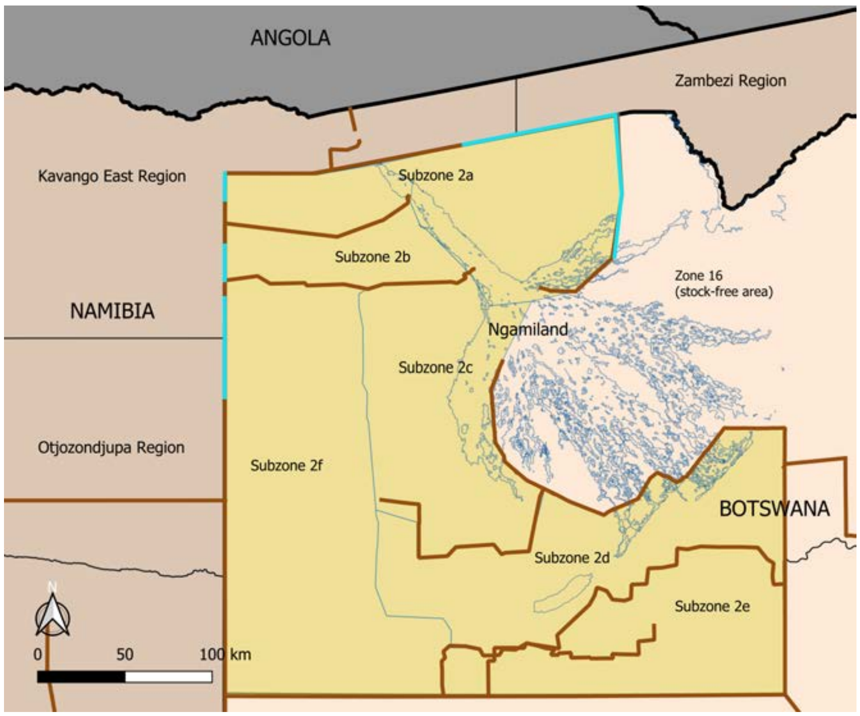

Figure 4. Veterinary disease control subzones in northern Botswana (Ngamiland), including livestock rearing areas (subzones 2a-2f) and stock free areas (zone 16), along with neighbouring regions in Namibia. Veterinary fences shown in brown and pale blue.

FMD outbreaks in Botswana have always been caused by the SAT serotypes; it has never had an outbreak of FMD serotype O. Since 2007, Botswana has experienced an increasing number of FMD outbreaks in Ngamiland, many of which have occurred far from the delta where buffalo contact might occur (Figure 5). Phylogenetic evidence from the World Reference Laboratory for FMD from outbreaks in Ngamiland is suggestive of endemic circulation of FMDV in the cattle population (Atkinson et al. 2019).

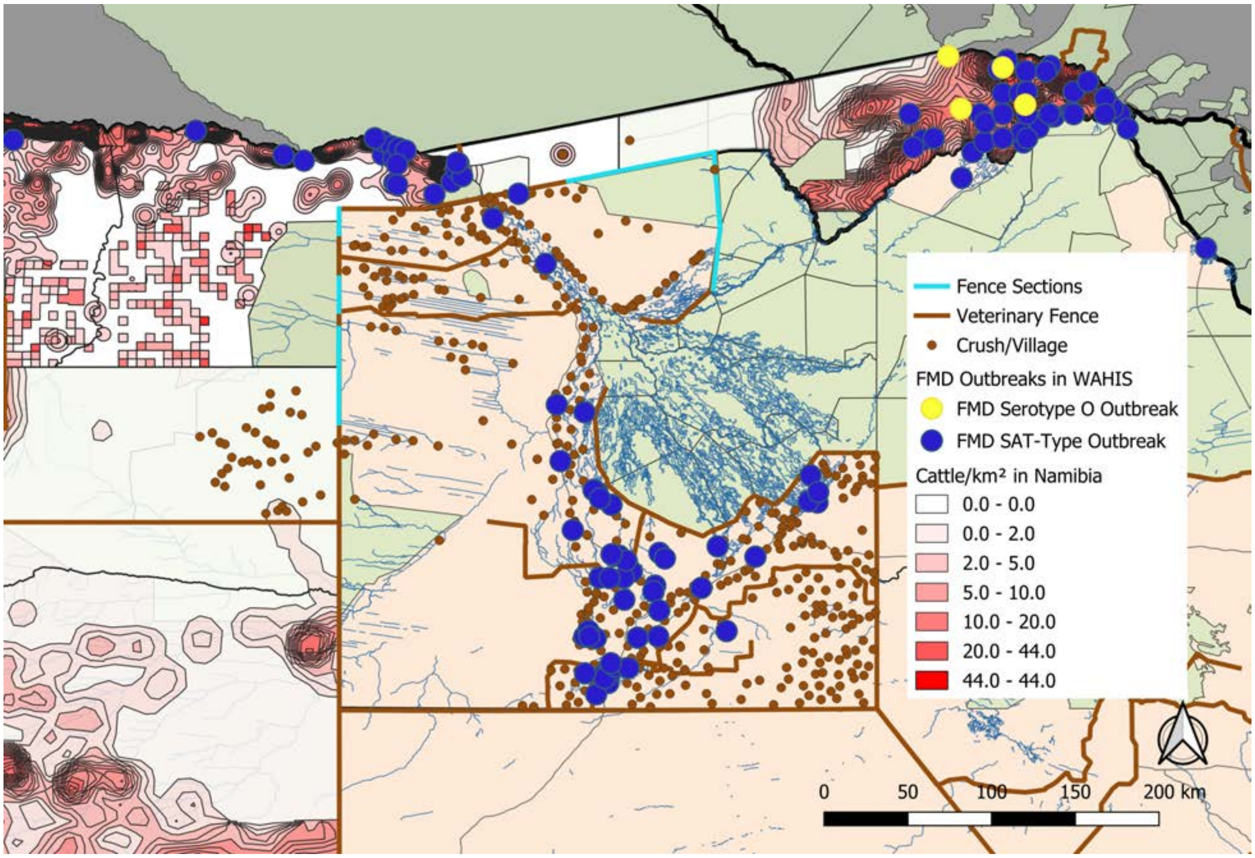

Figure 5. Map of FMD outbreaks from 2007–present in Botswana and Namibia recorded in WAHIS. Crushpen geodata were not available for Namibia so only select villages and publicly available cattle density data (2012 data for Kavango Region, 2002 Atlas of Namibia Project data otherwise) are plotted to give an indication of where cattle are most prevalent.

Namibia has a WOAH-endorsed official FMD control programme and uses a zonation system to control FMD, with the country divided into three zones, namely the free zone, protection zone and infected zone (or red zone). Namibia has maintained its free zone with a Veterinary Cordon Fence (VCF – also known as the Red Line) that divides the country into a commercial farming area south of the fence and communal cattle farming areas in the north. Buffalo are absent from most of the Northern Communal Areas (NCA) as suitable habitat is lacking, and much of this area is designated an FMD protection zone. However, the easternmost portion, consisting of Kavango East and Zambezi Regions (Figure 5 above), is not free of buffalo or FMD; it has no official WOAH status and is part of what Namibia considers its FMD infected zone. Namibia plans to eventually stop vaccination in the protection zone and seek endorsement from WOAH for FMD-free without vaccination status, while conceding that FMD-free status is not achievable in the infected zone (which forms most of Namibia's portion of KAZA) due to the presence of buffalo.

Namibia had historically only experienced SAT-type FMD outbreaks, but in 2021 an outbreak of FMD serotype O occurred in the Zambezi Region (Banda et al. 2022) (Figure 5). This followed the emergence since 2019 of serotype O viruses in the south-western provinces of Zambia (Banda et al. 2021). More recently, in October 2022, an FMD outbreak caused by SAT-2 was declared in the Zambezi Region which was reported as resolved by March 2023.

FMD also occurs in both Angola and Zambia. There are sporadic cases of SAT-type FMD in the south of Angola (Cunene and Cuando Cubango Provinces), most recently in 2022–2023. FMD serotype O has not been reported in Angola. Angola conducts clinical and serological surveillance with diagnostic support from Namibia’s Central Veterinary Laboratory. It has a national control programme for FMD. Zambia has experienced outbreaks of SAT-type FMD as well as serotypes O and A (the latter only occurring near the northern border with Tanzania). Zambia submitted a risk-based FMD strategic plan to WOAH in 2023 and also revised its surveillance protocol at that time. Past outbreaks have been attributed to inadequate resources or surveillance, challenges in timely vaccine procurement and inadequate post-vaccination monitoring (PVM), and rampant illegal movement of livestock.

In 1995, Botswana experienced a devastating outbreak of CBPP in Ngamiland which was eradicated by mass slaughter of 320,000 cattle in the district (Marobela-Raborokgwe 2011). Since 1998, Botswana has been officially recognised by WOAH as free from CBPP (Marobela-Raborokgwe 2011), and Botswana DVS conducts surveillance for CBPP at high-risk crushes in Ngamiland (Figure 6). In contrast, Namibia maintains a CBPP-free zone and has a WOAH-endorsed official CBPP control programme. Outbreaks of CBPP were declared in Namibia to WOAH during March, May, June and August 2022.

Angola and Zambia have also experienced CBPP outbreaks and neither has an official WOAH status for CBPP. In Angola, the four provinces bordering Zambia and Namibia are the most affected. Angola does vaccinate against CBPP and has a national disease control programme that includes CBPP.

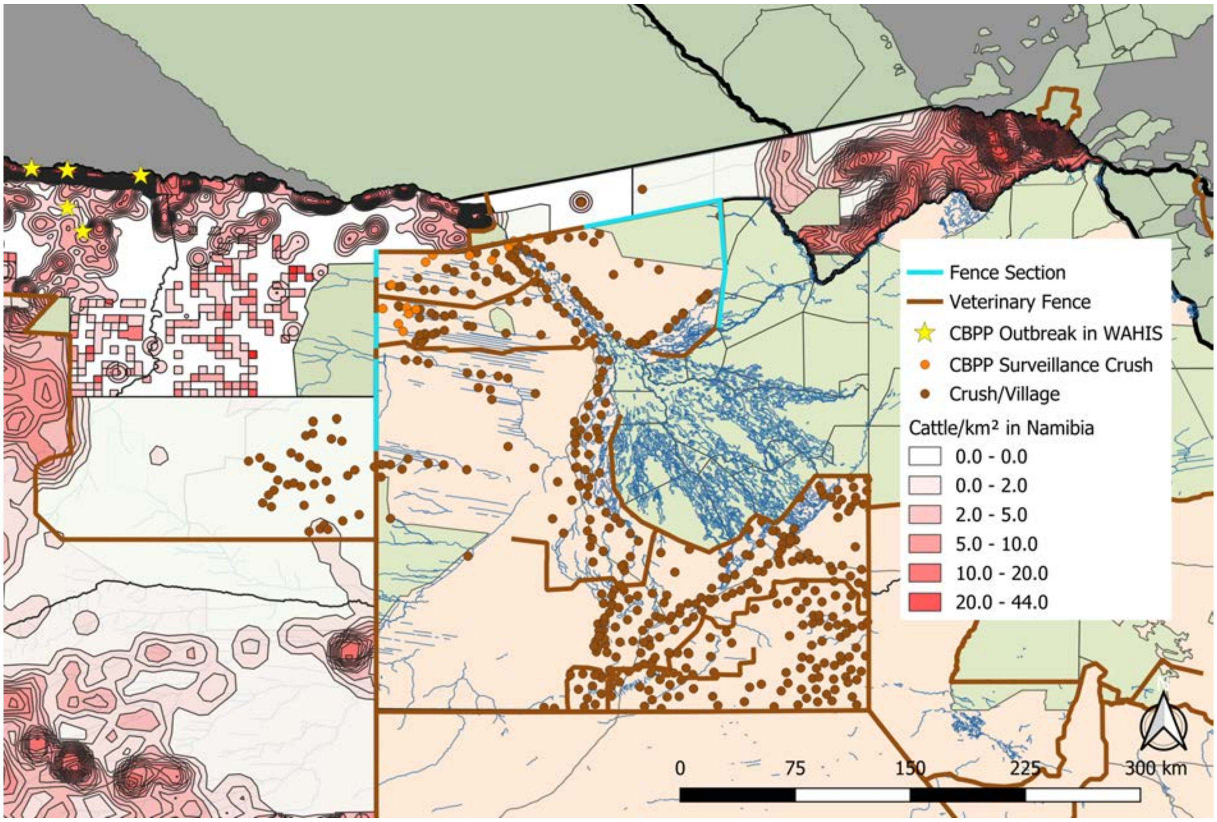

Figure 6. Map of high-risk crushpens selected for active CBPP surveillance in Botswana DVS Surveillance Plan in relation to CBPP outbreaks in Namibia recorded in WAHIS from 2007–present. Note: one surveillance crush, Rikonga II, is not shown as coordinates were not available. Crushpen geodata were not available for Namibia so only select villages and publicly available cattle density data (2012 data for former Kavango Region, 2002 Atlas of Namibia Project data otherwise) are plotted to give an indication of where cattle are most prevalent.

Clinical cases of PPR have never been identified in either Botswana or Namibia, but there is increasing concern about the spread of this disease to southern Africa. Botswana is officially recognised by WOAH as free from PPR and has identified high-risk crushes in Ngamiland for PPR surveillance (Figure 7). Namibia maintains a WOAH-recognized PPR-free zone south of the Red Line. Namibia is in the process of conducting surveillance in the rest of the country to support a dossier to WOAH for country status of freedom from PPR.

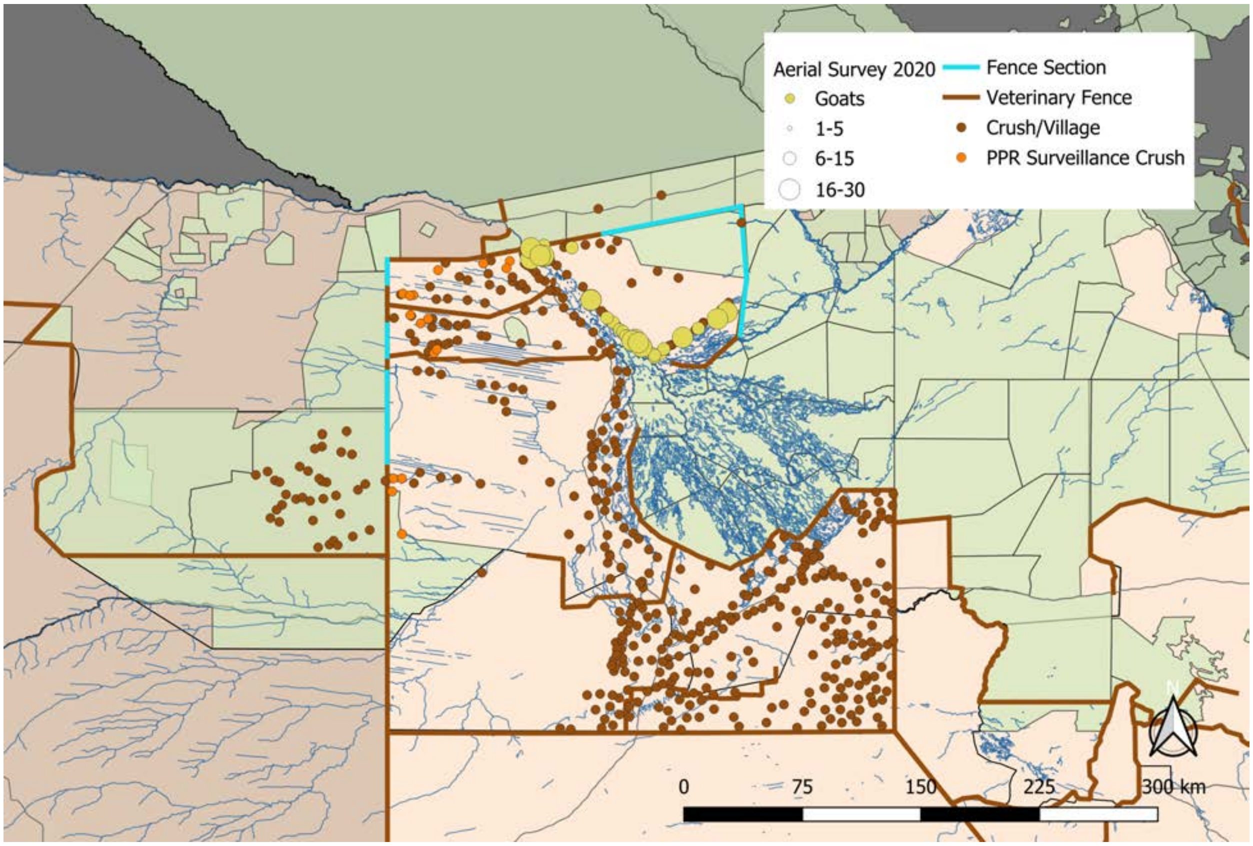

Figure 7. Map of goat populations in the eastern panhandle and northern Okavango Delta based on 2020 aerial survey results, as well as high-risk crushpens selected for active PPR surveillance in DVS Surveillance Plan. Note: two surveillance crushes, Rikonga II and Xhanxago, are not shown as coordinates were not available. Crushpen geodata were not available for Namibia so only select villages are shown.

Namibia is potentially at risk of PPR incursion through its neighbours Angola and Zambia. Neither country has an official WOAH status for PPR or current evidence of the disease being present, but they border other countries where there are clinical cases, including Democratic Republic of Congo, Malawi and Tanzania. Data in the World Animal Health Information System (WAHIS) database show detection of PPR in 2012 in Cabinda Province, Angola, an exclave separated from the rest of the country by territory belonging to the Democratic Republic of Congo. Positive serological results were detected during routine surveillance and associated with 55 small ruminants illegally imported from Democratic Republic of Congo, but no clinical cases were detected. Angola conducts risk-based surveillance along its borders with Democratic Republic of Congo, Republic of Congo and Namibia. For Zambia, data in WAHIS show detection of PPR antibodies in 2015, but no clinical cases were observed, and follow-up screening was negative for antibodies in the same areas. The initial seropositive cases are suspected to have been animals that were vaccinated in neighbouring countries and illegally moved across the border. More recent PPR serosurveillance has been negative.

2. APPROACH AND METHODOLOGY

2.1 Risk assessment method

A document outlining disease risk assessment methodologies potentially suitable for conducting the assessment was compiled in 2022 (Appendix B) and shared with collaborators in Botswana and Namibia. Following this, a series of group meetings and discussions were undertaken to gather expert opinion and feedback on the risk assessment process, data source availability, potential risk pathways and risk mitigation measures. Meetings with scientists based at local NGOs were also undertaken to gather further input on cattle movements, wildlife poaching, livestock predation, and other topics related to the potential risks and mitigation approaches around fence removal. In addition, a field site visit was made to both the Zambezi Border and Northern Buffalo fences, in the company of a Botswana Department of Veterinary Services (DVS) officer. A detailed chronology of these stakeholder consultations is outlined in Appendix C.

Based on the available data, a qualitative risk assessment approach, following the general format of the WOAH import risk analysis framework, was selected for this assessment. Hazards were identified and for each, a risk pathway delineated using a scenario tree. For each hazard, the risk of entry and exposure was assessed, as were the consequences of an outbreak, and from these the overall risk estimated (Figure 8). First, the risk of a hazard being introduced into a zone or country (entry) is assessed, followed by the risk of exposure of a susceptible animal to the hazard (exposure). The combined probability of the entry and exposure assessments is the probability of occurrence. For the consequence assessment, the direct economic and health impacts of an outbreak, as well as other indirect consequences, are assessed. In the final step of risk estimation, the probability of occurrence and consequence assessment are combined into an overall measure of risk.

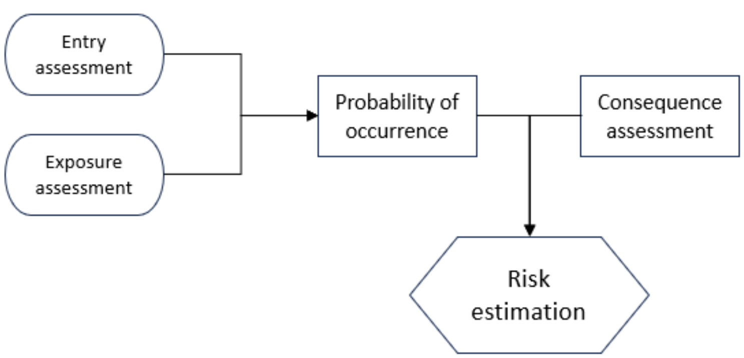

Figure 8. Outline of WOAH risk assessment framework, adapted from Dufour et al (2011).

Determining hazards for inclusion. In initial discussions about the risk assessment, FMD and CBPP were identified as the diseases of greatest interest, with cattle being the species of interest for FMDV infection. At the June 2023 KAZA Animal Health Sub Working Group meeting in Divundu, Namibia, discussions among Partner State veterinary officials identified PPR as an emerging disease threat to the region that should be included in the risk assessment as well.

Determining risk pathways for inclusion. Multiple risk pathways were identified for the entry and exposure assessments. These included the risk of SAT-type FMDV to both Botswana and Namibia from both cattle and buffalo; the risk of FMDV serotype O from Namibia to Botswana for cattle (FMDV serotype O has never been detected in Botswana); the risk of poaching as a source of FMDV; and the risk of CBPP and PPR from Namibia to Botswana (Botswana is officially recognised as free of both diseases by WOAH). These are described in more detail in section 2.3.2.

Using scenario trees to map risk pathways. For each of the risk pathways, a scenario tree was developed outlining the series of events necessary for an outbreak of the disease of interest to occur (Figure 9). Each event in the sequence is conditional, meaning that for an outbreak to occur, all the events in a certain pathway have to take place. If any of the events in the sequence do not occur, an outbreak does not occur.

Assigning values and determining overall qualitative risk. Qualitative probabilities were assigned to each event in the sequence based on published data and/or expert opinion. The probabilities for all events were then combined to produce a final probability of occurrence, which was combined with the consequences assessment to obtain an overall risk estimation. Further details on the probability categories and process for combining probabilities are outlined below in section 2.2.

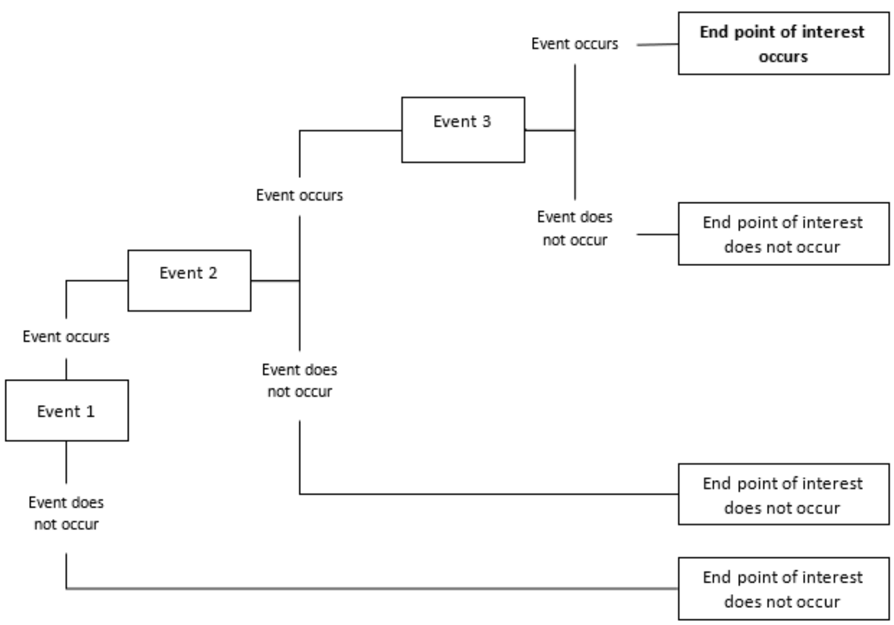

Figure 9. Generalised scenario tree for use in risk assessment, adapted from WOAH handbook on import risk analysis (Murray 2010).

2.2 Risk matrix and uncertainty definitions

Qualitative risk analyses use descriptive categories to assign a level of risk to each event along a risk pathway. However, no standardised set of risk categories are used across all qualitative assessments nor is there a universally recognised standard methodology to combine the probabilities of each event along a risk pathway to obtain an overall risk estimate. Matrices, however, provide a transparent methodology for combining risk levels (Horigan et al. 2023). Seminal work from Zepeda-Sein (1998) uses four risk categories (negligible, low, moderate, high) and includes two risk matrices. Many published papers use this system, although more recent publications have noted that this method of combining risks does not account for the conditional nature of the probabilities in a risk pathway and overestimates risk, while suggesting a modified approach (Dufour and Moutou 2007; Gale et al. 2010; Roche et al. 2015; Gale et al. 2016).

Consequently, for this assessment, five risk categories were selected (Table 1) and definitions modified from the six categories used by Rinchen et al. (2020). Using these definitions, the probability of each event occurring along the risk pathway was qualitatively assessed. These risk categories were then combined with each other in a sequential manner to obtain a total probability for the entry assessment. The same procedure was followed for the exposure assessment. The entry and exposure probabilities were then combined according to a combination matrix (Table 2) to produce a probability of occurrence estimate for the entire pathway. This matrix structure accounts for the fact that probabilities exist between 0 and 1 and therefore when multiplying probabilities, the product cannot be higher than the lower probability (Gale et al. 2010). The lowest probability levels in the pathway can therefore function as pinch points or “risk bottlenecks” that limit the overall risk of the pathway.

The magnitude of consequences of an outbreak was qualitatively assessed using the four descriptive levels defined by Zepeda-Sein in 1998 (Table 3). Thereafter, the final risk estimation for each pathway was derived by combining the probability of occurrence and magnitude of consequences. The risk matrix used includes five levels (Table 4), and is adapted from 10 levels of probability (Dufour et al. 2011). This system aligns well with how disease risk is often interpreted in the region, in that even though the probability of a disease being introduced may be small, the consequences could be devastating, and therefore the overall risk is greater than just the risk of introduction.

The assessment also considered three levels of uncertainty when interpreting the available data based on data quality and quantity. Uncertainty was assessed for each event in the risk pathway and for the consequence assessment using the categories in Table 5. For uncertainty, a conservative approach was adopted in which the highest level of uncertainty from the pathway was retained (Crotta et al. 2016; Rinchen et al. 2020).

Table 1. Probability risk levels used for the entry and exposure assessments, adapted from Rinchen et al. (2020).

Probability	Definition
Negligible	Likelihood of an event occurring is so rare that it does not merit consideration
Very low	Likelihood of an event occurring is rare but can occur
Low	Likelihood of an event occurring is occasional
Moderate	Likelihood of an event occurring is regular
High	Likelihood of an event occurring is very often

Table 2. Combination matrix used for combining two probabilities, modified from Rinchen et al. (2020).

	Probability 1				
Probability 2	**Negligible**	**Very Low**	**Low**	**Moderate**	**High**
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Very low	Negligible	Very low	Very low	Very low	Very low
Low	Negligible	Very low	Low	Low	Low
Moderate	Negligible	Very low	Low	Moderate	Moderate
High	Negligible	Very low	Low	Moderate	High

Table 3. Consequence levels and definitions used in the assessment, as defined by Zepeda-Sein (1998).

Magnitude	**Definition**
Negligible	Little or no impact on production, production costs, health and longevity of the hosts, national and international sales
Low	Minor impact on the factors above
Moderate	Impact of medium magnitude on the factors above
High	Severe impact on the factors above

Table 4. Risk estimation matrix used for combining probability of occurrence and consequences, modified from Dufour et al. (2011).

	Probability of Occurrence				
Consequences	**Negligible**	**Very Low**	**Low**	**Moderate**	**High**
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Very low	Negligible	Negligible	Negligible	Very low	Very low
Low	Negligible	Very low	Very low	Very low	Low
Moderate	Low	Low	Low	Moderate	Moderate
High	Moderate	Moderate	Moderate	Moderate	High

Table 5. Uncertainty categories used in the assessment, as defined by Fournié et al. (2014).

Uncertainty Category	**Definition**
Low	There are solid and complete data available; strong evidence is provided in multiple references; authors report similar conclusions. Several experts have multiple experiences of the event, and there is a high level of agreement between experts.
Moderate	There are some but not complete data available; evidence is provided in a small number of references; authors report conclusions that vary from one another. Experts have limited experience of the event and/or there is a moderate level of agreement between experts.
High	There are scarce or no data available; evidence is not provided in references but rather in unpublished reports or based on observations, or personal communication; authors report conclusions that vary considerably between them. Very few experts have experience of the event and/or there is a very low level of agreement between experts.

2.3 Data sources and assumptions

2.3.1 Data sources

Data were collated from a variety of sources, including academic literature, historical data reported to WOAH accessed from the WAHIS database, and a variety of internal data from Botswana DVS and Namibia DVS.

Public data sources

- Published literature on FMD, CBPP, PPR and other relevant topics
- WAHIS data for CBPP and FMD outbreaks reported from Botswana and Namibia
- WAHIS data for CBPP reported from Angola and Zambia
- WAHIS data for PPR reported from Tanzania, Democratic Republic of Congo, Angola and Zambia
- Genotyping reports from FAO World Reference Laboratory for Foot-and-Mouth Disease for Botswana and Namibia
- European Commission Directorate-General for Health and Food Safety audit reports of Botswana and Namibia animal health control systems
- 2018 Office of the Auditor General report on control of FMD by Botswana DVS
- 2020-2030 Namibia Ministry of Environment, Forestry and Tourism (MEFT) Management Plans for Bwabwata and Khaudum National Parks
- 2019 Namibia Ministry of Environment and Tourism (MET, now MEFT) aerial surveys of Khaudum National Park and neighbouring areas and Zambezi Region
- 2022 KAZA Elephant Survey reports volumes I (technical report) and II (stratum reports)
- 2012 risk analysis of animal disease hazards associated with import of animal commodities into Namibia
- 2002 Atlas of Namibia Project geodata on cattle density in Namibia
- 2012 geodata on cattle density for former Kavango Region from Namibia Environmental Information Service eLibrary

Non-public data sources

- Phase 1 report on assessment of veterinary fences and impacts on wildlife movements in Botswana's portion of KAZA
- Questionnaire data from survey administered to farmers and gatekeepers in Ngamiland on husbandry practices and fence conditions as a joint project between Botswana Ministry of Agriculture and University of Botswana Okavango Research Institute (ORI)
- FMD vaccination records from Ngamiland
- FMD vaccination campaign reports from Ngamiland
- Livestock census data from Ngamiland
- Buffalo and cattle incursion reports from Botswana DVS Shakawe office
- Botswana DVS North West District monthly reports
- Namibia-Botswana (NAMBOT) joint patrol reports
- PVM data from Botswana National Veterinary Laboratory (BNVL)
- Wildlife serosurveillance data from BNVL

- Botswana DVS disease surveillance plan
- Botswana DVS FMD contingency plan
- Namibia DVS FMD and CBPP contingency plans
- Cattle incursion data from Namibia DVS
- Herding for Health (H4H) producer agreement and compliance record forms
- 2019 and 2020 aerial survey data on livestock and wildlife numbers and locations in NG11/NG12/NG13 in Botswana from Ecoexist
- GPS locations of collared cattle in northern Okavango Delta from CLAWS Conservancy
- Cattlepost and kraal locations from CLAWS Conservancy
- Village locations and livestock census data for Nyae Nyae Conservancy from Kwando Carnivore Project
- KAZA veterinary fence geodata from World Wildlife Fund

Expert opinions

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- Dr Bernard Mbeha, Botswana DVS
- Dr Odireleng Thololwane, Botswana DVS
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- Dr Chandapiwa Marobela-Raborokgwe, BNVL
- Dr Janine Sharpe, MEFT
- Dr Piet Beytell, MEFT
- Dr Jacques van Rooyen, Herding4Hope
- Dr Lise Hanssen, Kwando Carnivore Project
- Mr Theunis Pietersen, MEFT
- Mr Donovan Jooste, African Parks
- Prof Mary Louise Penrith, University of Pretoria

2.3.2 Assumptions and negligible risk pathways

FMD. For the purposes of this assessment, the risk of SAT-type FMDV to both Botswana and Namibia was assessed from both cattle and buffalo. Because FMDV serotype O has only been reported from Namibia and not Botswana, only the risk of serotype O from Namibia to Botswana was assessed and not vice versa. In contrast to the SAT-type FMDV, which evolved in sub-Saharan Africa in association with buffalo (Vosloo and Thomson 2017), there is no evidence of buffalo maintaining FMDV serotype O nor viral isolation of FMDV serotype O from buffalo. There was some serological evidence of serotype O in buffalo in Uganda (Ayebazibwe et al. 2010) and in West African buffalo (*Syncerus caffer brachyceros*) rather than Cape buffalo (*Syncerus caffer caffer*) which occur in southern Africa (Di Nardo et al. 2015). Surveillance in Kenya showed circulation of SAT-1, SAT-2, O, and A serotypes in cattle while only SAT-1 and SAT-2 were isolated from nearby clinically normal buffalo (Wekesa et al. 2015; Omondi et al. 2020). A more recent study specifically noted that the low seroprevalence of serotypes O and A observed in buffalo likely represented occasional cattle-to-buffalo spillover or serological cross-reactivity and suggested that buffalo are not epidemiologically important for these serotypes (Casey-Bryars et al. 2018). Further research in this area is warranted, but for the purposes of this assessment, only cattle-cattle transmission was considered for assessment of FMDV serotype O.

The potential risk of poaching as a source of SAT-type FMDV was also considered as part of this assessment, as specifically requested by several governmental stakeholders. Discussion of and research on how poaching of buffalo might lead to an FMD outbreak in cattle produced several potential pathways, although these are mostly extremely unlikely. Observational evidence suggests that poaching is unlikely to be a major source of FMDV transmission. There is a high rate of poaching in Ngamiland, with an estimated 1,787 hunters operating around the Okavango Delta removing 620,000 kg of wildlife biomass annually, of which buffalo and kudu account for the most meat (Rogan et al. 2017). These hunters are likely to own cattle (Rogan et al. 2018). The relative rarity of FMD outbreaks among Ngamiland cattle suggests that any form of FMDV transmission from poaching is not common. As a specific example, subsistence poaching reportedly increased across southern Africa during the COVID-19 pandemic (Lucas 2022), but FMD outbreaks in Botswana and Namibia did not dramatically increase during this time.

Various potential routes of FMDV transmission are discussed below:

- **Swill feeding.** There are no published data or risk assessments on the risk of FMDV from poached meat specifically. The main pathway through which any meat has led to transmission of FMDV is when infected meat is fed to pigs as swill (Hartnett et al. 2007); such an outbreak occurred in South Africa with FMDV serotype O from ship galley waste fed to pigs (Bruckner et al. 2002). A review of the literature did not reveal any known outbreaks of SAT-type FMD associated with contaminated meat. Bushmeat from buffalo is prized for human consumption (Alexander et al. 2012) and unlikely to be fed to pigs as swill. Furthermore, there is little swine production in Ngamiland and in most regions in Namibia bordering Ngamiland (a 2021 livestock census recorded 86 pigs in Zambezi Region, 3,175 pigs in Kavango East Region and 26 pigs in Otjozondjupa Region), so the risk of FMD transmission across borders from this route may be considered negligible.

- **Viral persistence in the respiratory tract.** Discussions about risks from poaching included the potential risk from viral persistence in the human respiratory tract. Namibia's FMD contingency plan explicitly mentions this risk for 24–48 hr after exposure to infected animals (Musilika-Shilongo et al. 2022), based on WOAH's disease card for FMD (World Organisation for Animal Health 2013). Under experimental conditions in an enclosed room, personnel exposed to FMD infected animals had limited virus survival in their nasal cavities 16–22 hours after exposure (Wright et al. 2010). In another experiment, one individual had virus recovered from the nose 28 hr post-exposure, but not at 48 hr post-exposure (Sellers et al. 1970). Importantly, these studies are based on indoor exposure to animals with clinical signs of FMD, while buffalo are rarely observed with clinical disease (Vosloo and Thomson 2017), nor are live buffalo handled indoors. A study with buffalo and cattle found that even when two non-viraemic but infected buffalo were slaughtered and eviscerated "in the manner normally used by hunters" next to cattle pens, no overt disease occurred in the cattle (Condy and Hedger 1974). Even if viral particles survived for a short period of time in a poacher's nose, there would then need to be some form of subsequent close contact with cattle for transmission to occur.

Under experimental conditions, FMDV could be transmitted from a human nasal cavity to a steer, after exhaling, coughing, and sneezing directly onto its muzzle for at least 30 seconds, within ~15-20 minutes of being exposed to FMD infected pigs with clinical disease (Sellers 1971). Close contact of this nature and duration with cattle is unlikely to occur in any natural setting and having prolonged direct contact with cattle within 20 minutes of poaching a buffalo that is actively shedding large amounts of FMDV is equally unlikely. A risk assessment in the UK found that the likelihood of FMDV transmission via the human respiratory tract, from animals without obvious clinical signs or without close and prolonged contact with susceptible animals, is negligible (Auty et al. 2019). The risk of viral persistence through the respiratory tract of poachers may also be considered negligible.

- **Human infection.** Human infection with FMDV is extremely rare, especially considering the number of people who have had contact with the virus (Hyslop 1973). Human infection with FMDV may be facilitated by breaks in the skin (Hyslop 1973), which could occur during butchering. Human infection has been reported with serotypes O, C, and A (Hyslop 1973), but not with the SAT serotypes. This may reflect a lack of data due to fewer potential laboratory exposures to the SAT serotypes or lower likelihood of humans who are naturally exposed to SAT FMDV being tested in endemic countries. Given the rarity of human infection with FMDV and the fact that it is not regarded as a public health threat, the route may also be considered negligible.

- **Mechanical transfer**. Mechanical transfer of virus to cattle could potentially occur if someone who butchered infected wildlife or handled infected bushmeat had contaminated hands or clothing, and then handled livestock. Handwashing and changing outerwear were sufficient to prevent mechanical transmission of FMDV to pigs under experimental conditions (Amass et al. 2003), but such precautions may not occur in a poaching scenario. This scenario was considered further in the risk assessment.

- **Aerosol transmission.** Other routes of transmission for FMDV were not considered in this assessment. Aerosol transmission of FMDV over distances of more than a few metres is not thought to occur in southern Africa (Hargreaves et al. 2004), and this route has not been strongly suspected or demonstrated to be involved in spread of FMDV in the region (Thomson 1995). Local climatic factors (low humidity and high temperatures) also do not promote survival of FMDV in the environment (Thomson 1995).

- **Small ruminant transmission**. Small ruminants do not appear likely to be involved in FMDV transmission as carriers, but may be able to transmit virus in early clinical or subclinical FMD infection, up to seven days after infection (Barnett and Cox 1999). Evidence from decades of FMD outbreaks in southern Africa has not demonstrated that sheep and goats are important in the maintenance and transmission of FMDV (Sutmoller et al. 2000; Jori et al. 2009). No outbreak in southern Africa since 1931 has had significant involvement of small ruminants (Thomson and Bastos 2004). Namibia has not considered small ruminants relevant in FMDV transmission based on serosurveys from 2015, although this has been criticised in the most recent EU audit (European Commission 2022). Small ruminants are less efficient at transmitting SAT-type FMDV and are less able to travel long distances than cattle (Thomson and Venter 2012). In a previous risk assessment for Namibia, the risk of small ruminants crossing fences and transmitting FMDV was considered very low (Thomson and Venter 2012), and small ruminants were not considered in another risk assessment near Kruger National Park for the reasons above (Jori et al. 2009). For the purposes of this risk assessment, small ruminant transmission of FMDV was not considered.

- **Wildlife (other than buffalo) transmission**. Wildlife species other than buffalo, such as kudu and impala, may also be involved in transmission of FMDV. Kudu and impala can jump significant heights and cross fences of 1.8 metres, and in one instance, appear to have caused an FMD outbreak in Zimbabwe (Hargreaves et al. 2004). However, a previous risk assessment in Ngamiland did not find that impala or small ruminants had evidence of infection in zone 2 (Babayani and Thololwane 2022), although data provided by Botswana DVS for this assessment on serosurveillance conducted in game conservancies in Ngamiland from 2019 to 2020 showed a majority of buffalo (43/54, 79.6%) and kudu (3/5, 60%) and a minority of impala (4/35, 11.4%) had non-structural protein (NSP) antibodies. Clinical FMD has been observed in a single kudu in Botswana (Letshwenyo et al. 2006). Antibody titres in kudu remain higher and of longer duration than in other wildlife species except buffalo (Hedger et al. 1972), but kudu have not been widely implicated in transmission of FMDV. Impala have been shown to maintain FMDV infection in Kruger National Park, but in association with a high density of impala and high ratios of impala to buffalo (Vosloo et al. 2009). Kudu and impala have not been shown to be efficient transmitters of FMDV unless in high density populations (Thomson and Venter 2012), which are not present in the areas near Botswana's fences (Bussière and Potgieter 2023b), and therefore were not considered in this risk assessment.

CBPP. Because Botswana holds official freedom from CBPP, only the risk of CBPP from Namibia to Botswana was assessed. Cattle are the only species that were considered in the transmission of this disease, as African buffalo have never been shown to be a host for *Mycoplasma mycoides* subsp. *mycoides* small colony variant (MmmSC) and there is no evidence for small ruminant involvement.

PPR. Similarly, because Botswana also holds official freedom from PPR, only the risk of PPR from Namibia to Botswana was assessed. Namibia holds official freedom from PPR for the area south of the VCF, and it should be noted that PPR has never been found in Namibia. Namibia is in the process of gathering evidence to gain PPR-free status for the NCA, where it is potentially at risk of PPR from its neighbours Angola and Zambia. Angola has experienced PPR in the past after infected small ruminants were illegally imported from Democratic Republic of Congo, and Zambia has detected PPRV antibodies in goats that were likely illegally imported from neighbouring countries, where they were suspected to have been vaccinated against PPRV during a prior outbreak. The epidemiological role of wildlife in transmission of PPRV has not been thoroughly studied (Britton et al. 2019; Aguilar et al. 2020; Fine et al. 2020; Idoga et al. 2020; Esonu et al. 2022). Wildlife can be infected but are not known to play a significant role in transmission of the virus, and to date are considered to be at risk rather than posing a risk (Aguilar et al. 2020; Idoga et al. 2020; Njeumi et al. 2020; Jones et al. 2021; Mdetele et al. 2021). This is supported by surveys in Africa that indicated seropositive wildlife in areas where direct or indirect contact with sheep and/or goats was likely (Mahapatra et al. 2015; Torsson et al. 2016; Jones et al. 2021; Mdetele et al. 2021). For the purposes of this risk assessment, only sheep and goats were considered in the transmission of PPRV.

2.4 Risk mitigation strategies

A number of risk mitigation practices have been discussed in response to the disease threats identified. To avoid repetition, risk mitigation strategies are discussed here and referenced throughout the report.

- **Vaccination** is one of the most basic risk mitigation strategies against infectious diseases, although approaches can vary. Both Botswana and Namibia vaccinate cattle against SAT-type FMDV in the areas under study, although coverage varies locally. If frequent FMD vaccination cannot be maintained, vaccination at the beginning of dry periods may be most beneficial given higher contact rates among herds at that time of year (VanderWaal et al. 2017). FMDV serotype O can also be included in vaccines, but at substantially higher cost, which has necessitated targeted vaccination against FMDV serotype O under current budgets. Vaccination against CBPP is practised in northern Namibia but not in Botswana, as it has CBPP-free status. Vaccination against PPR is not practised in either northern Namibia, which is working to develop its application for PPR-free status for the area north of the VCF, nor Botswana, which has PPR-free status.

- **Post-vaccination monitoring**. An important corollary to the deployment of FMD vaccination is conducting PVM with rapid turn-around of results. Both Botswana and Namibia have experienced years-long delays in PVM results recently (European Commission 2022; European Commission 2023), which hampers the effectiveness of vaccination programmes. A previous risk assessment noted that vaccination with improved coverage and incorporation of novel strains is a logical management approach in the face of permeable cordon fences, with ongoing fence damage anticipated to continue at an unsustainable rate (Babayani and Thololwane 2022).

- **Removal of cattle from Bwabwata National Park**, which borders wildlife management area NG13 in Ngamiland across the Zambezi Border fence, has been deemed essential for reducing the risk of transboundary livestock disease in this region. Cattle are not permitted within a national park under Namibian law, but there are currently over 2,000 cattle living in Bwabwata National Park, concentrated around Omega settlement. While it has been mandated that the cattle in Bwabwata National Park be removed, this has not yet been enforced (for decades). Notably, discussions among key stakeholders have recently been revived. It is important to ensure land use types are similar across specific portions of international borders when considering removal of fences or fence sections.

- **Increasing security patrols** such as border patrols and anti-poaching units may limit risk of illegal movement of livestock or wildlife products. There are routine fence patrols by Botswana DVS and NAMBOT patrols, but these could be augmented with additional patrols by Botswana's DWNP, Botswana Defence Force, etc. The Botswana Defence Force camp at Xhoroma, at the corner of the Zambezi Border and Northern Buffalo fences, could play a role in ensuring border security along these fence lines.

- **Implementing CBT,** which includes the use of fixed or mobile quarantines, offers risk mitigation for the consequences of an FMD outbreak while also potentially lowering the risk of outbreaks related to FMD-contaminated products. Geographic approaches to FMD control for beef production, involving countries or zones free of FMD, are problematic in regions such as southern Africa, where large-scale elimination of FMDV is impossible given its endemic distribution in free-ranging buffalo. Under CBT, producers in areas not recognised as free from FMD can still participate in beef trade by management of risks along the value chain to result in a final product with negligible risk of FMDV. Ensuring that meat and meat products are free of FMDV can allow for continued processing and sale of meat within an FMD infected zone even during an FMD outbreak.

- **Herding 4 Health (H4H)** is a model of strategic active herding and kraaling by skilled herders implementing planned grazing through collective action at village level. The model is described in more detail in Appendix D. At its most basic level, H4H addresses the need to control unattended livestock. Cattle are kraaled in a predator-proof boma at night, ideally in a mobile kraal with a planned grazing regime. Cattle are also branded and/or have appropriate identification to allow traceability. Trained ecorangers are required to maintain records for all cattle, including for compliance with mandatory vaccinations (e.g. against FMDV). The model is designed to be wildlife-friendly in that herders avoid contact with wildlife (particularly buffalo, impala and predators) and H4H thus allows for less reliance on veterinary fencing. Herders also avoid contact with cattle outside their combined herd. For the purposes of this assessment, compliance with these practices is assumed to be high but not perfect, and this is accounted for in the characterisation of the degree of uncertainty for assessments where H4H is applied.

    - Intended benefits of the H4H model include better livestock productivity, animal handling, herd health, record keeping and reduction of risks from wildlife-livestock contact (van Rooyen 2016). Under H4H, cattle are expected to have a higher overall level of general health. First, they are observed on a daily basis by ecorangers with basic animal health care training. In the face of reduced veterinary extension officers in Botswana as identified in another risk assessment (Babayani and Thololwane 2022), training individuals who have frequent contact with livestock to recognise signs of disease is crucial. The rapid identification and reporting of illness, and an ability to isolate all herdmates/contacts, outweighs the risk of maintaining livestock in higher density, at least overnight, compared to the situation for free-ranging cattle. Second, cattle are actively herded and are acclimated to regular (low stress) handling and can therefore be easily rounded up and presented during FMD vaccination campaigns or surveillance efforts. Vaccination is a component of compliance with the H4H model, and better vaccine coverage leads to higher herd immunity. Finally, cattle are expected to be in better body condition and nutritional status under H4H, because the use of planned grazing and kraaling at night reduces the distances animals must walk to find adequate food and water. Under typical conditions in the region, cattle move within a radius of ~10 km to access water and grazing around their kraal, while under H4H, the goal is to keep total distance walked during a day to 5 km (or a 2.5 km radius). Ecorangers plan grazing such that they use mobile kraals to keep animals away from the village during the wet season when food and water are more abundant, and are then able to minimise energy expended by utilising grazing closer to the village during the dry season. Kraaling has additional benefits of reducing predation on livestock (Weise et al. 2018) and subsequent human-wildlife conflict (Hanssen and Fwelimbi 2019).

- While the control of cattle movements and limiting of contact with cattle outside the herding group reduces the risks associated with inter-herd contact, close herding and kraaling practices do increase contact rates and potential pathogen transmission within a herd. However, the benefits of the H4H model are thought to outweigh the small risks of intra-herd transmission. Poor herding practices have been recognised for years in Ngamiland and prior FMD campaign reports have recommended the adoption of H4H at least as far back as 2019. While H4H pilots are underway in Habu and Eretsha, adoption of the model over a broader scale would be advisable to mitigate risks associated with transboundary animal diseases. H4H implementation may also be an option if the removal of cattle from Bwabwata National Park continues to be politically untenable. While removal would be ideal, better control of those cattle is a reasonable alternative for mitigating disease risk. H4H implementation could also be considered in Nyae Nyae Conservancy for risk mitigation on Namibia's side of the Western Border fence.

- The current H4H model does not have an explicit policy for how to handle cattle that cross an international border (J. van Rooyen, personal communication). This risk assessment assumes that if H4H were implemented in communities along international borders, it would include a policy to ensure ecoranger compliance with the national veterinary legislation governing animal movements.

2.5 Consequence assessments

To avoid repetition throughout the report, consequences for each type of disease outbreak are assessed below and referred to in the risk estimation sections.

2.5.1 SAT-type FMD outbreak consequences in Botswana

Cattle morbidity and mortality from SAT-type FMD are typically low, although young calves may experience greater mortality (Kitching 2002). In endemic regions, animals with partial natural or vaccinal immunity may have mild clinical signs which are easily missed (Kitching 2002), particularly if animals are free-roaming and not being closely observed. However, there are indirect effects, including low milk yield and poor performance in draught animals (Kitching 2002), and cattle in this region are used for both milk and draught power (Babayani and Thololwane 2022). Milk output has been reported to be reduced by as much as 33% (Office of the Auditor General, Botswana 2018).

Indirect costs of FMD, particularly in terms of how it is managed, far outweigh the direct morbidity and mortality costs (Vosloo and Thomson 2017). There are considerable economic consequences of FMD management. An FMD outbreak in this area incurs control costs, including testing, vaccination, personnel time and surveillance. For instance, in the 2020 FMD outbreak in Ngamiland, savingram DVS 6/1/17 XXVIII (97) listed P8,800,000 budgeted for FMD control (P300,000 allocated for fencing, P600,000 for machines, P4,000,000 for travel, P1,500,00 for salary and wages of temporary staff and P2,400,000 for allowances for permanent staff). Annual budgets reported in the 2018 audit of the FMD control programme for 2009–2014 ranged from P8,240,000 to P20,016,000 (Office of the Auditor General, Botswana 2018). In addition, blanket movement restrictions associated with FMD outbreak management have sometimes been excessively long which inhibits beef trade in Ngamiland (Atkinson et al. 2019). In principle, CBT guidelines allow for management of FMD risk along beef value chains without necessarily stopping all trade of beef within zones where FMD is endemic (SADC and AHEAD 2021). While there have been positive developments in this respect in recent years, with areas subject to movement bans being limited to the immediate area experiencing an FMD outbreak, Botswana DVS has not yet formalised standard operating procedures for outbreak response and communicated these to relevant stakeholders.

An outbreak near the Western Border fence could have greater consequences now that the Government of Botswana is in the process of applying for subzone 2f to become an FMD-free without vaccination area. An FMD outbreak now would set back the application process to WOAH. If WOAH recognises the subzone as free of FMD without vaccination, an FMD outbreak would result in loss of that status and additional work to submit evidence to regain free status.

Overall the direct and indirect consequences of a SAT-type FMD outbreak in Botswana are considered **moderate with low uncertainty**. This assumes that the outbreak is caused by a virus strain covered by the vaccine in use. If the outbreak were caused by a virus strain not covered by the vaccine, the virus would be expected to have higher consequences based on greater morbidity and spread of disease. In this case, the consequences are considered **high with low uncertainty**.

2.5.2 FMD serotype O outbreak consequences in Botswana

In fully susceptible herds, as with cattle never exposed to or vaccinated against serotype O, clinical signs of FMD serotype O are typically severe (Kitching 2002). Apparent morbidity rates associated with outbreaks are consistently higher than those observed in SAT-type outbreaks (Vosloo and Thomson 2017). This was the case in the outbreak described in Namibia, with a much greater proportion of the cattle showing clinical signs simultaneously (Banda et al. 2022), which is typical for serotype O (Vosloo and Thomson 2017; Atkinson et al. 2019). Serotype O in Zambia and Namibia reportedly spread more rapidly than SAT-type FMD, which is typically characterised by slow, limited spread (Vosloo and Thomson 2017). The indirect costs of controlling an FMD serotype O outbreak can be assumed to be similar to that described for SAT-type FMD in the section above. Costs may be higher if cattle are vaccinated with a quadrivalent vaccine covering both the SAT serotypes and serotype O during a serotype O outbreak, as the quadrivalent vaccine is significantly more expensive. As an example, N$6,000,000 was spent on vaccine against FMD serotype O alone during the first round of vaccination in Namibia's 2021 serotype O outbreak in Zambezi Region (AHEAD 2022).

Overall the direct and indirect consequences of an FMD serotype O outbreak in Botswana are considered **high with low uncertainty**.

2.5.3 CBPP outbreak consequences in Botswana

African isolates of MmmSC usually cause severe clinical signs and high mortality in naïve herds, with losses up to 80% (Spickler et al. 2010a). Reductions in milk and beef production as well as draught power are expected (Tambi et al. 2006).

Reoccurrence of CBPP in cattle would result in the loss of Botswana's official CBPP-free status, although meat and meat products excluding lung are considered safe commodities regardless of the country's CBPP status (WOAH 2021a). Botswana does not have a national CBPP contingency plan that definitively outlines its response plan were there to be a CBPP outbreak, but the path to regaining free status is long, with a 12-month waiting period after the last case is stamped out and with serological surveillance and movement controls having been applied. If stamping out is not applied and instead vaccination is employed without subsequent slaughter, then there is a 24-month waiting period after the outbreak is over with no further vaccination having been carried out. However, it is possible to establish a containment zone should DVS be able to document evidence that an outbreak is limited. The containment zone would allow the rest of the country to regain free status sooner.

The cost of eradicating CBPP from Ngamiland through depopulation during the 1995 outbreak was estimated at BWP 360,850,00 (US$97.5 million) (Mullins et al. 2006). This does not include significant knock-on impacts on households and communities. In 1997, 55% of households sampled in one study were receiving government rations (Mullins et al. 2006). The number of households dependent on government assistance rose from virtually zero in 1996 to one in three in 1997 (Mullins et al. 2006).

In the years following the mass depopulation in Ngamiland, children under five years of age in the area experienced a 36% increase in the total malnutrition rate and one third of children 12–23 months were severely underweight given the loss of meat and milk from household cattle (Boonstra et al. 2001). The loss of draught power further contributed to food insecurity by limiting the ability to engage in subsistence agriculture; for example, 44.3% of households interviewed intended to depend on their own production for food but 70.8% of those said they would not have sufficient food (Mullins et al. 2006).

The removal of cattle and drop in disposable income associated with depopulation in a future CBPP outbreak would likely have negative impacts on wildlife populations as well, as households would likely turn to bushmeat as an alternative source of protein. This would put additional strain on wildlife populations that already experience considerable poaching pressure.

Overall the direct and indirect consequences of a CBPP outbreak in Botswana are considered **high with low uncertainty**, if stamping out were to be selected again as the response to another outbreak in Ngamiland.

2.5.4 PPR outbreak consequences in Botswana

Any outbreak of PPR in Botswana would result in loss of the country's official PPR-free status from WOAH. As with CBPP, it is possible to establish a containment zone should DVS be able to document evidence that an outbreak is limited. To recover free status after an outbreak, evidence of disease control can only be submitted to WOAH six months after disinfection of the last affected establishment, following either a stamping-out policy or surveillance according to the Terrestrial Animal Health Code. Botswana does not yet have a contingency plan to govern its response to a PPR outbreak. Given that the country is currently free of PPR, a stamping-out policy similar to that applied during the CBPP outbreak in 1995 would likely be applied.

There are myriad costs associated with a PPR outbreak. In naïve populations, morbidity and mortality from PPR can reach close to 100% (Albina et al. 2013; Jones et al. 2016). Affected animals experience loss of body weight and condition and producers suffer losses from abortions (Jemberu et al. 2022). The economic losses to farmers in an outbreak in Ethiopia were equivalent to 14% of annual household income (Jemberu et al. 2022). If animals are treated, there are veterinary costs as well (Jemberu et al. 2022). If the disease becomes endemic, morbidity and mortality rates decline but there are long-term impacts on small ruminant productivity (Jones et al. 2016).

Expected effects would be increased food insecurity given the decline in goat meat availability. There would be additional costs of compensation and/or restocking small stock. Formal trade in live animals or animal products from sheep and goats would likely be affected.

Overall the direct and indirect consequences of a PPR outbreak in Botswana are considered **moderate with moderate uncertainty**.

2.5.5 SAT-type FMD outbreak consequences in Namibia

Outbreak in the infected zone. For the purposes of the assessment of the Zambezi Border fence, a SAT-type FMD outbreak in Namibia's FMD infected zone (Figure 10) is considered. The clinical presentation and production effects of the disease would be as described for Botswana.

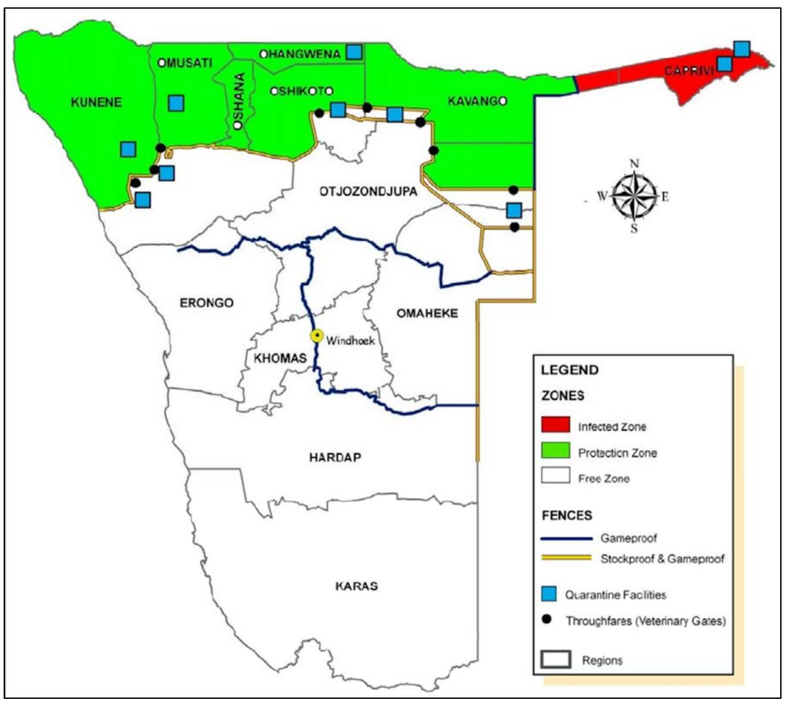


Figure 10. Map of FMD control zones in Namibia, with green representing the protection zone and red representing the infected zone. Source: Namibia FMD Contingency Plan (Musilika-Shilongo et al. 2022).

The cost of controlling an FMD outbreak varies widely depending on the size, with estimated costs from outbreaks in the communal area ranging from N$9.6 million to N$175 million (Musilika-Shilongo et al.

2022). During an FMD outbreak, animal movements in the area are restricted and active surveillance conducted. Cattle are vaccinated twice, 3–4 weeks apart, and samples collected four weeks after the second vaccination for ELISA to confirm ≥70% herd immunity. If this is attained, restrictions are withdrawn and the outbreak is considered resolved; otherwise vaccination and testing for herd immunity is repeated. After an outbreak, FMD restrictions are in place for a minimum of three months in the infected zone.

Overall the direct and indirect consequences in the infected zone are considered **moderate with low uncertainty**.

Outbreak in the protection zone. For the purposes of the assessment of the Western Border fence, an outbreak in the FMD protection zone (Figure 10) is considered. The control measures and costs would be as described for an outbreak in the infected zone.

Overall the direct and indirect consequences are considered **moderate with low uncertainty**. Because Namibia plans to stop FMD vaccination in the protection zone in the future and apply for FMD-free without vaccination status, FMD outbreaks in the future would carry a greater weight in order to recover free status. As a result, the future consequences are considered **high with low uncertainty**.

3. SPECIFIC FENCE LINE ASSESSMENTS

3.1 Background

Specific risk assessments were carried out for three fence lines, namely the Zambezi Border fence east of the Okavango River, the Northern Buffalo fence and the Western Border fence. The risk assessments cover three transboundary animal diseases, namely FMD, CBPP and PPR. This background section provides information that is common to several risk assessments in order to avoid unnecessary repetition. These include the risk assessment structure, some of the risks for cattle movement across fence lines and infection in cattle, the status of FMD in buffalo populations and the risk mitigation measures that are recommended.

The generic aspects of the risk of poaching are also described in this section, because although the ease of obtaining a buffalo to poach might vary among the three areas, once a buffalo has been obtained and cattle have been exposed to the contaminated poacher or the meat, the risk of this resulting in an outbreak of FMD is similar wherever it happens.

The individual risk assessments related to FMD are described in sections 3.2 to 3.4. CBPP and PPR differ in important ways from FMD and the risk assessments for them are described in sections 3.5 and 3.6.

3.1.1 Structure of the risk assessment

For the Zambezi Border fence (east of the Okavango River) and the Western Border fence, nine risk pathways are addressed. For each pathway, the risk of pathogen introduction is assessed under three different scenarios assuming that (i) no changes to a fence line are made, i.e. status quo, (ii) the fence section is removed and (ii) the fence section is removed with specific risk mitigation measures in place. Finally, the status quo and hypothetical scenarios are compared.

The hazards identified are as follows:

- SAT-1, SAT-2, and SAT-3 serotypes of the *Aphthovirus* genus in family *Picornaviridae*, endemic in southern Africa, causing FMD in cattle.

- FMDV serotype O, which occurred in Namibia for the first time in 2021, with evidence of transmission from Zambia (Banda et al. 2022). Serotype O has never been reported in Botswana.

- *Mycoplasma mycoides* subsp. *mycoides* small colony variant (MmmSC), endemic in parts of southern Africa, causing CBPP in cattle.

- Peste des petits ruminants virus (PPRV) of the *Morbillivirus* genus in family *Paramyxoviridae*, causing PPR in small ruminants.

The risk pathways are as follows:

- risk of SAT-type FMD outbreak from Namibia to Botswana via cattle-cattle transmission
- risk of SAT-type FMD outbreak from Namibia to Botswana via buffalo-cattle transmission
- risk of SAT-type FMD outbreak from Namibia to Botswana via poaching
- risk of FMD serotype O outbreak from Namibia to Botswana via cattle-cattle transmission
- risk of SAT-type FMD outbreak from Botswana to Namibia via cattle-cattle transmission
- risk of SAT-type FMD outbreak from Botswana to Namibia via buffalo-cattle transmission
- risk of SAT-type FMD outbreak from Botswana to Namibia via poaching
- risk of CBPP outbreak from Namibia to Botswana via cattle-cattle transmission
- risk of PPR outbreak from Namibia to Botswana via small stock-small stock transmission

For the Northern Buffalo fence, where the cattle remain in Botswana and no international borders are involved, only two risk pathways are addressed, as follows:

- the risk of SAT-type FMD outbreak from zone 16 to zone 2 via buffalo-cattle transmission
- the risk of SAT-type FMD outbreak from zone 16 to zone 2 via poaching

3.1.2 Factors that influence cattle movements and infection in cattle

3.1.2.1 Cattle movements

Free-ranging cattle may move up to 30 km/day in search of water and grazing in nomadic pastoralist systems, while 5–15 km/day was reported for settled pastoralists (van Raay and de Leeuw 1974). However, cattle clinically affected by FMD are unlikely to move far with fever and painful feet. Cattle contact networks have not been well-studied in pastoral systems; a study in Kenya showed cattle herds had more contacts during the dry season, and higher contact rates at waterholes and bomas (VanderWaal et al. 2017). In the event of an incursion of Botswana cattle into Namibia, cattle are destroyed immediately. Communities bordering the veterinary fences are also encouraged to report breakages promptly. Botswana veterinary officers near borders communicate regularly with their counterparts in Namibia, who contact Botswana officials when cattle incursions do occur. Surveillance of cattle at exposed crushes is undertaken by Botswana DVS after an incursion; this includes stratified sampling and visual inspections.

3.1.2.2 Vaccination of cattle against FMDV

Cattle in Ngamiland are vaccinated twice a year against FMDV using Aftovaxpur, a trivalent vaccine that protects against SAT-1, SAT-2 and SAT-3. Coverage is reported to be variable. In the last six vaccine campaigns, overall coverage in Ngamiland ranged from 75–86%. PVM samples from Ngamiland in June and December 2022 showed poor coverage (<85%) for all SAT serotypes. Effectiveness of the vaccine itself has been estimated at 78% previously (Babayani and Tthololwane 2022).

3.1.2.3 Transmission of FMDV by infected cattle

After intranasal inoculation with FMDV, a steer can transmit the virus for 7 to 8 days and is most infectious at day 3 (Graves et al 1971). In an experimental study where an infected steer was co-housed with other steers for 21–24 hours but not forced to have physical contact or drink and eat from the same bowls and mangers, steers exposed in the first 7 days after inoculation of the infected animal became infected with FMDV (Graves et al 1971).

3.1.3 Infection status in buffalo

Buffalo herds in endemic areas are nearly 100% serologically positive for antibodies to SAT-type FMDV by the age of 2 (Thomson et al. 1992). Buffalo lose their maternal immunity between 3 and 6 months of age, and natural infection occurs soon after maternal antibodies wane (Thomson et al. 1992). The infectious period for calves is short; in FMD-free buffalo yearlings experimentally infected with SAT-1 virus, virus was detected in the blood for only 1 to 3 days, and in other bodily fluids only up to 6 days (Gainaru et al. 1986). Other risk assessments have estimated between 3 to 5 days (Sutmoller et al. 2000) or up to 14 days for calves (Jori et al. 2009).

More recent experimental work suggests that carrier buffalo may contribute to endemic persistence of SAT-type FMDVs in buffalo herds, although prior experiments have suggested that such events are “rare at best” (Jolles et al. 2021). An assessment of risk from small buffalo herds in conservancies to cattle in Zimbabwe estimated the fraction of a year with at least one contagious buffalo calf as ~0.07 (Sutmoller et al. 2000). The probability of adult buffalo excreting virus was considered negligible in a risk assessment based in Kruger National Park, while the probability of young buffalo excreting virus was considered high (Jori et al. 2009).

3.1.4 Risk of buffalo-cattle contact and effective FMDV transmission during contact

3.1.4.1 Buffalo-cattle contact

Under experimental conditions, co-housed buffalo and cattle avoided one another and were unlikely to have direct contact (Gainaru et al. 1986). Even where buffalo and cattle naturally co-exist, contact rates appear to be relatively uncommon. In a study of cattle and buffalo in Zimbabwe, GPS collars were placed to assess animal movements and potential contacts (where a contact was conservatively defined as cattle within 300 m of a buffalo location <15 days after the buffalo location was recorded) (Miguel et al. 2013). For 39 of 70 cattle/season combinations, no contacts with buffalo were recorded, and contact occurred at low rates (1.1×10^{-4} – 6.6×10^{-8} contacts relative to number of cattle-buffalo location pairs) (Miguel et al. 2013). Cattle and buffalo may be more likely to have contact when sharing resources (i.e. grazing areas or water), particularly during the dry season (Miguel et al. 2013). Herders may be reluctant to collect cattle that are mixed with buffalo for fears of personal safety and thus leave them together (van Rooyen 2016). However, even if spatial use of resources overlaps between species, temporal use may not. In some areas, buffalo reportedly tend to come to grazing areas overnight, when cattle are typically kraaled (van Rooyen 2016); this further limits potential direct contact.

3.1.4.2 Effective transmission of FMDV from buffalo to cattle

Studies from Zimbabwe and Botswana showed that viruses isolated from buffalo had the potential to survive for long periods (>10 yr) in buffalo with little to no transmission to cattle under normal conditions (Hedger 1976). Natural transmission of FMDV from buffalo to cattle has been documented (Dawe et al. 1994; Vosloo et al. 2002), but the exact nature of how transmission occurs is not understood. Only buffalo acutely infected with SAT-type FMDV – likely to be young animals whose maternal antibodies have recently waned – are likely to serve as direct sources of infection for cattle (Gainaru et al. 1986). Experimental studies have often failed to produce infection in cattle as a result of contact with buffalo. Cattle and impala often failed to become infected even when co-housed with acutely infected buffalo, and only transmitted FMDV if there was direct contact with cattle (Gainaru et al. 1986). In a study where susceptible cattle were herded with FMD infected buffalo over 2.5 years, transmission of FMDV only occurred between buffalo, and none from buffalo to cattle (Hedger 1976). In another study, cattle sharing drinking troughs and hay racks with FMDV infected buffalo for 15 months did not become infected (Bengis et al. 1986). Conditions under which indirect transmission via shared grazing or water sources may be possible are unclear, but this does not appear to be a common route for transmission.

FMD outbreaks do not occur continuously in areas where buffalo and cattle are in regular contact, suggesting that transmission of FMDV from buffalo to cattle is relatively rare. For instance, Chobe District, which has no fences separating buffalo and cattle but has higher vaccination coverage and more active herding and kraaling practices due to the risk of predators, has had one FMD outbreak event recorded in WAHIS in the last decade, while Ngamiland has had seven. A study in Ol Pejeta Conservancy in Kenya, where 8,500 cattle and 1,200 buffalo co-exist in continual spatial and temporal contact through shared grazing and water points, found no evidence of buffalo-cattle FMDV transmission and noted that cattle in the conservancy experience very few clinical outbreaks of FMD compared to cattle in the surrounding communities which have far less buffalo exposure (Omondi et al. 2020).

3.1.5 Risk of SAT-type FMDV transmission via poaching of buffalo

Common features among the risk pathways are dealt with generically, as they involve an infected buffalo being poached and butchered and FMDV being spread to cattle either by the meat or by fomites, principally the poacher's clothing or hands. Local differences in risk are covered in the specific fence line risk assessments.

3.1.5.1 Risk of buffalo being viraemic

The viraemia stage in buffalo is evidently fairly short, with experimentally infected buffalo being viraemic for up to seven days post infection (Gainaru et al. 1986; Maree et al. 2016). The window for virus to be present in blood or other tissues is short; within 14 days of infection, FMDV can no longer be recovered from tissues, secretions, or excretions other than the pharyngeal mucosa (Jori et al. 2009). While young buffalo are those most likely to actively shed virus from acute infection, they are less desirable targets for poaching as adult buffalo result in a greater payoff (i.e. more meat) to offset the risk of poaching (T. Pietersen, personal communication).

3.1.5.2 Contamination of poacher with FMDV

Butchering a large animal such as a buffalo is inherently messy and poachers would not be expected to use PPE while doing so, so contamination of hands and clothes with blood would be likely, but the transfer of virus to hands is uncertain. In a food safety study using feline calicivirus as a surrogate for norovirus, where uncontaminated finger pads were pressed into virus-inoculated ham, only ~6% of virus was transferred (Bidawid et al. 2004). The risk of effective contact also depends on the handling of the meat, which can either be moved fresh or first dried as biltong/segwapa. FMDV is inactivated by deboning, salting and completely drying meat (WOAH 2021b); meat that is salted and dried as biltong or segwapa for human consumption is therefore not a potential source of FMDV. Botswana's own FMD contingency plan allows for processing of buffalo meat into biltong after a buffalo incursion (Botswana Department of Veterinary Services 2015). Biltong drying takes several days, over which FMDV would deteriorate. The risk of SAT-type FMDV survival in fresh meat under field or abattoir conditions that do not include maturation to ensure a low pH is reached is not well-studied and results from studies on other serotypes have been variable (Paton et al. 2010), but these viruses have poor thermal stability in general compared to other FMDV serotypes (Doel and Baccarini 1981). Infection with FMDV by ingestion has invariably been associated with feeding swill to pigs, of which there are few in Ngamiland and the relevant adjacent areas in Namibia.

3.1.5.3 Effective contact between poacher and cattle

This step relies on no handwashing or change of clothing between poaching an animal, processing the meat and handling livestock, as handwashing and changing outerwear were sufficient to prevent mechanical transmission of FMDV to pigs under experimental conditions (Amass et al. 2003). A study of bushmeat hunting in the Okavango Delta found that hunting was positively correlated with livestock wealth (Rogan et al. 2018), therefore it is likely that poachers own cattle and may handle them. Namibia's FMD contingency plan cites an internal commodity risk analysis in which fomites were considered low risk for spread of FMD (Musilika-Shilongo et al. 2022). A quantitative risk assessment of potential routes of livestock exposure to FMDV from contaminated meat in the UK estimated that the risk of infection from human fomites, as with contamination of hands followed by handling livestock, was <0.01% of the total risk from all pathways (Hartnett et al. 2007).

3.1.6 Mitigation measures recommended

While the risk assessment indicated that removing the specific fence sections selected would not increase the risk from that of maintaining the status quo, the risk would be further reduced by implementing certain measures to protect cattle from contact with potential sources of infection. Improving vaccine coverage, particularly for crushpens considered to be at higher risk due to proximity to the border, with PVM to monitor effectiveness, is strongly recommended. The implementation of H4H by cattle owners is aimed at controlling cattle movement, preventing contact with other herds or buffalo, particularly at night, as well as protecting livestock from predation and stock theft and improving pasture management. It also supports improved vaccine coverage by ensuring that all of the cattle are presented for vaccination and good records are kept.

The assumption is that these measures will be fully implemented, and if this is the case the risk of infection with FMDV as well as certain other diseases should be reduced. Non-compliance with the mitigation measures will reduce their effectiveness and the level of risk will be the same as removing the fences without mitigation measures. Fortunately, the overall risk in these areas is very low, but this should not be a reason for non-compliance with risk mitigation measures that are tailored to improve the general health and wellbeing of livestock and support CBT to enable higher prices for the meat.

3.2 Zambezi Border fence (east of the Okavango River) assessment

3.2.1 Livestock disease prevalence and recent history

In Botswana, the most recent FMD outbreaks occurred in Ngamiland in 2020 at Xakao II crush in subzone 2a and Malatso crush in subzone 2b. In 2014, there were outbreaks in Mohembo East, Kauxwi, Xakao I and Xakao II. Other outbreaks in Ngamiland in the past decade have occurred in subzones not bordering the fences of interest. In Namibia, the Zambezi Region has had recurring FMD outbreaks over the last decade, although these have occurred closer to Chobe National Park in Botswana and not near the Zambezi Border fence. Outbreaks in Namibia occurred in 2013, 2014, 2015, 2017, 2019, 2021 and 2022. The most recent outbreak of FMD in Kavango East Region occurred in 2020. These outbreaks include the SAT-1, SAT-2 and SAT-3 serotypes. An outbreak of FMDV serotype O occurred in 2021 in the Zambezi Region, a first for Namibia (Banda et al. 2022).

3.2.2 Status of the fence

The fence extends approximately 133 km from the east banks of Okavango River to the intersection with Botswana's Northern Buffalo fence. There are two parallel fences on the Botswana side and evidence in places of a previous fence line on the Namibian side, i.e. remnants of old fence posts. On the Botswana side, each fence line has 6 wire strands – the fourth strand replaced with a steel cable. The fence posts are wooden gum poles with wooden droppers secured to each fence strand by a loop of wire. In some places page (woven) wire is also present at the bottom of the fence. The fence was electrified at one time and the insulators are still present. Kaputura camp has 10 staff who are only able to maintain 5 km of fence on either side of the camp as no vehicle is available. Pickets are present every 10 km although these have been abandoned. The main veterinary camp at Kilo 70 is abandoned and the veterinary camp at Xhoroma on the far east end where the Zambezi Border fence meets the Northern Buffalo fence is being used by the Botswana Defence Force rather than DVS.

In terms of condition, Botswana DVS monthly reports and joint Namibia-Botswana (NAMBOT) patrol reports rate the condition of this fence as 1/5 (5 being completely intact and upright) with no maintenance activity occurring. Further details on fence condition, gathered during a field site visit (driving on the Botswana-side) in November 2022, are described below.

Figure 11. Variable conditions of the eastern Zambezi Border fence during a site visit in November 2022.

The fence's condition varies from virtually completely intact and upright (upper image in Figure 11) to lying on the ground with missing wires (Figure 12). The overall condition of the fence deteriorates and the level of bush encroachment increases further east along the fence line. The top two wires are missing from much of the fence line. Loose wire exists along the road and poses a hazard to vehicles and animals. Some gum poles have rotted from the inside, as have some droppers, while others have disintegrated completely. In some cases where wooden droppers have rotted away, metal droppers have been added, although some of these have been severely bent, presumably by elephants (lower image in Figure 11). The cable was observed to be intact throughout the entire 140 km length. Many sections of fence are leaning over at an angle or down completely, for sections of up to 100 m.

Figure 12. Eastern Zambezi Border fence, showing intact and upright fence posts followed by a section of downed posts and wires during a site visit in November 2022.

The bush between the two Botswana fence lines is thick and shows no evidence of maintenance in recent years. In general, the condition of the second fence, closer to the Namibian side, is worse, although it is often not easily visible from the road due to thick bush.

The road along the fence is through deep sand which is difficult to navigate even in a 4x4 vehicle. Vehicles are prone to overheating in such conditions and the uncleared bush poses tire puncture hazards. There is no mobile service in the area and there are no inhabited settlements visible from the road between Kaputura and Xhoroma, so this road should not be attempted alone given the risk of a breakdown.

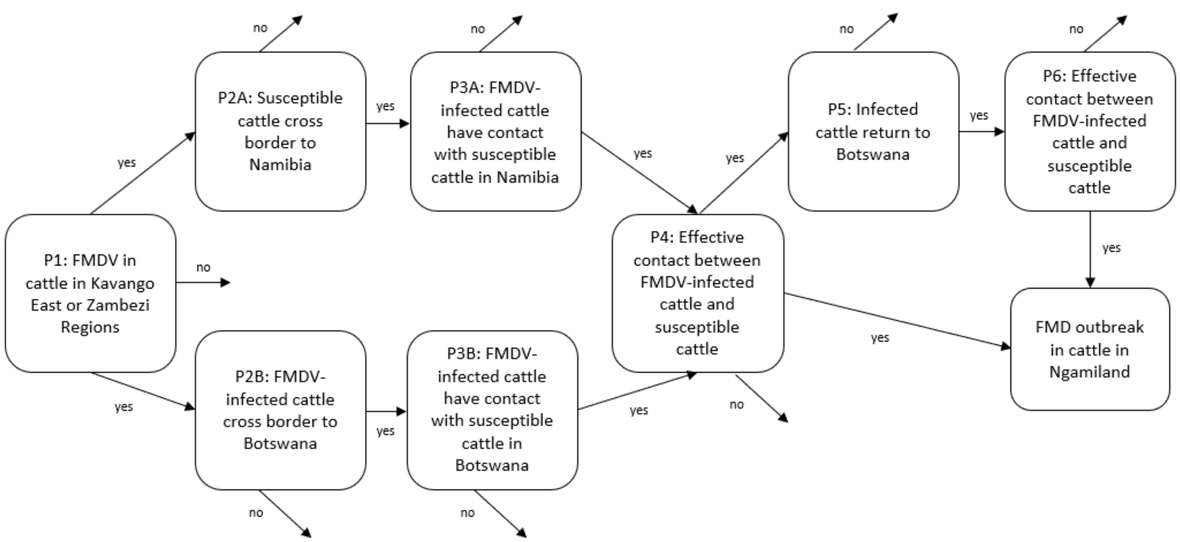
Bush encroachment on the far eastern portion of the fence is often severe (Figure 13), with growth of trees up to 3–4 m in height and through the fence. It is clear that the initial fence construction was of excellent quality but it has not been maintained or undergone any bush clearing in recent years.

Figure 13. Heavy bush encroachment on the eastern Zambezi Border fence during a site visit in November 2022.

3.2.3 Assessment of risk of SAT-type FMD outbreak in Botswana from Namibian cattle

3.2.3.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Botswana. The scenario tree (below) involves either cattle crossing the border from Namibia and having contact with cattle in Botswana, or cattle crossing the border to Namibia, having contact with cattle there, and returning to Botswana.



3.2.3.2 Probability of occurrence assessment

P1: SAT-type FMDV in cattle in Kavango East or Zambezi Regions near Zambezi Border fence

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: In Namibia's FMD infected zone (see Figure 10), which includes part of Kavango East starting at Divundu Settlement (east of the Kavango River) and extends eastward to include all of Zambezi Region, cattle are vaccinated tri-annually against SAT-type FMDV. At least 85% of the target cattle population in Namibia was vaccinated against FMD in the last three years, but PVM is not being achieved regularly to ensure adequate protection (European Commission 2022). A total of 609,385 doses of trivalent FMD vaccine were administered in Zambezi Region and 217,549 doses in Kavango East Region in 2022, although only 34,209 doses in Zambezi Region and 0 in Kavango East Region had been administered by mid-2023. The livestock census in 2021 recorded 183,069 cattle in Zambezi Region and 109,912 in Kavango East, and recent outbreaks of SAT-type FMD in Zambezi Region have involved relatively few cases (e.g. 20 cases in 2022, 59 cases in 2019, 9 cases in 2017). FMD serosurveillance in the entire NCA in 2020 found that 84/420 (20%) of samples were positive for antibodies to FMDV, whereas only 4/902 (0.4%) samples from 2022 were positive. There could be infected cattle coming across from Angola or Zambia for informal trade, although areas of Angola adjacent to Bwabwata National Park have low densities of cattle or none at all, based on observations during the KAZA Elephant Survey (Bussière and Potgieter 2023a).
- Remove fence section: Removing the eastern section of the fence would be unlikely to affect the risk of SAT-type FMDV-infected cattle in Kavango East or Zambezi Regions. The number of predators and lack of water during the dry season make the multiple use area of the park inhospitable for illegal movement of cattle.
- Remove fence section with risk mitigation: In addition to the above, removal of cattle from Bwabwata National Park would make the cattle expected on the Namibian side of the fence virtually zero. Maintaining high vaccination coverage in the Kavango East and Zambezi Regions would reduce the risk of cattle infections nearby, although appropriate PVM should be implemented to ensure this.

P2A: Cattle crossing border to Namibia

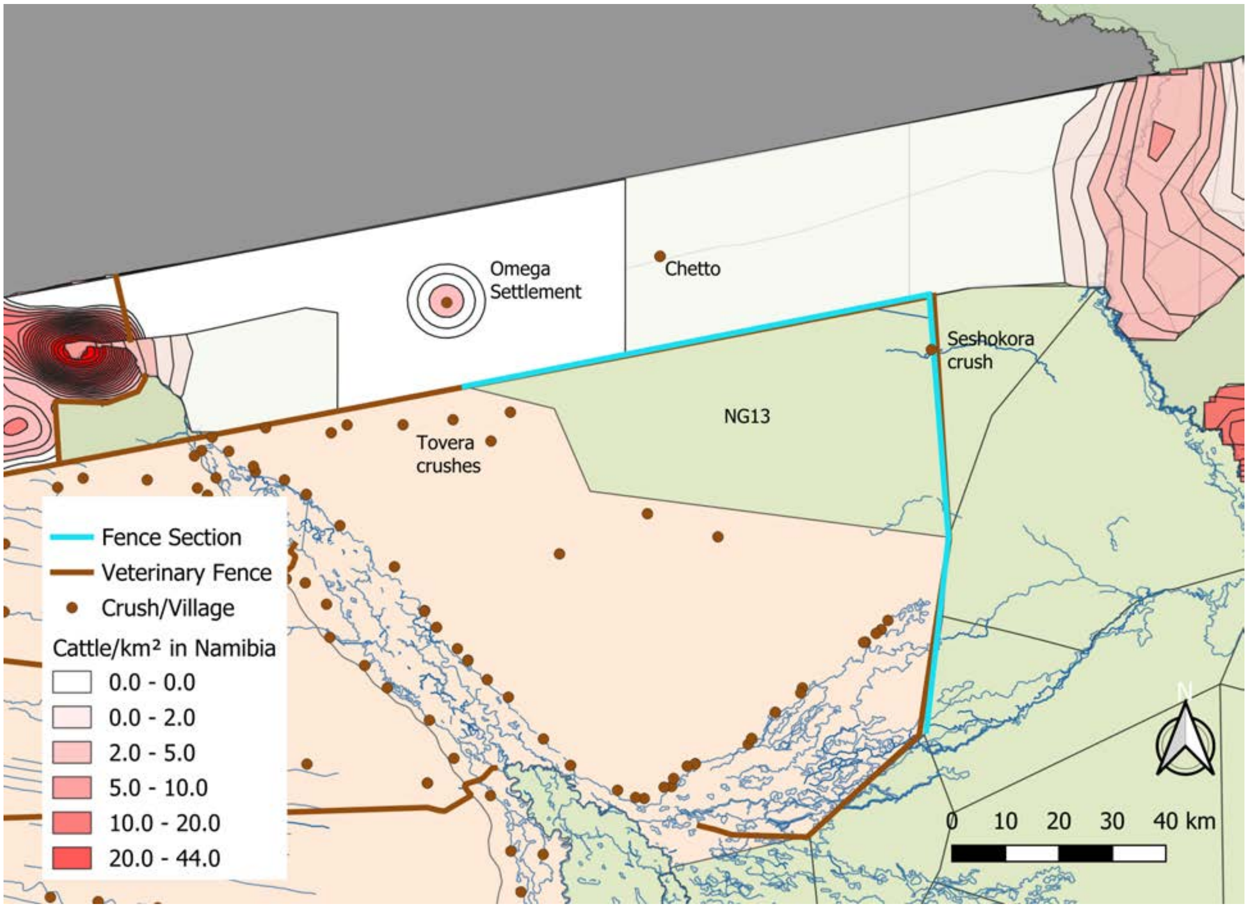


Figure 14. Map of eastern Zambezi Border fence, with Bwabwata National Park north of the fence and NG13 south of the section proposed for removal.

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: The NAMBOT patrol in 2022 found that the Zambezi Border fence east of the Okavango River was bush-encroached and mostly down; no repairs were made to these fences, and conditions were similar during this study's site visit in November 2022. There are few cattleposts in this area. Seshokora crush is the only crush near the far eastern aspect of the Zambezi Border fence, with ~350 cattle according to expected numbers on Botswana DVS vaccination returns, but only ~250 actually vaccinated in October 2021. At the western end of the section proposed for removal (Figure 14) are the Tovera crushes in Xakao extension area, with ~650 cattle vaccinated in October 2023. In 2022, 3 cattle from Botswana were reported in Omega settlement and had crossed from Tovera, but were not found in Namibia on later searches. The fence is in poor condition along much of the length in question, and therefore cattle could cross downed sections. There was cattle spoor near

the fence around the Tovera settlements and up to ~10 km from Tovera 4, but no cattle spoor near Seshokora (Atkinson et al. 2022). Cattle movement may also occur as a result of illegal activities. In 2022, 11 cattle from Seshokora crush were found in Zambia and believed to have been stolen; they were later destroyed in Zambia. In 2023 another 22 cattle were stolen near Xhoroma and sold in Zambia.
- Remove fence section: Removing the eastern section of the fence would be unlikely to significantly change the risk of cattle crossing the border. Some cattle spoor was detected near the Tovera crushes in the area proposed for removal, but the only evidence of continuous cattle presence was in a section not proposed for removal (Atkinson et al. 2022). The poor condition of the fence means that the border is already semi-permeable; illegal cattle movement could increase without the psychological barrier of a fence, but this area is remote and inhospitable for trekking cattle.
- Remove fence section with risk mitigation: In addition to the above, active herding techniques from the H4H model would mean that cattle movements are better controlled to avoid crossing the border.

P2B: Cattle crossing to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: Fence conditions are described in P2A above. In spite of the poor conditions of the fence, it remains an impediment to animal movement; only ~18% (5/28) of attempted ungulate crossings were successful in the phase 1 surveys (Atkinson et al. 2022). The nearest cattle on the Namibian side are those in Bwabwata National Park, concentrated around Omega settlement ~15 km from the fence. There are no cattle present starting ~10-20 km west of Chetto and moving eastward through the park (L. Hanssen, personal communication). The cattle are unlikely to move long distances from Omega given the lack of water sources in the dry season. This area has a high density of predators. Additionally, cattle infected with FMDV in the maximal shedding stage would be less likely to walk long distances.
- Remove fence section: Removing the eastern section of the fence would be unlikely to significantly change the risk of cattle crossing the border. Although the physical barrier would be removed, few cattle would likely stray as far as the border.
- Remove fence section with risk mitigation: Removal of cattle living in Bwabwata National Park would lower the risk of cattle crossing the border from the Namibian side to perhaps only the occasional stray animal.

P3A: Contact between susceptible cattle from Botswana and infected cattle in Namibia

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**

Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: Because cattle in Bwabwata National Park are concentrated around Omega settlement ~15 km from the border, Botswana cattle would need to travel well into the park to make contact with other cattle.
- Remove fence section: Removing the eastern section of the fence would not change the risk of contact after the border has already been crossed.
- Remove fence section with risk mitigation: Removal of cattle from Bwabwata National Park would eliminate the risk of having contact with resident cattle anywhere near the fence section.

P3B: Contact between susceptible and infected cattle in Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3A above. Contact with cattle in Ngamiland would be most likely around the Tovera crushes at the western aspect of the section proposed for removal, although past ground and aerial surveys have observed these cattle further west or south rather than near the fence in NG13 (Atkinson et al. 2022, A. Songhurst, unpublished data).
- Remove fence section: See justification for P3A above.
- Remove fence section with risk mitigation: Active herding techniques under H4H would limit contact with any stray cattle from Namibia.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: For Xakao extension area, which includes the cattleposts nearest the western portion of the section of interest, coverage in the October 2022 FMD vaccination campaign was 67% but higher numbers of cattle were presented than expected in the May 2023 campaign, where coverage was 108%. In the last six vaccine campaigns, overall coverage in Ngamiland ranged from 75-86%. PVM samples from Ngamiland in June and December 2022 showed poor coverage (<85%) for all SAT serotypes. Effectiveness of the vaccine has been estimated as 78% previously (Babayani and Thololwane 2022).
- Remove fence section: Removing the eastern section of the fence would not change the risk of effective contact after the border has already been crossed.

- Remove fence section with risk mitigation: Active herding techniques, improved animal health and higher vaccination coverage of cattle in the H4H model would lower the risk of effective contact.

P5: Cattle return to Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: If discovered, cattle that have crossed to Namibia are destroyed rather than repatriated to avoid the risk of diseases. Cattle that are undetected may cross or be herded back to Botswana, although there is a high density of predators. The fence is semi-permeable and could be crossed if cattle were able to return through Bwabwata National Park.
- Remove fence section: Removing the eastern section of the fence would make it marginally easier to cross the border by the lack of a fence, but cattle would still need to navigate through Bwabwata National Park to return from contacting cattle in Namibia.
- Remove fence section with risk mitigation: Cattle under H4H should not be herded back to Botswana to have contact with the rest of the herding group.

P6: Effective contact between susceptible and infected cattle after returning to Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: See justification for P4 above. Strain characterisation data from Ngamiland suggest that recent outbreak strains circulate independently in cattle, where contact levels are considered to be high enough to sustain FMDV circulation .
- Remove fence section: Removing the eastern section of the fence would not affect effective contact after returning to Botswana.
- Remove fence section with risk mitigation: Improved animal health and higher vaccination coverage of cattle in the H4H model would raise individual immunity.

3.2.3.3 Risk estimation of SAT-type FMD from cattle

Calculations for this risk pathway are shown in Appendix E. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 6). After fence removal alone, the risk would remain **unchanged**. After removal with risk mitigation measures in place – specifically removal of cattle from Bwabwata National Park – the risk would become **negligible**. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from cattle at the Zambezi Border fence (east of Okavango River) is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

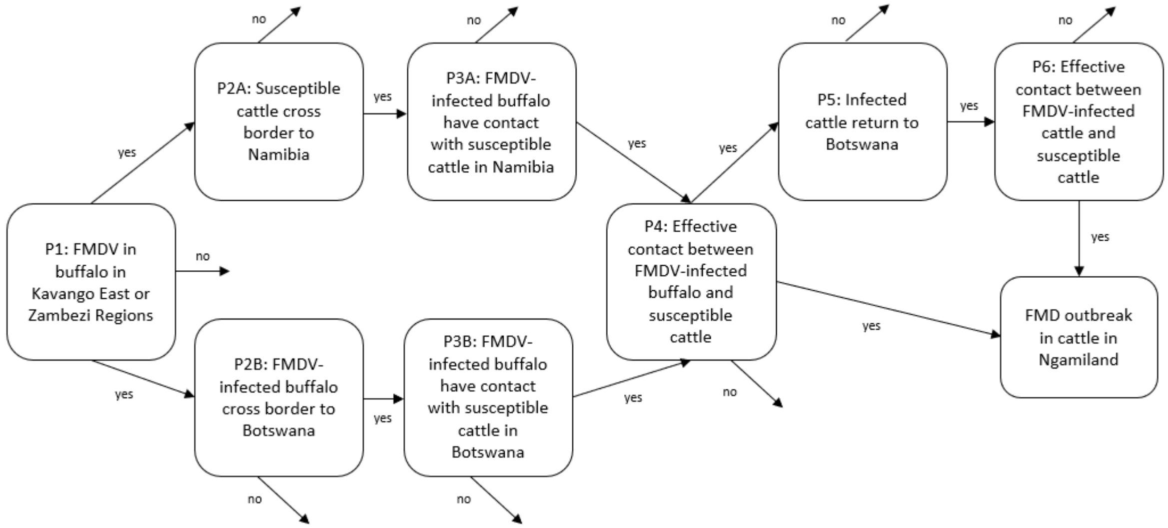
Table 6. Probability of disease occurrence for SAT-type FMD from cattle in Namibia to cattle in Botswana along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
FMDV in cattle in Namibia (P1)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle cross to Botswana (P2B)	Very low (moderate)	Very low (moderate)	Negligible (low)
Cattle have contact with cattle in Namibia (P3A)	Very low (moderate)	Very low (moderate)	Negligible (low)
Cattle have contact with cattle in Botswana (P3B)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective contact between cattle (P4)	High (low)	High (low)	Low (moderate)
Cattle return to Botswana (P5)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Moderate (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (low)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (low)**

3.2.4 Assessment of risk of SAT-type FMD outbreak in Botswana from Namibian buffalo

3.2.4.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Botswana. The scenario tree (below) involves either buffalo crossing the Botswana-Namibia border and having contact with cattle, or cattle crossing the border, having contact with buffalo, and returning to Botswana.



3.2.4.2 Probability of occurrence assessment

P1: SAT-type FMDV excreted by buffalo in Kavango East or Zambezi Regions

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Buffalo are the natural host of SAT-type FMDV and are almost invariably serologically positive for antibodies to FMDV throughout the region but transmission from adult buffalo to cattle is considered to be inefficient (section 3.1.3 refers).
- Remove fence section: Removing the eastern section of the fence will not impact the prevalence of FMDV infection in buffalo, and the risk of FMDV infection and excretion by free-ranging buffalo is considered equivalent in Botswana and Namibia.
- Remove fence section with risk mitigation: There are no practical interventions to reduce prevalence of FMDV in the free-ranging buffalo population.

P2A: Cattle crossing to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.2.3.2.
- Remove fence section: See justification for P2A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.2.3.2.

P2B: Buffalo crossing to Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: Buffalo spoor were observed parallel to much of this section of the fence in the phase 1 surveys; much of the fence is dilapidated and buffalo had successfully crossed the fence 50% of the time (n=2/4 attempts) (Atkinson et al. 2022). Radio collar data suggest that buffalo along the Kwando and Kavango rivers in Namibia are strongly attracted to the Okavango Delta (Naidoo et al. 2014). Although further west than the fence section of interest, buffalo from Mahango Core Area in Bwabwata National Park cross the river on a daily basis to avoid lions overnight and then return in the morning.
- Remove fence section: Wildlife have been shown to return to crossing after fence removal (Arthur Albertson Consulting (Pty) Ltd 2005), so buffalo crossings would be expected to increase.
- Remove fence section with risk mitigation: Restoration of wildlife corridor connectivity is the goal of fence removal, so increased wildlife movements are to be expected and efforts to inhibit movement of buffalo would be counterproductive.

P3A: Buffalo-cattle contact in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Contact between buffalo and cattle is usually limited and unlikely to be direct (section 3.1.4.1 provides available information).
- Remove fence section: Removing the eastern section of the fence would not affect buffalo-cattle contact in Namibia.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step.

P3B: Buffalo-cattle contact in Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3A above.

- Remove fence section: See justification for P3A above.
- Remove fence section with risk mitigation: Implementation of H4H would reduce the risk of cattle-buffalo contact by direct avoidance of buffalo.

P4: Effective contact between FMDV-infected buffalo and susceptible cattle

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Evidence indicates that FMDV transmission from buffalo to cattle is inefficient and would be a rare event even when the two species are in contact (see section 3.1.4).
- Remove fence section: Removing the eastern section of the fence will not affect effective buffalo-cattle contact.
- Remove fence section with risk mitigation: Implementation of H4H would reduce the risk of cattle-buffalo contact by direct avoidance of buffalo. Cattle under H4H are likely to be in better physical condition and immune status. They are also required to be vaccinated, and an efficacious vaccine with high coverage would offer protection.

P5: Cattle return to Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P5 as for section 3.2.3.2.
- Remove fence section: Removing the eastern section of the fence would make it marginally easier to cross the border by the lack of a fence, but cattle would still need to navigate through Bwabwata National Park to return from contacting cattle in Namibia.
- Remove fence section with risk mitigation: Cattle under H4H should not be herded back to Botswana to have contact with the rest of the herding group.

P6: Effective contact between susceptible and infected cattle in Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: The variable vaccination coverage of cattle in the area offers uncertain protection against FMDV, particularly among cattle in the same herd who would be expected to have regular close contact. Strain characterisation data from Ngamiland suggest that recent outbreak strains are circulating independently in cattle, where contact levels are considered to be high enough to sustain FMDV circulation (Atkinson et al. 2019). Infected cattle are highly infectious for a short period post infection to animals in close but not necessarily direct contact (see section 3.1.2.3).
- Remove fence section: Removing the eastern section of the fence would not affect the risk of effective contact between cattle.
- Remove fence section with risk mitigation: Improved animal health and higher vaccination coverage of cattle in the H4H model would raise individual immunity.

3.2.4.3 Risk estimation of SAT-type FMD outbreak in Botswana from Namibian buffalo

Full calculations for this risk pathway are shown in Appendix F. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 7). After fence removal alone or with risk mitigation, the risk remains **unchanged**. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from buffalo at the Zambezi Border fence (east of Okavango River) is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

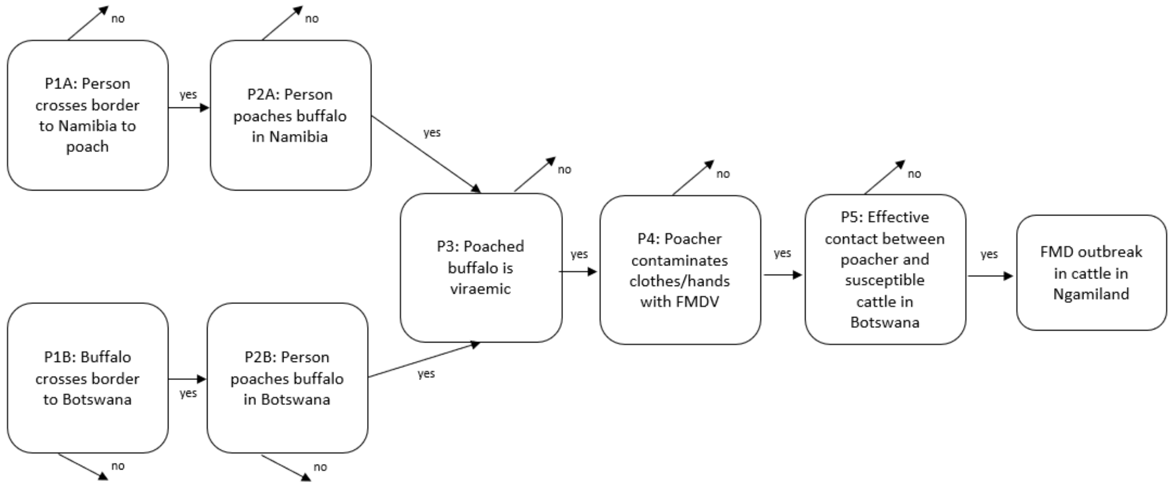
Table 7. Probability of occurrence for SAT-type FMD from buffalo in Namibia to cattle in Botswana along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
FMDV excretion by buffalo (P1)	Low (moderate)	Low (moderate)	Low (moderate)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (moderate)	Very low (moderate)
Buffalo cross to Botswana (P2B)	High (low)	High (low)	High (low)
Buffalo contact cattle in Namibia (P3A)	Low (moderate)	Low (moderate)	Low (moderate)
Buffalo contact cattle in Botswana (P3B)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective buffalo-cattle contact (P4)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle return to Botswana (P5)	Low (moderate)	Low (moderate)	Low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Moderate (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**

3.2.5 Assessment of risk of SAT-type FMD outbreak in Botswana from poaching

3.2.5.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Botswana. The scenario tree (below) involves either a poacher crossing the Botswana-Namibia border and poaching a buffalo in Namibia or poaching a buffalo after it crossed the Botswana-Namibia border, followed by the poacher having contact with cattle in Botswana.



3.2.5.2 Probability of occurrence assessment

P1A: Poacher crossing to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- <u>Status quo</u>: There have been some cases of poachers from Botswana crossing the border to poach in Bwabwata National Park (Kandovazu 2022). However, Bwabwata now has a dedicated active anti-poaching unit and the incidence of poaching has reduced considerably (P. Beytell, L. Hanssen, T. Pietersen, personal communication).
- <u>Remove fence section</u>: Discussions among the core group of experts noted that poaching risk wasn't that relevant to the presence of the fence, as it happens regardless. There may be some psychological impact of a fence that acts as a deterrent to some poachers, so that the risk of poaching could increase if this deterrent is removed.
- <u>Remove fence section with risk mitigation</u>: Maintaining a strong anti-poaching presence would be the most effective mitigation measure to reduce the risk of poaching.

P1B: Buffalo crossing to Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: See justification for section 3.2.4.2.
- Remove fence section: See justification for section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for section 3.2.4.2.

P2A: Buffalo being poached in Namibia

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Buffalo is prized bush meat in Botswana (Alexander et al. 2012). However, there is considerable anti-poaching presence in Bwabwata National Park which may deter poachers.
- Remove fence section: Removing the eastern section of the fence will not impact the risk of a buffalo being poached in Namibia.
- Remove fence section with risk mitigation: See justification for P1A above.

P2B: Buffalo being poached in Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: The rate of poaching in Ngamiland is high, and buffalo are one of the most frequently hunted species (Rogan et al. 2017). A farmer interviewed at Seshokora noted that buffalo are no longer reported because of the very long response time from DVS (N. Babayani unpublished data); such animals may be poached instead to remove the disease risk (Kahler and Gore 2015).
- Remove fence section: In this step, the presence or absence of the fence does not influence the behaviour of the poacher, as the buffalo is being poached inside the country.
- Remove fence section with risk mitigation: See justification for P1A above.

P3: Buffalo being viraemic

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:
- Status quo: Viraemia in buffalo is of short duration and under natural conditions only likely to occur in calves infected after maternally derived immunity has waned (see section 3.1.5.1)
- Remove fence section: Removing the eastern section of the fence will not impact the risk of a buffalo being viraemic.
- Remove fence section with risk mitigation: There are no practical interventions to reduce the risk of viraemia in buffalo.

P4: Contamination of poacher with FMDV

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:
- Status quo: Spread of FMDV as a result of contamination is unlikely (see section 3.1.5.2).
- Remove fence section: Removing the eastern section of the fence will not impact the risk of a poacher becoming contaminated with virus.
- Remove fence section with risk mitigation: There are no practical interventions to improve hygiene during and after poaching.

P5: Effective contact between poacher and cattle

Risk (uncertainty)

Status quo: **negligible (moderate)**
Remove fence section: **negligible (moderate)**
Remove fence section with risk mitigation: **negligible (moderate)**

Justification:
- Status quo: Infection by handling cattle is not considered probable according to previous risk assessments (see section 3.1.5.3).
- Remove fence section: Removing the eastern section of the fence will not impact the risk of effective contact between a poacher and cattle.
- Remove fence section with risk mitigation: See justification for P4 above.

3.2.5.3 Risk estimation of SAT-type FMD outbreak in Botswana from poaching

Calculations for this risk pathway are shown in Appendix G. The current risk of disease occurrence for SAT-type FMD is **negligible** with moderate uncertainty (Table 8). After fence removal alone, the risk would remain **negligible** with moderate or high uncertainty. After removal with risk mitigation measures in place, the risk remains **negligible** with moderate uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from poaching at the Zambezi Border fence (east of Okavango River) is **low** with moderate or high uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

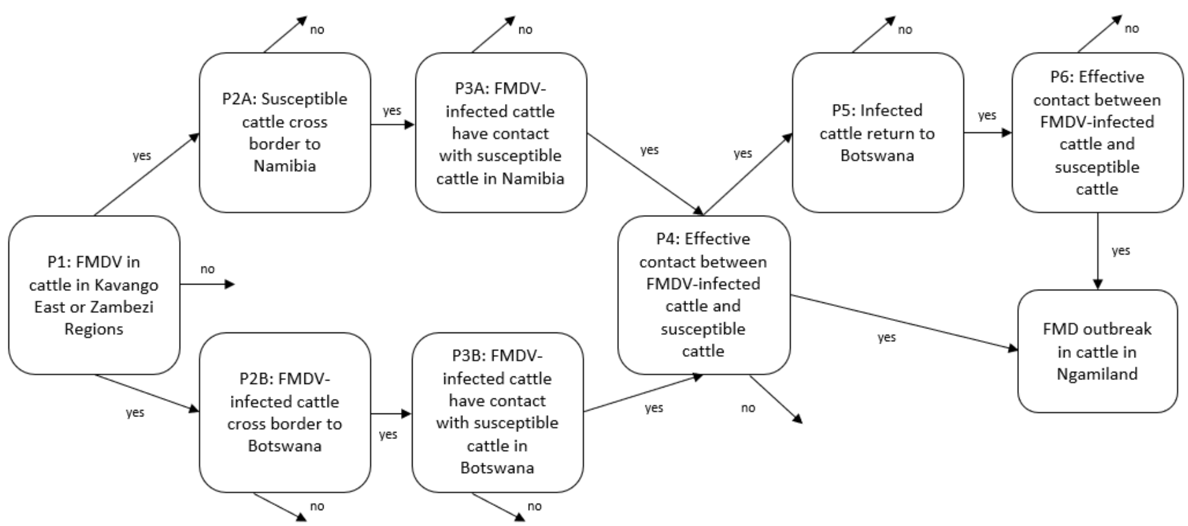
Table 8. Probability of occurrence for SAT-type FMD from poaching to cattle in Botswana along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
Poacher crosses to Namibia (P1A)	Low (moderate)	Low (high)	Low (moderate)
FMD host crosses to Botswana (P1B)	High (low)	High (low)	High (low)
Poaching in Namibia (P2A)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Poaching in Botswana (P2B)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Poached animal is viraemic (P3)	Very low (low)	Very low (low)	Very low (low)
Contamination of poacher with FMDV (P4)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Effective contact with cattle (P5)	Negligible (moderate)	Negligible (moderate)	Negligible (moderate)
Risk pathway in Namibia (P1A, P2A, P3, P4, P5)	**Negligible (moderate)**	**Negligible (high)**	**Negligible (moderate)**
Risk pathway in Botswana (P1B, P2B, P3, P4, P5)	**Negligible (moderate)**	**Negligible (moderate)**	**Negligible (moderate)**

3.2.6 Assessment of risk of FMD serotype O outbreak in Botswana from Namibian cattle

3.2.6.1 Hazard identification and scenario tree

The hazard for this assessment is FMDV serotype O causing FMD in cattle in Botswana. The scenario tree (below) involves either cattle crossing the border from Namibia and having contact with cattle in Botswana, or cattle crossing the border to Namibia, having contact with cattle there, and returning to Botswana.



3.2.6.2 Probability of occurrence assessment

P1: FMDV serotype O in cattle in Kavango East or Zambezi Regions near the Zambezi Border fence

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Namibia experienced an outbreak of FMD serotype O in 2021 (Banda et al. 2022) and achieved >90% emergency vaccination coverage during this outbreak (E. Hikufe, unpublished data). As of 2022, cattle in the FMD infected zone are vaccinated against FMDV serotype O in addition to the SAT-type viruses tri-annually. However, illegal movement of cattle from Zambia poses a threat to cattle in Namibia. Namibia conducts serosurveillance in the NCA.
- Remove fence section: Removing the eastern section of the fence will not affect the risk of FMDV serotype O in cattle in Kavango East or Zambezi Regions.
- Remove fence section with risk mitigation: In addition to the above, removal of cattle from Bwabwata National Park would make the cattle expected on the Namibian side of the fence virtually zero. Maintaining high vaccination coverage in Zambezi Region would reduce the risk of cattle infections nearby, although appropriate PVM should be implemented to ensure this.

P2A: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.2.3.2.
- Remove fence section: See justification for P2A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.2.3.2.

P2B: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: See justification for P2B in section 3.2.3.2.
- Remove fence section: See justification for P2B in section 3.2.3.2.

- Remove fence section with risk mitigation: See justification for P2B in section 3.2.3.2.

P3A: Contact between susceptible and infected cattle in Namibia

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: See justification for P3A in section 3.2.3.2.
- Remove fence section: See justification for P3A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P3A in section 3.2.3.2.

P3B: Contact between susceptible and infected cattle in Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3B in section 3.2.3.2.
- Remove fence section: See justification for P3A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P3A in section 3.2.3.2.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Cattle in Ngamiland are not currently vaccinated against FMD serotype O, therefore all cattle should be considered susceptible to this serotype. The R_0 for FMDV serotype O in a crop-livestock mixed system in Ethiopia was estimated as 1.68 (Tadesse et al. 2019), but the serotype O outbreak in Zambia was reported to spread rapidly.
- Remove fence section: Removing the eastern section of the fence will not affect the risk of effective contact between susceptible and infected cattle.
- Remove fence section with risk mitigation: Adding FMD serotype O to the vaccine used in cattle at crushes in high-risk border areas would offer significant additional protection to these animals. Given the higher cost of using a quadrivalent vaccine rather than the standard trivalent vaccine, select crushes could be identified by Botswana's epidemiological team, in conjunction with

counterparts in Namibia, to target the cattle most at risk. Active herding techniques, improved animal health and higher vaccination coverage of cattle in the H4H model would lower the risk of effective contact.

P5: Cattle crossing back to Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P5 in section 3.2.3.2. However, FMDV serotype O has a higher morbidity rate than SAT-types, so an infected cow would need to return to Botswana fairly quickly before clinical signs developed or it would likely be too lame to walk long distances.
- Remove fence section: See justification for P5 in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.2.3.2.

P6: Effective contact between susceptible and infected cattle after returning to Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Cattle in Ngamiland are not currently vaccinated against FMD serotype O, therefore all cattle should be considered susceptible to this serotype. Serotype O was reported to spread rapidly in Zambia and Namibia.
- Remove fence section: See justification for P6 in section 3.2.3.2.
- Remove fence section with risk mitigation: Adding FMDV serotype O to the vaccine used in cattle at crushes in high-risk border areas would offer protection to these animals. Given the higher cost of using a quadrivalent vaccine rather than the standard trivalent vaccine, select crushes could be identified by Botswana's epidemiological team, in conjunction with counterparts in Namibia, to target the cattle most at risk. Improved animal health in the H4H model would raise individual immunity.

3.2.6.3 Risk estimation of FMD serotype O outbreak in Botswana from Namibian cattle

Calculations for this risk pathway are shown in Appendix H. The current risk of disease occurrence for FMD serotype O is **very low** with moderate uncertainty (Table 9). After fence section removal alone, the risk would remain **unchanged**. After fence section removal with risk mitigation measures in place – specifically removal of cattle from Bwabwata National Park – the risk would decrease to **negligible** with moderate uncertainty. In combination with the perceived consequences (**high** magnitude with low uncertainty), the final risk estimate for FMD serotype O from cattle at the Zambezi Border fence (east of Okavango River) is **moderate** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation.

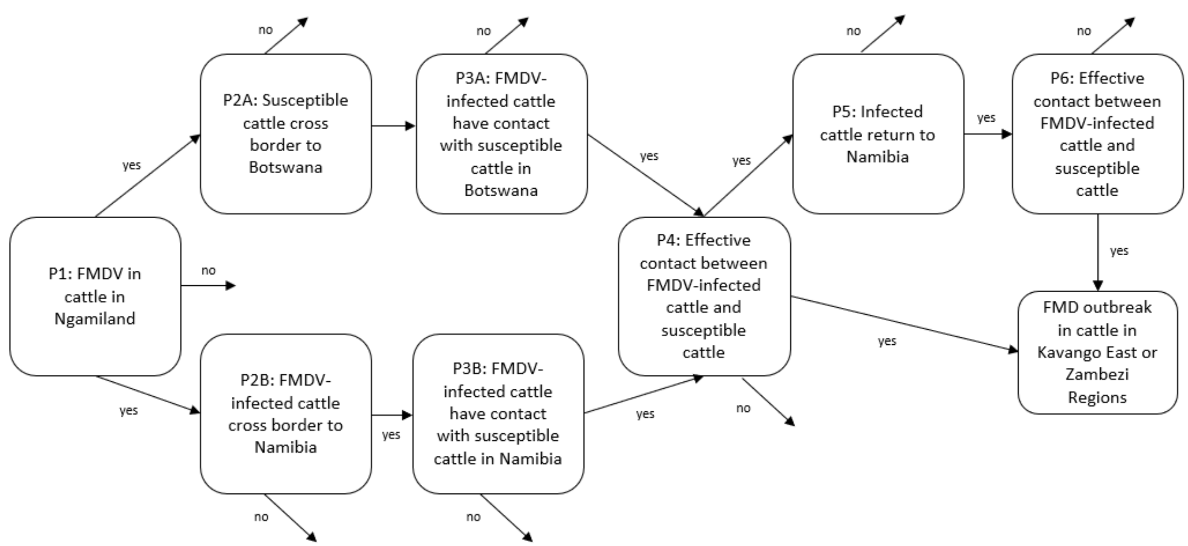
Table 9. Probability of occurrence for FMD serotype O from cattle in Namibia to cattle in Botswana along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
FMDV in cattle in Namibia (P1)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle cross to Botswana (P2B)	Very low (moderate)	Very low (moderate)	Negligible (moderate)
Cattle have contact with cattle in Namibia (P3A)	Very low (moderate)	Very low (moderate)	Negligible (moderate)
Cattle have contact with cattle in Botswana (P3B)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective contact between cattle (P4)	High (low)	High (low)	Low (moderate)
Cattle return to Botswana (P5)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Moderate (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**

3.2.7 Assessment of risk of SAT-type FMD outbreak in Namibia from Botswana cattle

3.2.7.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Namibia. The scenario tree (below) involves either cattle crossing the border from Botswana and having contact with cattle in Namibia, or cattle crossing the border to Botswana, having contact with cattle there, and returning to Namibia.



3.2.7.2 Probability of occurrence assessment

P1: SAT-type FMDV in cattle in Ngamiland near Zambezi Border fence

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification

- Status quo: See justification for P4 and P6 in section 3.2.3.2.
- Remove fence section: Removing the eastern section of the fence would be unlikely to affect the risk of SAT-type FMDV in cattle near the fence.
- Remove fence section with risk mitigation: Maintaining consistent high vaccination coverage with a vaccine that matches circulating strains along with PVM to confirm protection would lower the risk of FMDV.

P2A: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: See justification for P2B in section 3.2.3.2.
- Remove fence section: See justification for P2B in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.2.3.2.

P2B: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.2.3.2.
- Remove fence section: See justification for P2A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.2.3.2.

P3A: Contact between susceptible and infected cattle in Botswana

Risk (uncertainty)

Status quo: **low (moderate)**

Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:
- Status quo: See justification for P3B in section 3.2.3.2.
- Remove fence section: See justification for P3B in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P3B in section 3.2.3.2.

P3B: Contact between susceptible and infected cattle in Namibia

Risk (uncertainty)
Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:
- Status quo: See justification for P3A in section 3.2.3.2.
- Remove fence section: See justification for P3A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P3A in section 3.2.3.2.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)
Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:
- Status quo: See justification for P1 in section 3.2.3.2.
- Remove fence section: See justification for P4 in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P4 in section 3.2.3.2.

P5: Cattle return to Namibia

Risk (uncertainty)
Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:
- Status quo: If discovered, cattle that have crossed to Botswana are repatriated. Cattle that are undetected may cross or be herded back to Namibia. The fence is semi-permeable and could be crossed if cattle were able to return through Bwabwata National Park.

- Remove fence section: Removing the eastern section of the fence would make it marginally easier to cross the border by the lack of a fence, but cattle would still need to navigate through Bwabwata National Park to return from contacting cattle in Botswana.
- Remove fence section with risk mitigation: If resident cattle were removed from Bwabwata National Park, there would be no incentive for stray cattle to return there.

P6: Effective contact between susceptible and infected cattle after returning to Namibia

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: In Namibia's FMD infected zone, which includes part of Kavango East starting at Divundu Settlement (east of the Kavango River) and extends eastward to include all of Zambezi Region, cattle are vaccinated tri-annually against SAT-type FMDV. At least 85% of the target cattle population in Namibia was vaccinated against FMD in the last three years, but PVM is not being achieved regularly to ensure adequate protection (European Commission 2022).
- Remove fence section: Removing the eastern section of the fence would not affect effective contact after returning to Namibia.
- Remove fence section with risk mitigation: If there were no resident cattle in Bwabwata National Park, the closest cattle that could possibly become infected would be outside the park. It would be extremely unlikely that cattle would traverse the entire park and then exit into communal livestock rearing areas to have contact with resident cattle there.

3.2.7.3 Risk estimation of SAT-type FMD outbreak in cattle to Namibia from Botswana cattle

Calculations for this risk pathway are shown in Appendix I. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 10). After fence removal alone, the risk would remain **unchanged**. After fence removal with risk mitigation measures in place – specifically removal of cattle from Bwabwata National Park – the risk would become **negligible** with moderate uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD in Namibia from Botswana cattle at the Zambezi Border fence line (east of Okavango River) under the fencing status quo is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

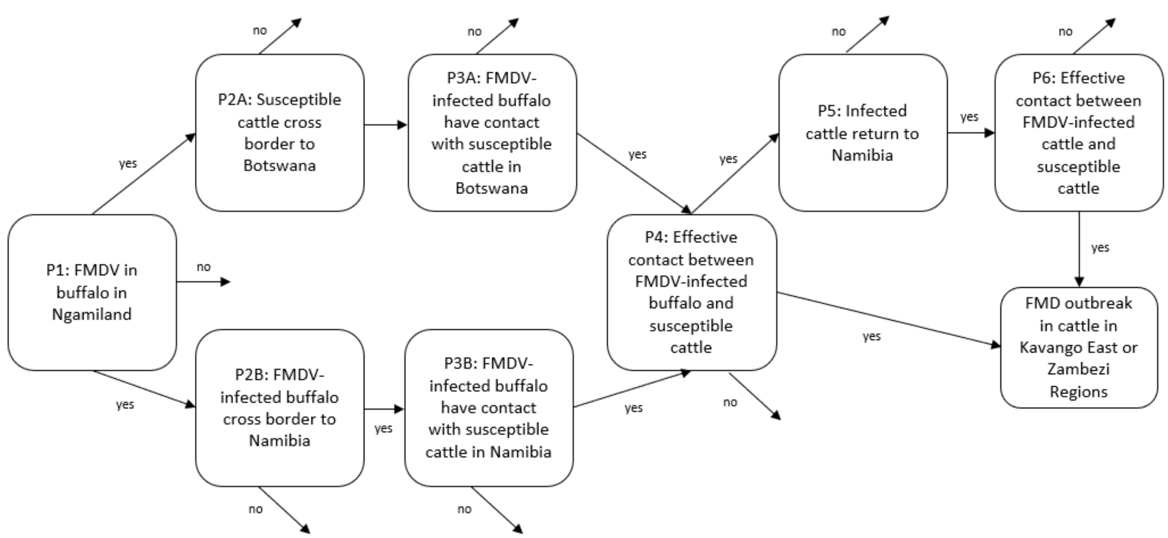
Table 10. Probability of occurrence for SAT-type FMD from cattle in Botswana to cattle in Namibia along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
FMDV in cattle in Botswana (P1)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Cattle cross to Botswana (P2A)	Very low (moderate)	Very low (moderate)	Negligible (low)
Cattle cross to Namibia (P2B)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle have contact with cattle in Botswana (P3A)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle have contact with cattle in Namibia (P3B)	Very low (moderate)	Very low (moderate)	Negligible (low)
Effective contact between cattle (P4)	Moderate (moderate)	Moderate (moderate)	Low (moderate)
Cattle return to Namibia (P5)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Effective contact between cattle (P6)	Moderate (moderate)	Moderate (moderate)	Negligible (low)
Risk pathway in Botswana (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**
Risk pathway in Namibia (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**

3.2.8 Assessment of risk of SAT-type FMD outbreak in Namibia from Botswana buffalo

3.2.8.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Namibia. The scenario tree (below) involves either buffalo crossing the Botswana-Namibia border and having contact with cattle, or cattle crossing the border, having contact with buffalo, and returning to Namibia. It should be noted that the prevalence of FMDV in buffalo in Namibia vs. buffalo in Botswana would be expected to be equal.



3.2.8.2 Probability of occurrence assessment

P1: SAT-type FMDV excreted by buffalo in Ngamiland

Risk (uncertainty)

Status quo: **low (moderate)**

Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: See justification for P1 in section 3.2.4.2. Serosurveillance conducted in game conservancies in Ngamiland from 2019-2020 showed a majority of buffalo (43/54, 79.6%) had NSP antibodies.
- Remove fence section: See justification for P1 in section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for P1 in section 3.2.4.2.

P2A: Cattle crossing to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: See justification for P2B in section 3.2.3.2.
- Remove fence section: See justification for P2B in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2B in 3.2.3.2.

P2B: Buffalo crossing to Namibia

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: The current configuration of the Zambezi Border and Northern Buffalo fences limits the movement of wildlife into Namibia and should limit buffalo presence in the eastern panhandle (the primary purpose of the adjoining Northern Buffalo fence is to prevent buffalo from moving northwards from the delta towards villages in the eastern panhandle). However, buffalo spoor were observed parallel to much of this section of the Zambezi Border fence in the phase 1 surveys; much of the fence is dilapidated and buffalo had successfully crossed the fence 50% of the time (n=2/4 attempts) (Atkinson et al. 2022).
- Remove fence section: See justification for P2B in section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.2.4.2.

P3A: Buffalo-cattle contact in Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:
- Status quo: See justification for P3A in section 3.2.4.2.
- Remove fence section: See justification for P3A in section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for P3A in section 3.2.4.2.

P3B: Buffalo-cattle contact in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:
- Status quo: See justification for P3A in section 3.2.4.2.
- Remove fence section: See justification for P3A in section 3.2.4.2.
- Remove fence section with risk mitigation: Removal of cattle from Bwabwata National Park would remove the risk of buffalo-cattle contact aside from an occasional stray.

P4: Effective buffalo-cattle contact

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:
- Status quo: See justification for P4 in section 3.2.4.2.
- Remove fence section: See justification for P4 in section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for P4 in section 3.2.4.2.

P5: Cattle returning to Namibia

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P5 in section 3.2.7.2.
- Remove fence section: See justification for P5 in section 3.2.7.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.2.7.2.

P6: Effective contact between infected and susceptible cattle in Namibia

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: At least 85% of the target cattle population in Namibia was vaccinated against FMD in the last three years, but PVM is not being achieved regularly to ensure adequate protection (European Commission 2022). Infected cattle are highly infectious for a short period post infection to animals in close but not necessarily direct contact (see section 3.1.2.3).
- Remove fence section: See justification for P6 in section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for P6 in section 3.2.7.2.

3.2.8.3 Risk estimation of SAT-type FMD outbreak in Namibia from Botswana buffalo

Calculations for this risk pathway are shown in Appendix J. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 11). After fence removal alone, the risk would remain **unchanged**. After fence removal with risk mitigation measures in place – specifically removal of cattle from Bwabwata National Park – the risk would decrease to **negligible** with moderate uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from buffalo at the Zambezi Border fence (east of Okavango River) is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

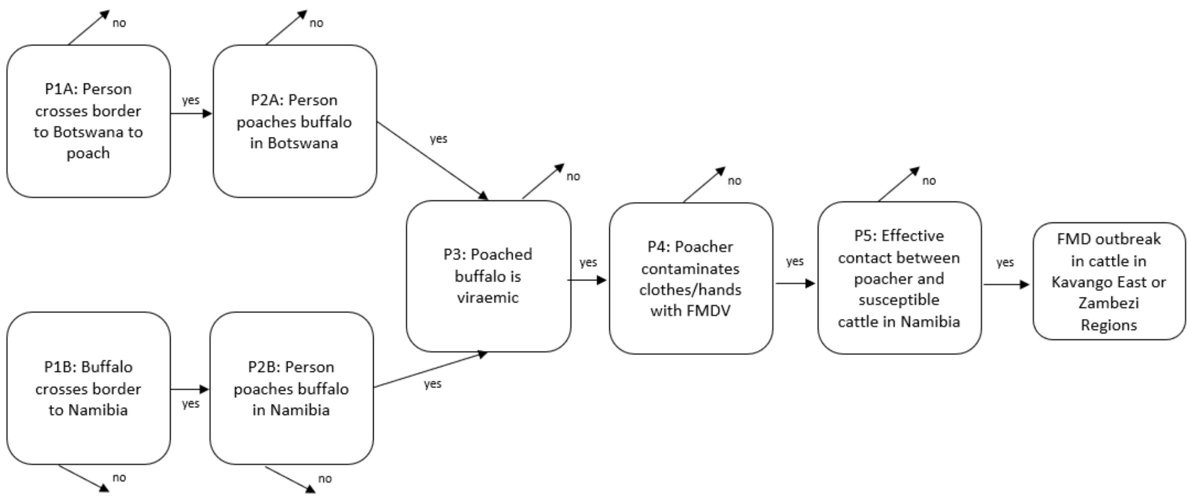
Table 11. Probability of occurrence for SAT-type FMD from buffalo in Botswana to cattle in Namibia along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
FMDV excretion by buffalo (P1)	Low (moderate)	Low (moderate)	Low (moderate)
Cattle cross to Botswana (P2A)	Very low (moderate)	Very low (moderate)	Negligible (low)
Buffalo cross to Namibia (P2B)	High (low)	High (low)	High (low)
Buffalo have contact with cattle in Botswana (P3A)	Low (moderate)	Low (moderate)	Very low (low)
Buffalo have contact with cattle in Namibia (P3B)	Low (moderate)	Low (moderate)	Negligible (low)
Effective contact between buffalo and cattle (P4)	Very low (low)	Very low (low)	Negligible (low)
Cattle return to Namibia (P5)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Effective contact between cattle (P6)	Moderate (moderate)	Moderate (moderate)	Negligible (moderate)
Risk pathway in Botswana (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**
Risk pathway in Namibia (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**

3.2.9 Assessment of risk of SAT-type FMD outbreak in Namibia from poaching

3.2.9.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Namibia. The scenario tree (below) involves either a poacher crossing the Botswana-Namibia border and poaching a buffalo in Botswana or poaching a buffalo after it crossed the Botswana-Namibia border, followed by the poacher having contact with cattle in Namibia.



3.2.9.2 Probability of occurrence assessment

P1A: Poacher crossing to Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Much of the eastern Zambezi Border fence (east of Okavango River) is in poor condition, with entire sections lying on the ground. However, there are no nearby settlements in Namibia, with the Omega settlement in Bwabwata being the closest.
- Remove fence section: See justification for P1B in section 3.2.5.2.
- Remove fence section with risk mitigation: See justification for P1B in section 3.2.5.2.

P1B: Buffalo crossing to Namibia

Risk (uncertainty)

Status quo: **high (low)**

Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:
- Status quo: See justification for P2B in section 3.2.4.2.
- Remove fence section: See justification for P2B in section 3.2.4.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.2.4.2.

P2A: Buffalo being poached in Botswana

Risk (uncertainty)
Status quo: **moderate (low)**
Remove fence section: **moderate (low)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:
- Status quo: The rate of poaching in Ngamiland is high, and buffalo are one of the most frequently hunted species (Rogan et al. 2017).
- Remove fence section: Removing the eastern section of the fence would not affect the risk of a buffalo being poached in Botswana.
- Remove fence section with risk mitigation: Increased anti-poaching presence in Botswana may act as a deterrent, as Botswana maintains a shoot-to-kill policy for suspected poachers.

P2B: Buffalo being poached in Namibia

Risk (uncertainty)
Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:
- Status quo: Buffalo poaching in Bwabwata National Park is disincentivised by some permitted own use hunting and the valuable buffalo trophy hunting industry, which also results in the distribution of meat to the local communities (T. Pietersen, personal communication). However, buffalo are considered vulnerable to poaching elsewhere in Zambezi Region, in part due to fear of spread of FMD to cattle (Kahler and Gore 2015)
- Remove fence section: See justification for P2 in section 3.2.5.2.
- Remove fence section with risk mitigation: See justification for P2 in section 3.2.5.2.

P3: Buffalo being viraemic

Risk (uncertainty)
Status quo: **very low (low)**
Remove fence section: **very low (low)**

Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: See justification for P3 in section 3.2.5.2.
- Remove fence section: See justification for P3 in section 3.2.5.2.
  Remove fence section with risk mitigation: See justification for P3 in section 3.2.5.2.

P4: Contamination of poacher with FMDV

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: See justification for P4 in section 3.2.5.2.
- Remove fence section: See justification for P4 in section 3.2.5.2.
- Remove fence section with risk mitigation: See justification for P4 in section 3.2.5.2.

P5: Effective contact between poacher and cattle

Risk (uncertainty)

Status quo: **negligible (moderate)**
Remove fence section: **negligible (moderate)**
Remove fence section with risk mitigation: **negligible (moderate)**

Justification:

- Status quo: See justification for P5 in section 3.2.5.2.
- Remove fence section: See justification for P5 in section 3.2.5.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.2.5.2.

3.2.9.3 Risk estimation of SAT-type FMD outbreak in Namibia from poaching

Calculations for this risk pathway are shown in Appendix K. The current risk of disease occurrence for SAT-type FMD is **negligible** with moderate uncertainty (Table 12). After fence removal alone or with risk mitigation measures in place, the risk would remain **negligible** with moderate or high uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from poaching at the Zambezi Border fence (east of Okavango River) is **low** with moderate or high uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

Table 12. Probability of occurrence for SAT-type FMD from poaching to cattle in Namibia along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
Poacher crosses to Botswana (P1A)	Low (moderate)	Low (high)	Low (moderate)
Buffalo crosses to Namibia (P1B)	High (low)	High (low)	High (low)
Poaching in Botswana (P2A)	Moderate (moderate)	Moderate (moderate)	Low (moderate)
Poaching in Namibia (P2B)	Low (moderate)	Low (moderate)	Low (moderate)
Poached buffalo is viraemic (P3)	Very low (low)	Very low (low)	Very low (low)
Contamination of poacher with FMDV (P4)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Effective contact with cattle (P5)	Negligible (moderate)	Negligible (moderate)	Negligible (moderate)
Risk pathway in Botswana (P1A, P2A, P3, P4, P5)	**Negligible (moderate)**	**Negligible (high)**	**Negligible (moderate)**
Risk pathway in Namibia (P1B, P2B, P3, P4, P5)	**Negligible (moderate)**	**Negligible (moderate)**	**Negligible (moderate)**

3.3 Northern Buffalo fence assessment

3.3.1 Livestock disease prevalence and recent history

There have been no FMD outbreaks in Ngamiland in close proximity to the Northern Buffalo fence in the last 10 years. The most recent Ngamiland outbreak was in 2020, which occurred at Malatso crush (west of the Okavango River) and later spread to Xakao II (east of the Okavango River; Figure 15). The Northern Buffalo fence separates subzone 2a from zone 16, the stock-free area around the Okavango Delta where buffalo are free-roaming. An example of buffalo distribution during the dry season is shown in Figure 16.

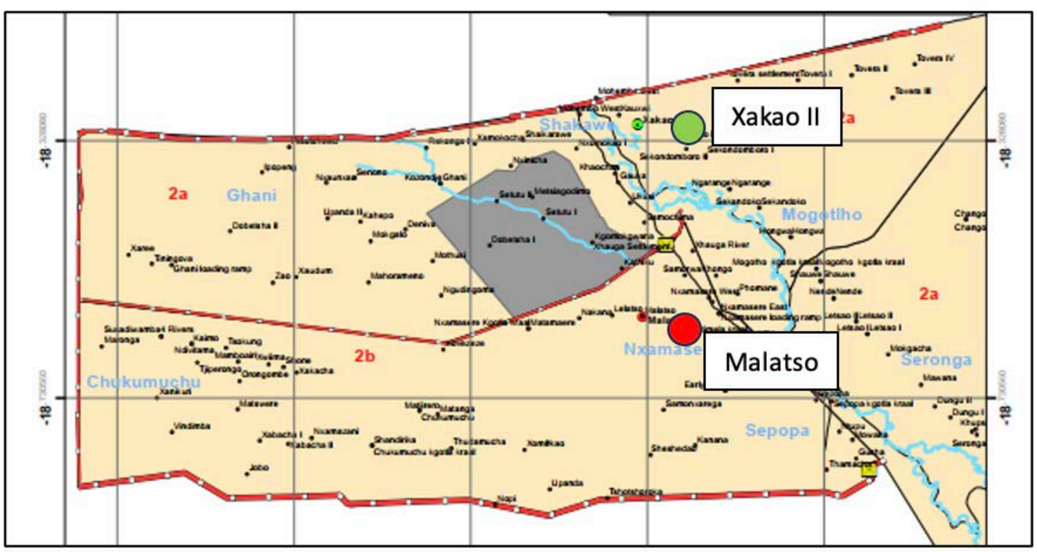


Figure 15. Map of FMD outbreak in Ngamiland in 2020. Source: Botswana DVS.

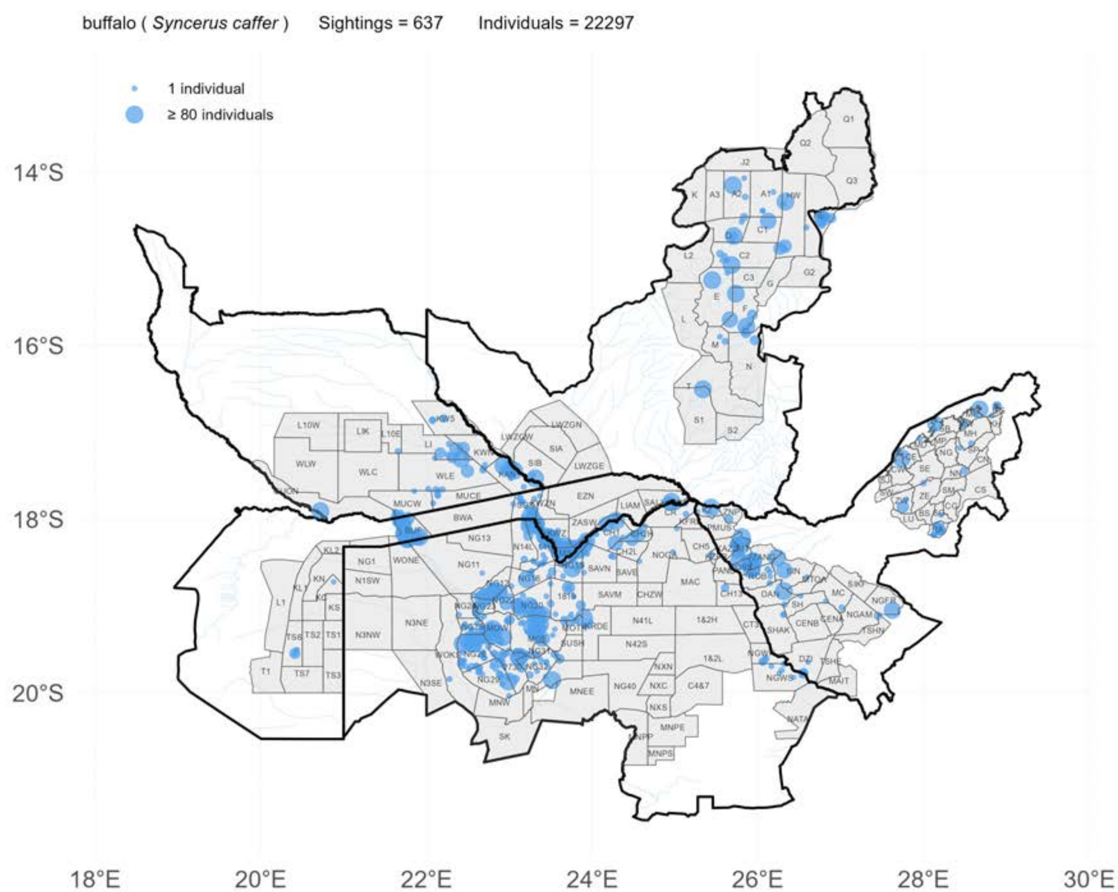


Figure 16. Map of buffalo observed during the 2022 KAZA Elephant Survey. Source: KAZA Elephant Survey Report Volume I (Bussière and Potgieter 2023a)

3.3.2 Status of the fence

The fence extends 129 km south beginning at the Zambezi Border fence junction and terminating at the Okavango Delta (Figure 14). This single fence comprises six wire strands – the fourth strand being replaced with a steel cable. In some places page wire is also present at the bottom of the fence. The fence was electrified at one time and the insulators are still present. The fence posts are wooden gum poles with wooden droppers secured to each fence strand by a loop of wire.

In terms of condition, a June 2021 NAMBOT patrol report indicated that this fence required rehabilitation, with major breaks at Seshokora. Further details on fence condition, gathered during a field site visit (on the zone 16 side of the fence) in November 2022, are described below.

The fence's condition varies from completely intact and upright (Figure 17) to completely destroyed, with missing wires, cable and gum poles (Figure 18). The fence line is in good condition in the north near Xhoroma but deteriorates further south. Loose wire exists along the road and poses a hazard to animals and vehicles. In some cases, gum poles have been replaced. Breaks in the cable were observed at several points between Xhoroma and Selinda gate. The road is difficult to traverse as Botswana Defence

Force vehicles using this road are wider than a standard 4x4 vehicle. Sections of the road are also prone to flooding during the rainy season and may become impassable during heavy rainfall.

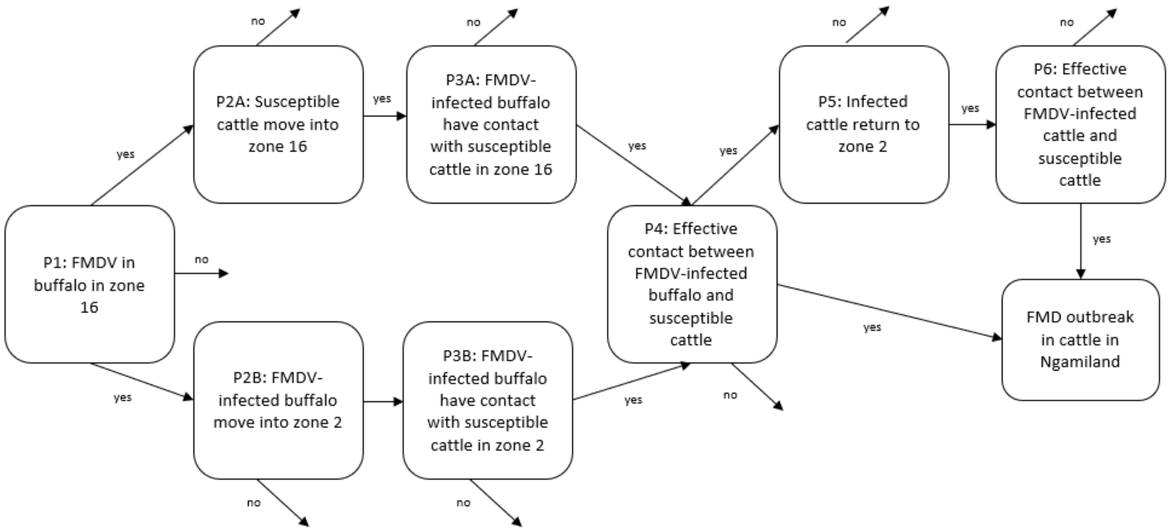
Figure 17. Northern Buffalo fence in good condition, although with a lack of bush-clearing, as observed during a site visit in November 2022.

Figure 18. Northern Buffalo fence in poor condition with missing wires and major breaks during a site visit in November 2022.

3.3.3 Assessment of risk of SAT-type FMD outbreak in zone 2 from buffalo in zone 16

3.3.3.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in zone 2. The scenario tree (below) involves either buffalo crossing the Northern Buffalo fence and having contact with cattle in zone 2, or cattle crossing the fence, having contact with buffalo in zone 16, and returning to zone 2.



3.3.3.2 Probability of occurrence assessment

P1: SAT-type FMDV excreted by buffalo in Ngamiland

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Most buffalo in Ngamiland are seropositive for antibodies to FMDV (see section 3.1.3).
- Remove fence section: Removal the northern section of the fence will not impact the prevalence of FMDV infection in buffalo.
- Remove fence section with risk mitigation: There are no practical interventions to reduce prevalence of FMDV in the free-ranging buffalo population.

P2A: Cattle crossing to zone 16

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **moderate (moderate)**

Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Cattle are generally found along the northern Okavango Delta near the southern end of the fence, which is not recommended for removal in the Phase 1 report. To the north, along the 80 km section recommended for removal in the Phase 1 report, from Xhoroma camp in the north to 20 km south of the Selinda gate, there is one cattlepost (Seshokora) in immediate proximity to the fence in land use zone NG13 (a wildlife management area). The fence is in poor condition which would allow cattle to easily move eastwards into zone 16 in some sections, although this area has a very low density of cattle. The Seshokora cattlepost is where cattle would be most likely to cross into zone 16. As noted, there are no cattleposts other than Seshokora near the northern half of the fence, and land use zones east of the fence are wildlife concessions. Cattle were observed near Seshokora during 2019 and 2020 aerial surveys, and 2 cattle were observed in zone 16 near Seshokora during 2019 surveys (A. Songhurst, unpublished data; Figure 19). No cattle spoor or cattle were observed during the phase 1 fence surveys conducted in 2020 (Atkinson et al. 2022), but there were ~250 cattle vaccinated in 2021 with ~350 expected according to Botswana DVS FMD vaccination returns. Major breaks in the fence near Seshokora were observed during the June 2021 NAMBOT patrol. In spite of the poor condition of the fence, only ~19% (37/193) of attempted fence crossings by ungulates were successful in the phase 1 surveys (Atkinson et al. 2022). A North West District monthly report from June 2022 also described fence damage due to people cutting the fence to graze cattle in zone 16. Further south close to the northern Okavango Delta near Selinda Gate (~62 km south of Xhoroma Camp), cattle occur in higher density within 10 km of the fence. However, no cattle were observed in zone 16 across from these cattleposts in the 2019 or 2020 aerial surveys (A. Songhurst, unpublished data). Cattle in this area prefer areas close to human settlements and experience significant risk of predation by lions >4 km from settlements (Weise et al. 2019). GPS collar data from this study show that over the course of a year, cattle moved in an area roughly 12–16 km in diameter (Figure 20).
- Remove fence section: The Northern Buffalo fence is in relatively good condition near Xhoroma camp and the 2019 and 2020 aerial surveys showed cattle in close proximity to the fence. If it were removed, cattle would move eastward to graze in zone 16. The cattle in the northern delta would not likely move into zone 16 based on the evidence presented above.
- Remove fence section with risk mitigation: Under H4H, cattle movements would be controlled and remain within zone 2.

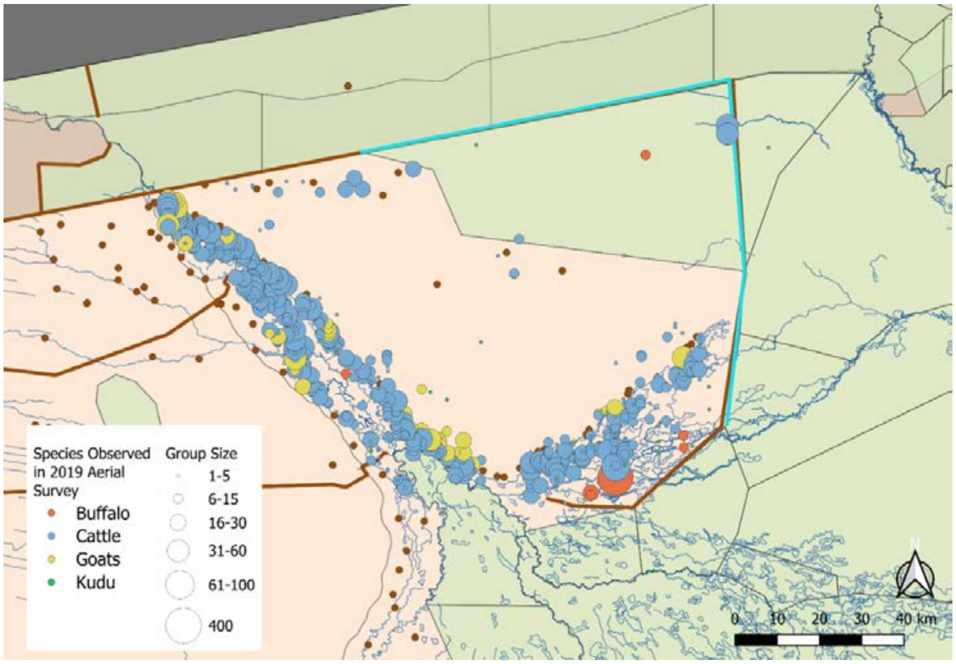


Figure 19. Map of eastern panhandle and northern Okavango Delta, showing select livestock and wildlife observed in 2019 aerial survey. Aerial survey data provided by Ecoexist Trust.

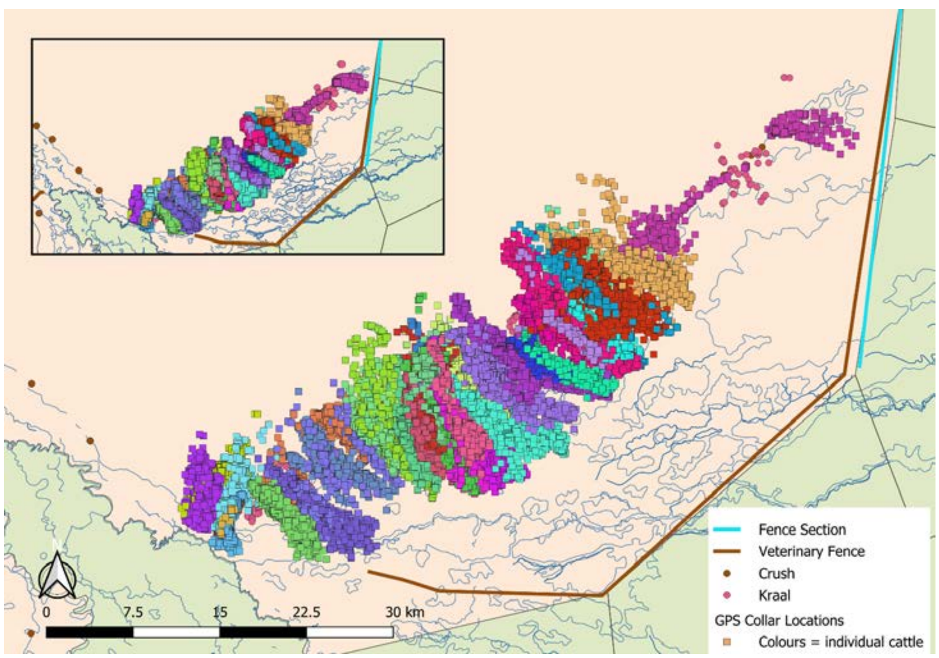


Figure 20. Map of cattle movements from 2017–2018 near the southern aspect of the Northern Buffalo fence, collected via GPS transponders by CLAWS Conservancy. Shown are ~73,000 locations of 42 individual cattle (41 females, 1 male) from 30 different herds. Most females were herd lead cows and therefore movements are representative of the entire herd, which roam unattended but are habituated to return to the home kraal. Most cattle had a maximum range of 12-16 km in diameter over the entire time period; the cow shown in light green toward the upper right corner had a maximum range of ~24 km in diameter. GPS positions provided by CLAWS Conservancy.

P2B: Buffalo crossing to zone 2

Risk (uncertainty)

Status quo: **moderate (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: This fence is in variable condition, worsening on the southern aspect further from Xhoroma camp. A herd of 15 buffalo was observed in NG13 during 2019 aerial surveys, and 2 buffalo were observed in NG13 during the 2020 aerial survey (A. Songhurst, unpublished data; Figures 19 and 21). Fence surveys in 2020 found evidence of considerable buffalo spoor parallel to the fence and 15 attempted buffalo crossings, 3 of which (20%) were successful (Atkinson et al. 2022). There were 3 reports of buffalo incursions from the Okavango Delta in 2022, but this is an underestimate as many farmers surveyed no longer report buffalo incursions due to lack of response (N. Babayani, unpublished data). Aerial surveys in 2019 and 2020 found herds of up to 400 buffalo had crossed the fence north of the Okavango Delta, (A. Songhurst, unpublished data; Figures 19 and 21), although this southernmost section is not proposed for removal.
- Remove fence section: Buffalo spoor was recorded along this fence during phase 1 surveys (Atkinson et al. 2022); without a fence, buffalo would likely return to this area, as wildlife have been shown to return to crossing after fence removal (Arthur Albertson Consulting (Pty) Ltd 2005), although the density of buffalo is lower further from the Kwando River (Bussière and Potgieter 2023a).
- Remove fence section with risk mitigation: Restoration of wildlife corridor connectivity is the goal of fence removal, so increased wildlife movements are to be expected and efforts to inhibit movement of buffalo would be counterproductive.

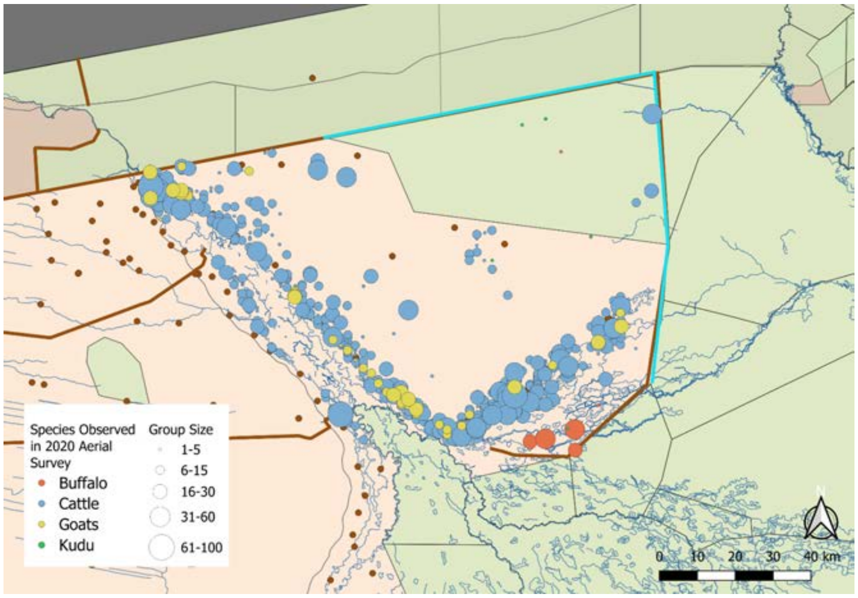


Figure 21. Map of eastern panhandle and northern Okavango Delta, showing select livestock and wildlife species observed in 2020 aerial survey.

P3A: Buffalo-cattle contact in zone 16

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: In the 2022 KAZA Elephant Survey, buffalo occurred at high density in the northern delta and were concentrated closer to the Kwando River, but were more sparse towards NG13 (Bussière and Potgieter 2023a). Buffalo tend to avoid contact with cattle (see section 3.1.4.1).
- Remove fence section: Cattle from Seshokora would be most likely to enter zone 16 if any cattle were to enter; this has already been shown to occur with the fence present.
- Remove fence section with risk mitigation: Active herding with H4H would limit the risk of cattle straying into zone 16 and having contact with buffalo. There is already H4H in place in Eretsha close to the southern section of the fence, but it is not being applied universally in the northern delta.

P3B: Buffalo-cattle contact in zone 2

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3A above. In addition, past aerial surveys show that buffalo do move out of the delta into zone 2 (A. Songhurst, unpublished data; Figures 19 and 21).
- Remove fence section: Although buffalo are already known to be present in zone 2, this number would likely increase after fence removal and therefore the contact rate between buffalo and cattle could become more frequent.
- Remove fence section with risk mitigation: Active herding with H4H would limit the risk of cattle having contact with buffalo.

P4: Effective buffalo-cattle contact

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Studies in the southern African region have indicated that transmission of FMDV from buffalo to cattle is relatively rare (see section 3.1.4.2).

- Remove fence section: Removing the northern section of the fence will not affect effective buffalo-cattle contact.
- Remove fence section with risk mitigation: Implementation of H4H would reduce the risk of cattle-buffalo contact by direct avoidance of buffalo. Cattle under H4H are likely to be in better physical condition and immune status. They are also required to be vaccinated, and an efficacious vaccine with high coverage would offer protection.

P5: Cattle returning to zone 2

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Although cattle that enter FMD infected areas are intended to be destroyed (Babayani and Thololwane 2022), the area along the Northern Buffalo fence is remote and not regularly patrolled. Cattle would not likely be reported and if they were, getting transport and manpower to retrieve them in a timely manner is also unlikely. In a qualitative risk assessment along the Southern Buffalo fence, the probability of cattle returning was evaluated as high with low uncertainty (Babayani and Thololwane 2022).
- Remove fence section: Removing the northern section of the fence would make it easier for cattle to return without the physical barrier, although they would still need to traverse the stock-free area of zone 16.
- Remove fence section with risk mitigation: Cattle under H4H should not be herded back to zone 2 to have contact with the rest of the herding group.

P6: Effective contact between infected and susceptible cattle in zone 2

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: The variable vaccination coverage of cattle in the area offers uncertain protection against FMDV, particularly among cattle in the same herd who would be expected to have regular close contact. Strain characterisation data from Ngamiland suggest that recent outbreak strains are circulating independently in cattle, where contact levels are considered to be high enough to sustain FMDV circulation (Atkinson et al. 2019). Section 3.1.2.3 provides information about transmission by cattle.
- Remove fence section: Removing the northern section of the fence would not affect effective contact after returning to zone 2.

- Remove fence section with risk mitigation: Improved animal health and higher vaccination coverage of cattle in the H4H model would raise individual immunity and should prevent contact by mingling with potentially infected animals.

3.3.3.3 Risk estimation of SAT-type FMD outbreak in zone 2 from buffalo in zone 16

Calculations for this risk pathway are shown in Appendix L. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 13). After fence removal alone or with risk mitigation measures in place, the risk would remain **unchanged**. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from buffalo at the Northern Buffalo fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate moderate.

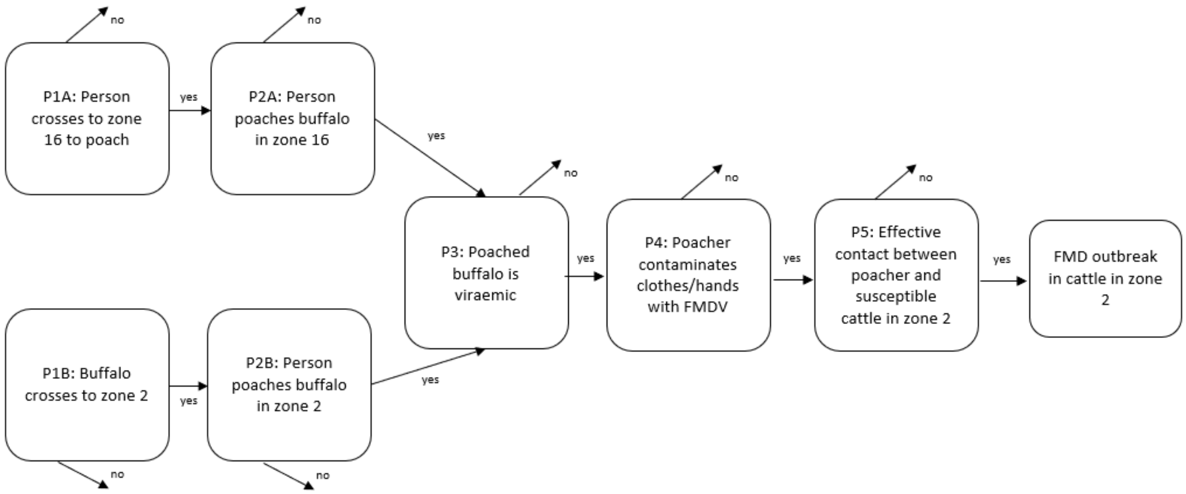
Table 13. Probability of occurrence for SAT-type FMD from buffalo in zone 16 to cattle in zone 2 along the Northern Buffalo fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
FMDV excretion by buffalo (P1)	Low (moderate)	Low (moderate)	Low (moderate)
Cattle cross to zone 16 (P2A)	Low (moderate)	Moderate (moderate)	Very low (moderate)
Buffalo cross to zone 2 (P2B)	Moderate (low)	High (low)	High (low)
Buffalo contact cattle in zone 16 (P3A)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Buffalo contact cattle in zone 2 (P3B)	Low (moderate)	Moderate (moderate)	Very low (low)
Effective buffalo-cattle contact (P4)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle return to zone 2 (P5)	High (low)	High (low)	Low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Moderate (moderate)
Risk pathway in zone 16 (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**
Risk pathway in zone 2 (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**

3.3.4 Assessment of risk of SAT-type FMD outbreak in zone 2 from poaching

3.3.4.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in zone 2. The scenario tree (below) involves either a poacher crossing the Northern Buffalo fence and poaching a buffalo in zone 16 or poaching a buffalo after it crossed into zone 2, followed by the poacher having contact with cattle in zone 2.



3.3.4.2 Probability of occurrence assessment

P1A: Poacher crossing to zone 16

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (high)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: This area is remote, so a poacher would be unlikely to encounter law enforcement away from the Botswana Defence Force camp. The terrain is heavily sandy and difficult even in a 4x4 vehicle, making it difficult to access. The fence is in poor condition with major breakages and can easily be crossed by a person.
- Remove fence section: Discussions among the core group of experts noted that poaching risk wasn't that relevant to the presence of the fence, as it happens regardless. There may be some psychological impact of a fence that acts as a deterrent to some poachers, so that the risk of poaching could increase if this deterrent is removed.
- Remove fence section with risk mitigation: Maintaining a strong anti-poaching presence would be the most effective mitigation measure to reduce the risk of poaching.

P1B: Buffalo crossing to zone 2

Risk (uncertainty)

Status quo: **moderate (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:
- Status quo: See justification for P2B in section 3.3.3.2.
- Remove fence section: See justification for P2B in section 3.3.3.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.3.3.2.

P2A: Buffalo being poached in zone 16

Risk (uncertainty)

Status quo: **moderate (low)**
Remove fence section: **moderate (high)**
Remove fence section with risk mitigation: **moderate (high)**

Justification:
- Status quo: Zone 16 contains a high density of buffalo, which are one of the most frequently hunted species in Ngamiland (Rogan et al. 2017). A farmer interviewed at Seshokora noted that buffalo are no longer reported because of the very long response time from DVS (N. Babayani, unpublished data); such animals may be poached instead to remove the disease risk (Kahler and Gore 2015).
- Remove fence section: The risk of poaching may increase if fences are removed, with an influx of wildlife into areas where they were previously excluded and more availability to people who may not have had an opportunity to poach in the past. However, wildlife may also occur at lower densities if they have the ability to disperse further without the restriction of the fence.
- Remove fence section with risk mitigation: See justification for P1A above.

P2B: Buffalo being poached in zone 2

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (high)**
Remove fence section with risk mitigation: **moderate (high)**

Justification:
- Status quo: See justification for P2A above.
- Remove fence section: See justification for P2A above.
- Remove fence section with risk mitigation: See justification for P1A above.

P3: Buffalo being viraemic

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: Viraemia in buffalo is of short duration and under natural conditions only likely to occur in calves infected after maternally derived immunity has waned (see section 3.1.5.1)
- Remove fence section: Removing the northern section of the fence will not impact the risk of a buffalo being viraemic.
- Remove fence section with risk mitigation: There are no practical interventions to reduce the risk of viraemia in buffalo.

P4: Contamination of poacher with FMDV

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Spread of FMDV as a result of contamination is unlikely (see section 3.1.5.2).
- Remove fence section: Removing the northern section of the fence will not impact the risk of a poacher becoming contaminated with virus.
- Remove fence section with risk mitigation: There are no practical interventions to improve hygiene during and after poaching.

P5: Effective contact between poacher and cattle

Risk (uncertainty)

Status quo: **negligible (moderate)**
Remove fence section: **negligible (moderate)**
Remove fence section with risk mitigation: **negligible (moderate)**

Justification:

- Status quo: Infection by handling cattle is not considered probable according to previous risk assessments (see section 3.1.5.3).
- Remove fence section: Removing the northern section of the fence will not impact the risk of effective contact between a poacher and cattle.
- Remove fence section with risk mitigation: See justification for P4 above.

3.3.4.3 Risk estimation of SAT-type FMD outbreak in zone 2 from poaching

Calculations for this risk pathway are shown in Appendix M. The current risk of disease occurrence for SAT-type FMD is **negligible** with moderate uncertainty (Table 14). After fence removal alone, the risk would remain **negligible** but with high uncertainty. After fence removal with risk mitigation measures in place, the risk remains **negligible** with high uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from poaching at the Northern Buffalo fence is **low** with moderate or high uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

Table 14. Probability of occurrence for SAT-type FMD from poaching to cattle in zone 2 along the Northern Buffalo fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
Poacher crosses to zone 16 (P1A)	Moderate (moderate)	Moderate (high)	Moderate (moderate)
FMD host crosses to zone 2 (P1B)	Moderate (low)	High (low)	High (low)
Poaching in zone 16 (P2A)	Moderate (low)	Moderate (high)	Moderate (high)
Poaching in zone 2 (P2B)	Moderate (moderate)	Moderate (high)	Moderate (high)
Poached animal is viraemic (P3)	Very low (low)	Very low (low)	Very low (low)
Contamination of poacher with FMDV (P4)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Effective contact with cattle (P5)	Negligible (moderate)	Negligible (moderate)	Negligible (moderate)
Risk pathway in zone 16 (P1A, P2A, P3, P4, P5)	**Negligible (moderate)**	**Negligible (high)**	**Negligible (high)**
Risk pathway in zone 2 (P1B, P2B, P3, P4, P5)	**Negligible (moderate)**	**Negligible (high)**	**Negligible (high)**

3.4 Western Border fence assessment

3.4.1 Livestock disease prevalence and recent history

Within Botswana, this area of Ngamiland has experienced relatively few FMD outbreaks. Since 2007, there have been no outbreaks recorded in WAHIS in subzone 2a west of the Okavango River. Subzone 2b experienced an outbreak at Malatso in 2020 (see Figure 15), but this is far from the Western Border fence. A Botswana DVS map of outbreaks shows several crushes in subzone 2f as being part of outbreaks in 2009, although there are no coordinates of outbreaks from subzone 2f in WAHIS. For Namibia, there are no outbreaks of FMD or CBPP recorded in WAHIS for areas directly adjacent to the Western Border fence north of Dobe. There have been numerous CBPP outbreaks near the Namibia-Angola border in Kavango West Region, the closest being ~150 km from the fence.

3.4.2 Status of the fence

Time constraints did not allow for an in-person visit to this fence. Botswana maintains a double cordon fence which runs parallel to the international border, which is also fenced, but Namibia no longer maintains the stock- and game-proof fence on its side.

At the time of the phase 1 surveys in 2020, the fence on the Botswana side was undergoing maintenance and repairs, including the addition of a second cable. Heavy elephant pressure on this fence is responsible for damage. A June 2021 NAMBOT patrol found this fence in very good shape; a roan or sable antelope was observed caught in the fence at kilo 85. A subsequent March 2022 NAMBOT patrol noted major breaks where animals (it was not specified whether livestock or wildlife) were crossing from both sides, though these breaks were repaired. Ten Namibian cattle were also observed between the Botswana fences at Maronga adjacent to Khaudum National Park, but subsequently crossed back. The June 2022 North West District monthly report rated the Western Border fence as 3/5 condition with major breaks. In 2023, the entire length of the fence on the Botswana side from the southernmost point (at the junction with the Kuke fence) to the northern endpoint (at the junction with the Zambezi Border fence) adjacent to Khaudum National Park was reportedly undergoing complete rebuilding, with the old fence being removed by heavy machinery and being completely replaced. Several kilometre-long sections of the fence bordering southern Khaudum National Park were reported to be gone but not yet replaced in August 2023, with bush clearing having been undertaken for replacement fencing (P. Beytell, personal communication)

In early 2024, the fence adjacent to the central part of Khaudum National Park showed evidence of recent (within the last few years) repairs on the Botswana side but the fence on the Namibia side was reported to be almost non-existent (M. Hofmeyr, personal communication). Photographs show sections in similar condition to the Zambezi Border and Northern Buffalo fences as previously described, with some still upright but bush-encroached (Figure 22) and with others leaning or down completely (Figure 23). An elephant was observed crossing from Khaudum into Botswana (Figure 24).

Figure 22. Upright fence with bush encroachment on the Western Border fence adjacent to Khaudum National Park. Photo: Markus Hofmeyr.

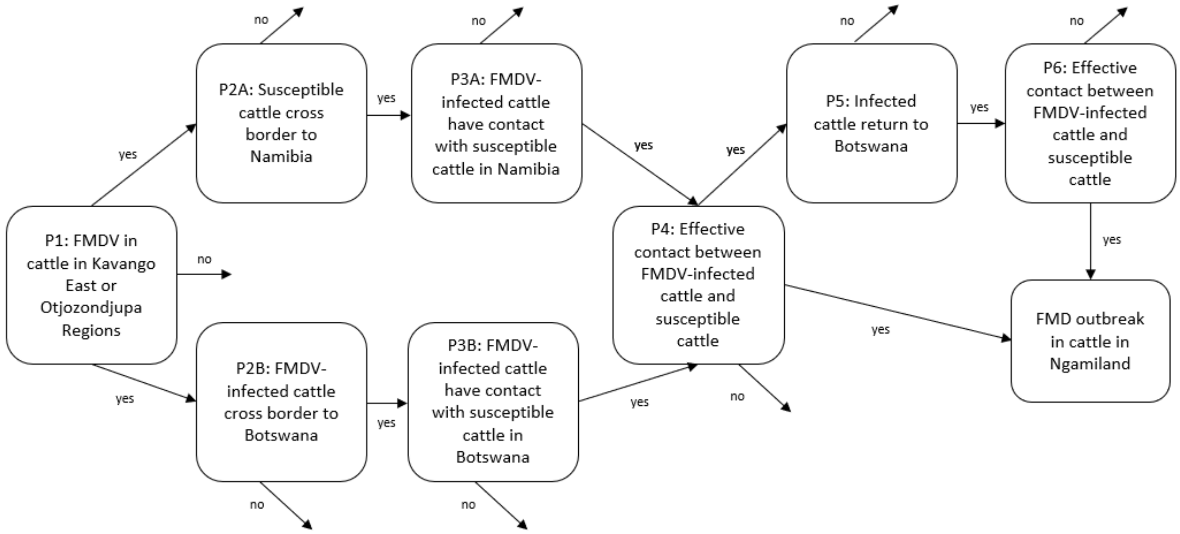
Figure 23. Partly down fence adjacent to Khaudum National Park. Photo: Markus Hofmeyr.

Figure 24. Elephant crossing dilapidated Western Border fence from Khaudum National Park into Ngamiland. Photo: Markus Hofmeyr.

3.4.3 Assessment of risk of SAT-type FMD outbreak in Botswana from Namibian cattle

3.4.3.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Botswana. The scenario tree (below) involves either cattle crossing the border from Namibia and having contact with cattle in Botswana, or cattle crossing the border to Namibia, having contact with cattle there, and returning to Botswana.



3.4.3.2 Probability of occurrence assessment

P1: SAT-type FMDV in cattle in Kavango East or Otjozondjupa Regions

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: In Namibia's FMD protection zone, which extends west of the Kavango River at Divundu and above the Veterinary Cordon Fence (known as the Red Line), cattle in high-risk areas are vaccinated bi-annually against SAT-type FMDV. High-risk areas are those within 30 km of the border. At least 85% of the target cattle population in Namibia was vaccinated against FMD in the last three years, but PVM is not being achieved regularly to ensure adequate protection (European Commission 2022). A total of 217,549 doses were administered in Kavango East Region in 2022, while none had been administered by mid-2023. The livestock census in 2021 recorded 109,912 cattle in Kavango East and 9,924 in Otjozondjupa, and the most recent outbreaks of SAT-type FMD in Kavango East Region have involved relatively few cases (e.g. 68 cases across 3 regions in 2020). FMD serosurveillance in the entire NCA in 2020 found that 84/420 (20%) of samples were positive for antibodies to FMDV whereas only 4/902 (0.4%) samples from 2022 were positive.
- Remove fence section: Removing the fence section would be unlikely to affect the risk of SAT-type FMDV in cattle in Kavango East or Otjozondjupa Regions.
- Remove fence section with risk mitigation: Maintaining high vaccination coverage in the Kavango East Region would reduce the risk of cattle infections nearby, although appropriate PVM should be implemented to ensure this.

P2A: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: On the Namibian side, Khaudum National Park's western border with commercial farms is fenced. *Dichapetalum cymosum* (gifblaar in Afrikaans or mogau in Setswana), a toxic plant, is prevalent in the northern soils of Khaudum National Park and serves as a deterrent to cattle (Ministry of Environment, Forestry and Tourism 2020). There are occasional cattle incursions from Botswana; in 2022, 31 cattle from Botswana were contained at kilometre 105 of the fence and in 2023, there was one incursion reported to Botswana DVS, where 27 cattle crossed at Phalaphala and strayed 40 km into Otjozondjupa Region near Dobe and were destroyed. In 2024, 12 cattle crossed at Magopa and were rounded up in Namibia. Phase 1 ground surveys in 2020 found continuous livestock presence near the Western Border fence north and south of Samochima fence, a small area south of the Ikoga fence, and near Xaranxago and Dobe. In general, however, livestock distribution was limited, with permanent cattle presence only recorded along ~18% of the northern section down to Dobe, which lies within KAZA (Atkinson et al. 2022). A 2022 NAMBOT patrol found evidence of cattle crossing in both directions at fence breaks in multiple places along the Khaudum National Park border. This fence has had more recent maintenance work and only ~13% of attempted herbivore crossings detected in the phase 1 surveys were successful (Atkinson et al. 2022), although major repairs were reported to be underway in 2023 with large sections of the fence missing (P. Beytell, personal communication).
- Remove fence section: Removing sections of the fence would be unlikely to significantly change the risk of cattle coming across the border, given the limited number of cattle near the fence sections in Botswana. Evidence of continuous cattle presence near the fence was not near the sections proposed for removal (Atkinson et al. 2022). The poor condition of the fence means that the border is already semi-permeable; illegal cattle movement could increase without the psychological barrier of a fence, but this area is remote and inhospitable for trekking cattle.
- Remove fence section with risk mitigation: In addition to the above, active herding techniques from the H4H model would mean that cattle movements are better controlled to avoid crossing the border.

P2B: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: There are few cattle in close proximity to the Namibian side of the fence. Cattle are not permitted in Khaudum National Park, and none were observed in the park during an aerial survey in 2019 (Craig and Gibson 2019) although they have occasionally been seen on other surveys (Ministry of Environment, Forestry and Tourism 2020). In 2022, 32 Namibian cattle from the CBPP protection zone crossed the fence near Kilo 105 on the border with Khaudum National Park and were later repatriated. There was another incursion of 6 Namibian cattle from the CBPP protection zone into Ghani extension area at Zao in 2022. There are commercial cattle farms west of Khaudum National Park. The cattle population in Nyae Nyae Conservancy is 1,126 (L. Hanssen, unpublished data), with only one cattlepost close (<10 km) to the fence. There are no cattleposts in the far northeast corner adjacent to one of the sections of the Western Border fence being evaluated for fence removal. Of four security agents interviewed near this fence, three had not seen Namibian cattle near the fence, although they had been deployed there for less than a year (N. Babayani, unpublished data). Cattle were seen crossing from Namibia on a 2022 NAMBOT patrol along the Khaudum National Park border.
- Remove fence section: Removing sections of the fence would be unlikely to significantly change the risk of cattle coming across the border, given the limited number of cattle near the fence in Namibia.
- Remove fence section with risk mitigation*:* There are plans to add a cable to the fence on the western border of Khaudum National Park to prevent incursions from the neighbouring cattle farms (L. Hanssen, personal communication). Application of H4H and/or kraaling would limit uncontrolled cattle movements.

P3A: Contact between susceptible cattle from Botswana and infected cattle in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Cattle from Botswana that enter Namibia through Khaudum National Park would be unlikely to encounter other cattle in the park and would be unlikely to make it as far west as the farms west of Khaudum due to the park and farms being separated by a fence. There is a possibility of encountering cattle in Nyae Nyae Conservancy, although they are present at low density and concentrated away from the fence, as observed during the KAZA Elephant Survey (Bussière and Potgieter 2023a).
- Remove fence section: Removing sections of the fence would not change the risk of contact after the border has already been crossed.
- Remove fence section with risk mitigation: If cattle strayed across the border to Namibia, they would not be under active herding and the risk would be as described above.

P3B: Contact between infected cattle from Namibia and susceptible cattle in Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Cattle crossing from Namibia could encounter cattle in Botswana in some areas near the fence; Phase 1 ground surveys in 2020 found continuous livestock presence near the Western Border fence north and south of Samochima fence, a small area south of the Ikoga fence, and near Xaranxago and Dobe. In general, however, livestock distribution was limited, with permanent cattle presence only affecting about 18% of the fence, i.e. of the part down to Dobe, which lies within KAZA (Atkinson et al. 2022). Zone 2f as a whole is sparsely populated with cattle due to the presence of mogau.
- Remove fence section: See justification for P3A above.
- Remove fence section with risk mitigation: Active herding techniques under H4H would limit contact with any stray cattle from Namibia.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Cattle vaccination rates in western Ngamiland during the October 2022 vaccination campaign were below the target of 85%, with 80% coverage in Chukumuchu and 73% in Ghani extension areas. Subzone 2f is in the process of stopping vaccination to apply for freedom from FMD without vaccination. In the last six vaccine campaigns, overall coverage in Ngamiland ranged from 75-86%. PVM samples from Ngamiland in June and December 2022 showed poor coverage (<85%) for all SAT serotypes. Effectiveness of the vaccine has been estimated as 78% previously (Babayani and Tholowane 2022).
- Remove fence section: Removing sections of the fence would not change the risk of effective contact after the border has already been crossed.
- Remove fence section with risk mitigation: Active herding techniques, improved animal health and higher vaccination coverage of cattle in the H4H model would lower the risk of effective contact.

P5: Cattle return to Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**

Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: If discovered, cattle that have crossed to Namibia are destroyed rather than repatriated to avoid the risk of CBPP and other diseases. Cattle that are undetected may cross or be herded back to Botswana, although there is a high density of predators. The fence is semi-permeable and could be crossed if cattle were able to return through Khaudum National Park or Nyae Nyae Conservancy.
- Remove fence section: Removing sections of the fence would make it marginally easier to cross the border by the lack of a fence, but cattle would still need to navigate through Khaudum National Park or Nyae Nyae Conservancy to return from contacting cattle in Namibia.
- Remove fence section with risk mitigation: Cattle under H4H should not be herded back to Botswana to have contact with the rest of the herding group.

P6: Effective contact between susceptible and infected cattle after returning to Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: See justification for P4 above. Strain characterisation data from Ngamiland suggest that recent outbreak strains circulate independently in cattle, where contact levels are considered to be high enough to sustain FMDV circulation.
- Remove fence section: Removing sections of the fence would not affect effective contact after returning to Botswana.
- Remove fence section with risk mitigation: Improved animal health and higher vaccination coverage of cattle in the H4H model would raise individual immunity.

3.4.3.3 Risk estimation of SAT-type FMD outbreak in Botswana from Namibian cattle

Calculations for this risk pathway are shown in Appendix N. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 15). After fence removal alone or with risk mitigation measures in place, the risk remains **very low** with moderate or high uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from cattle at the Western Border fence is **low** with moderate or high uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

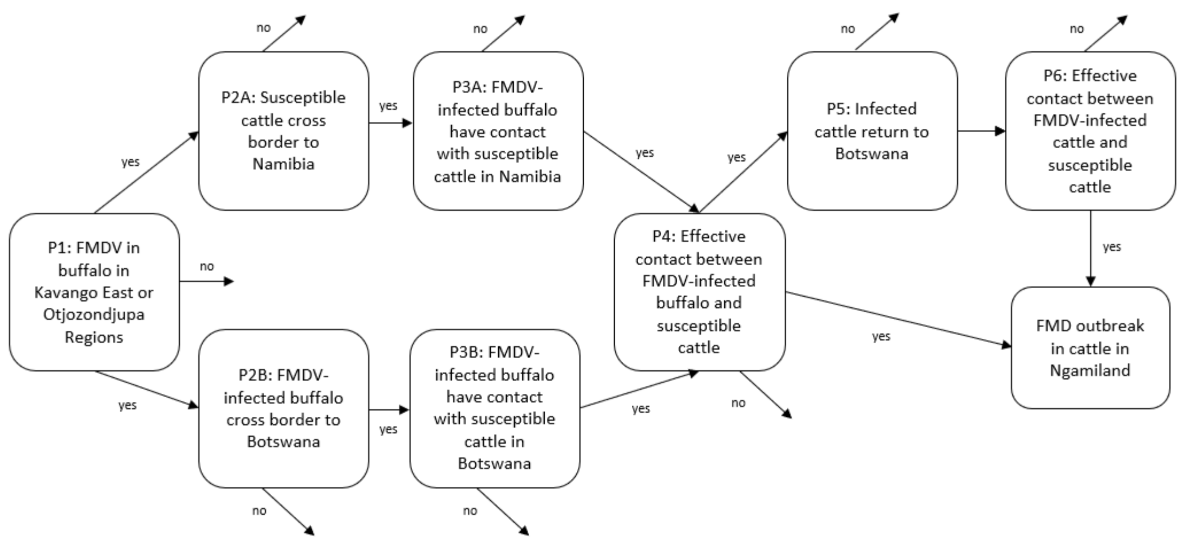
Table 15. Probability of occurrence for SAT-type FMD from cattle in Namibia to cattle in Botswana along the Western Border fence

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
FMDV in cattle in Namibia (P1)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (high)	Very low (moderate)
Cattle cross to Botswana (P2B)	Low (moderate)	Very low (moderate)	Very low (moderate)
Cattle have contact with cattle in Namibia (P3A)	Low (moderate)	Low (moderate)	Low (moderate)
Cattle have contact with cattle in Botswana (P3B)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P4)	High (low)	High (low)	Moderate (moderate)
Cattle return to Botswana (P5)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Moderate (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (high)**	**Very low (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**

3.4.4 Assessment of risk of SAT-type FMD outbreak in Botswana from Namibian buffalo

3.4.4.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Botswana. The scenario tree (below) involves either buffalo crossing the Botswana-Namibia border and having contact with cattle, or cattle crossing the border, having contact with buffalo, and returning to Botswana.



3.4.4.2 Probability of occurrence assessment

P1: SAT-type FMDV in buffalo in Kavango East or Otjozondjupa Regions

Risk (uncertainty)

Status quo: **negligible (low)**
Remove fence section: **negligible (low)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: In this area of Namibia, buffalo only occur in a fenced camp near Tsumkwe within Nyae Nyae Conservancy. This herd was FMDV negative when first placed at the camp and is routinely tested, with negative results (Musilika-Shilongo et al. 2022). During aerial surveys of Khaudum National Park and Nyae Nyae Conservancy in 2019 there were only three sightings of buffalo, all within the fenced camp at Tsumkwe (Craig and Gibson 2019).
- Remove fence section: Removing sections of the Western Border fence would not affect the risk of SAT-type FMDV in the Tsumkwe buffalo herd.
- Remove fence section with risk mitigation: Given that this herd of buffalo is FMD-free, **no additional risk mitigation is required**. The herd should continue to be tested to ensure no introduction of FMDV has occurred, as infected buffalo may not show clinical signs of disease, and the camp fences should be maintained against elephant damage. However, the Khaudum National Park Management Plan indicates that the park has the potential to establish buffalo populations (Ministry of Environment, Forestry and Tourism 2020); any introduction of buffalo into the park would require careful planning for disease management purposes.

P2A: Cattle crossing to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.4.3.2.
- Remove fence section: See justification for P2A in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.4.3.2.

P2B: Buffalo crossing to Botswana

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Buffalo only occur within the fenced camp at Tsumkwe. Buffalo typically avoid the fence as the inner fence is electrified. For buffalo to escape would require a breach in the fence, which occasionally occurs due to elephant damage (T. Pietersen, personal communication). Escaped buffalo are shot on sight and not allowed to return to the camp (T. Pietersen, personal communication). If undetected, a buffalo would then need to make its way to the Western Border fence and successfully cross it. Of four security agents interviewed near this fence, none had seen buffalo near the fence, although three had been deployed there for less than a year (N. Babayani, unpublished data).

- Remove fence section: Removing sections of the fence would not meaningfully change the risk of buffalo crossing to Botswana, as they are unlikely to escape the buffalo camp in the first place.
- Remove fence section with risk mitigation: Continued maintenance of the buffalo camp fence against elephant damage is important for preventing buffalo escapes, although this is an FMD-free herd.

P3A: Buffalo-cattle contact in Namibia

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: Botswana cattle crossing into Namibia would need to traverse Nyae Nyae Conservancy and breach the game fence around the buffalo camp at Tsumkwe to potentially have contact with buffalo in this area. Buffalo typically avoid the fence as the inner fence is electrified (T. Pietersen, personal communication).
- Remove fence section: Removing sections of the Western Border fence would not affect the risk of buffalo-cattle contact within Namibia.
- Remove fence section with risk mitigation: Continued monitoring and maintenance of the game fence around the buffalo camp would prevent contact if stray cattle were present.

P3B: Buffalo-cattle contact in Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: The area east of Nyae Nyae Conservancy within Botswana has few cattleposts where buffalo might encounter cattle.
- Remove fence section: Removing sections of the Western Border fence would not affect the risk of buffalo-cattle contact within Botswana.
- Remove fence section with risk mitigation: Implementation of H4H would reduce the risk of cattle-buffalo contact by direct avoidance of buffalo.

P4: Effective contact between FMDV-infected buffalo and susceptible cattle

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Studies in the southern African region have indicated that transmission of FMDV from buffalo to cattle is relatively rare (see section 3.1.4.2).
- Remove fence section: Removing sections of the Western Border fence would not affect effective buffalo-cattle contact.
- Remove fence section with risk mitigation: Implementation of H4H would reduce the risk of cattle-buffalo contact by direct avoidance of buffalo. Cattle under H4H are likely to be in better physical condition and immune status. They are also required to be vaccinated, and an efficacious vaccine with high coverage would offer protection.

P5: Cattle return to Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P5 in section 3.4.3.2.
- Remove fence section: See justification for P5 in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.4.3.2.

P6: Effective contact between susceptible and infected cattle in Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: See justification for P6 in section 3.4.3.2.
- Remove fence section: See justification for P6 in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P6 in section 3.4.3.2.

3.4.4.3 Risk estimation of SAT-type FMD outbreak in Botswana from Namibian buffalo

Calculations for this risk pathway are shown in Appendix O. The current risk of disease occurrence for SAT-type FMD is **negligible** with moderate uncertainty (Table 16). After fence removal alone or with risk mitigation measures in place, the risk would remain **negligible** with moderate or high uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from buffalo at the Western Border fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

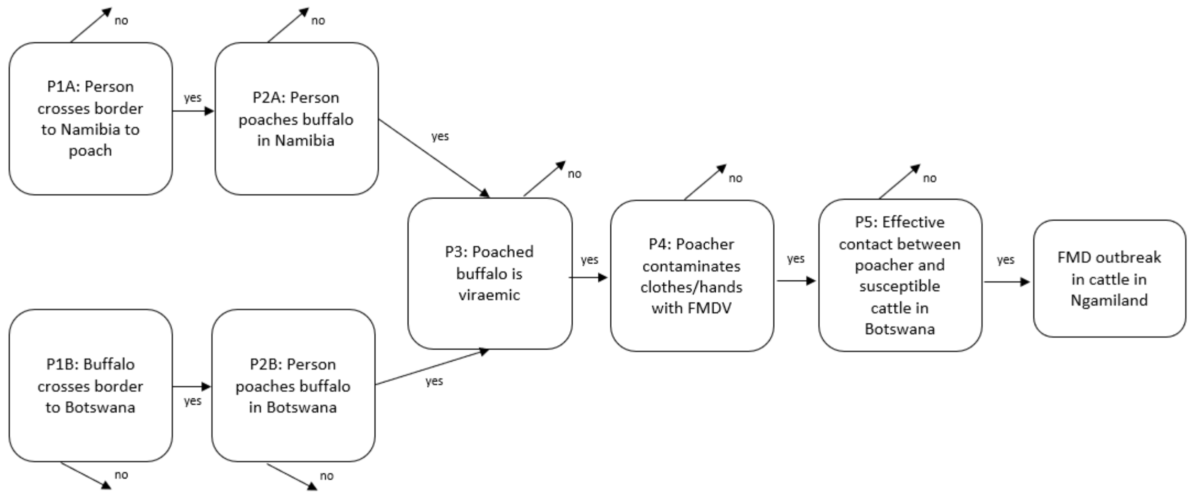
Table 16. Probability of occurrence for SAT-type FMD from buffalo in Namibia to cattle in Botswana along the Western Border fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
FMDV excretion by buffalo (P1)	Negligible (low)	Negligible (low)	Negligible (low)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (high)	Very low (low)
Buffalo cross to Botswana (P2B)	Very low (low)	Very low (moderate)	Very low (moderate)
Buffalo contact cattle in Namibia (P3A)	Very low (low)	Very low (low)	Very low (low)
Buffalo contact cattle in Botswana (P3B)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Effective buffalo-cattle contact (P4)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle return to Botswana (P5)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Low (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Negligible (moderate)**	**Negligible (high)**	**Negligible (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Negligible (moderate)**	**Negligible (moderate)**	**Negligible (moderate)**

3.4.5 Assessment of risk of SAT-type FMD outbreak in Botswana from poaching

3.4.5.1. Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Botswana. The scenario tree (below) involves either a poacher crossing the Botswana-Namibia border and poaching a buffalo in Namibia or poaching a buffalo after it crossed the Botswana-Namibia border, followed by the poacher having contact with cattle in Botswana.



3.4.5.2 Probability of occurrence assessment

P1A: Poacher crossing to Namibia

Risk (uncertainty)

Status quo: **moderate (low)**
Remove fence section: **moderate (high)**
Remove fence section with risk mitigation: **moderate (high)**

Justification:

- <u>Status quo</u>: There is some bushmeat poaching in Khaudum National Park from Ngamiland, although this has tended to be giraffe and oryx (P. Beytell, personal communication). Poaching is more likely to occur in Khaudum National Park than in Nyae Nyae Conservancy, given the former's remote location where poaching is less likely to be detected (P. Beytell, personal communication).
- <u>Remove fence section</u>: Discussions among the core group of experts noted that poaching risk wasn't that relevant to the presence of the fence, as it happens regardless. There may be some psychological impact of a fence that acts as a deterrent to some poachers, so that the risk of poaching could increase if this deterrent is removed.
- <u>Remove fence section with risk mitigation</u>: Maintaining a strong anti-poaching presence would be the most effective mitigation measure to reduce the risk of poaching.

P1B: Buffalo crossing to Botswana

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: Status quo: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.4.2.
- Remove fence section: See justification for P2B in section 3.4.4.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.4.1.2.

P2A: Buffalo being poached in Namibia

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: There are no free-ranging buffalo resident in this area of Namibia. The only buffalo are the FMD-free herd in the fenced camp at Tsumkwe, which are protected by an electric fence.
- Remove fence section: Removing sections of the Western Border fence will not impact the risk of a buffalo being poached in Namibia.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step.

P2B: Buffalo being poached in Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Buffalo occasionally enter this part of Ngamiland while migrating from the delta or Namibia but are not typically permanent residents and would not easily be targeted by poachers. However, the poor response time to buffalo incursion reports has disincentivized reporting and some interviewees noted that farmers may poach a buffalo to remove it as a potential FMD risk (N. Babayani, unpublished data).
- Remove fence section: In this step, the presence or absence of the fence does not influence the behaviour of the poacher, as the buffalo is being poached inside the country.
- Remove fence section with risk mitigation: See justification for P1A above.

P3: Buffalo being viraemic

Risk (uncertainty)

Status quo: **negligible (low)**
Remove fence section: **negligible (low)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: The buffalo herd at Tsumkwe is FMD-free; wildlife in the Namibia's FMD protection zone are thought to pose an insignificant risk of an FMD outbreak (Musilika-Shilongo et al. 2022).
- Remove fence section: Removing sections of the fence will not impact the risk of a buffalo being viraemic.
- Remove fence section with risk mitigation: Ensuring maintenance of the fences around the buffalo camp at Tsumkwe is the best measure to prevent contact with stray buffalo or cattle that may transmit FMDV.

P4: Contamination of poacher with FMDV

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Spread of FMDV as a result of contamination is unlikely (see section 3.1.5.2).
- Remove fence section: Removing sections of the fence will not impact the risk of a poacher becoming contaminated with virus.
- Remove fence section with risk mitigation: There are no practical interventions to improve hygiene during and after poaching.

P5: Effective contact between poacher and cattle

Risk (uncertainty)

Status quo: **negligible (moderate)**
Remove fence section: **negligible (moderate)**
Remove fence section with risk mitigation: **negligible (moderate)**

Justification:

- Status quo: Infection by handling cattle is not considered probable according to previous risk assessments (see section 3.1.5.3).
- Remove fence section: Removing sections of the fence will not impact the risk of effective contact between a poacher and cattle.
- Remove fence section with risk mitigation: See justification for P4 above.

3.4.5.3 Risk estimation of SAT-type FMD outbreak in Botswana from poaching

Calculations for this risk pathway are shown in Appendix P. The current risk of disease occurrence for SAT-type FMD is **negligible** with moderate uncertainty (Table 17). After fence removal alone or with risk mitigation measures in place, the risk would remain **negligible** but with moderate or high uncertainty. After fence removal with risk mitigation measures in place, the risk remains **negligible** with moderate or high uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from poaching at the Western Border fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

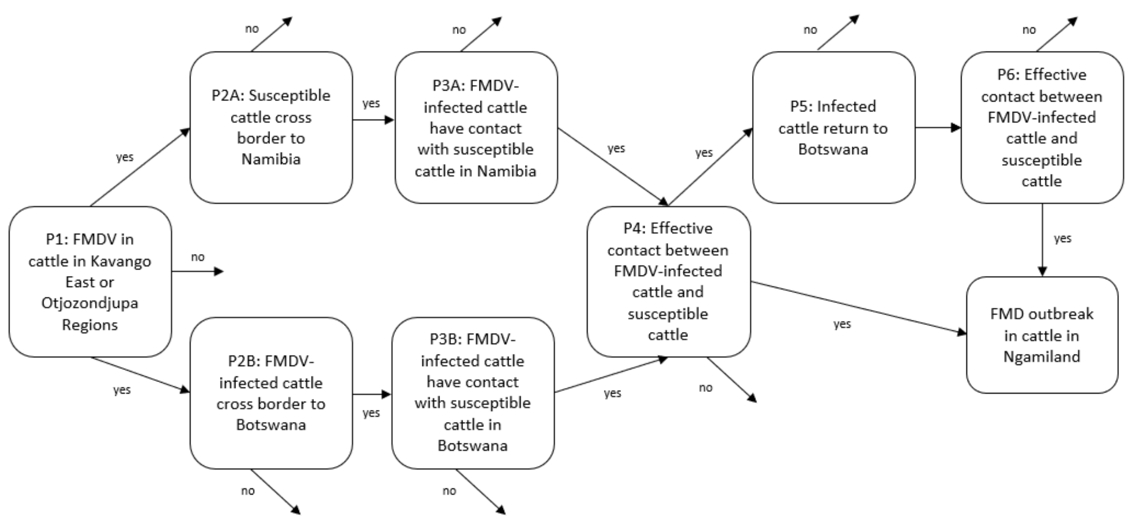
Table 17. Probability of occurrence for SAT-type FMD from poaching to cattle in Botswana along the Western Border fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
Poacher crosses to Namibia (P1A)	Moderate (low)	Moderate (high)	Moderate (high)
FMD host crosses to Botswana (P1B)	Very low (low)	Very low (moderate)	Very low (moderate)
Poaching in Namibia (P2A)	Very low (low)	Very low (low)	Very low (low)
Poaching in Botswana (P2B)	Low (moderate)	Low (moderate)	Low (moderate)
Poached animal is viraemic (P3)	Negligible (low)	Negligible (low)	Negligible (low)
Contamination of poacher with FMDV (P4)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Effective contact with cattle (P5)	Negligible (moderate)	Negligible (moderate)	Negligible (moderate)
Risk pathway in Namibia (P1A, P2A, P3, P4, P5)	**Negligible (moderate)**	**Negligible (high)**	**Negligible (high)**
Risk pathway in Botswana (P1B, P2B, P3, P4, P5)	**Negligible (moderate)**	**Negligible (moderate)**	**Negligible (moderate)**

3.4.6 Assessment of risk of FMD serotype O outbreak in Botswana from Namibian cattle

3.4.6.1 Hazard identification and scenario tree

The hazard for this assessment is FMDV serotype O causing FMD in cattle in Botswana. The scenario tree (below) involves either cattle crossing the border from Namibia and having contact with cattle in Botswana, or cattle crossing the border to Namibia, having contact with cattle there, and returning to Botswana.



3.4.6.2 Probability of occurrence assessment

P1: FMDV serotype O in cattle in Kavango East or Otjozondjupa Regions

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Cattle in Kavango East and Otjozondjupa Regions are not currently vaccinated against FMDV serotype O and these regions have never had an outbreak of serotype O. These regions are not perceived to be at the highest risk of introduction of serotype O given their distance from Zambia, where serotype O would be most likely to originate from if re-introduced.
- Remove fence section: Removing sections of the fence would not affect the risk of FMDV serotype O in Kavango East or Otjozondjupa Regions.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step, as cattle in this region are not currently vaccinated against FMDV serotype O.

P2A: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.4.3.2.
- Remove fence section: See justification for P2A in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.4.3.2.

P2B: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.3.2.
- Remove fence section: See justification for P2B in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.4.3.2.

P3A: Contact between susceptible cattle from Botswana and infected cattle in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3A in section 3.4.3.2.
- Remove fence section: See justification for P3A in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P3A in section 3.4.3.2.

P3B: Contact between infected cattle from Namibia and susceptible cattle in Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3B in section 3.4.3.2.
- Remove fence section: See justification for P3B in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P3B in section 3.4.3.2.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Cattle in this area are not vaccinated against FMDV serotype O and have no natural immunity to this serotype and would therefore be completely susceptible.
- Remove fence section: Removing sections of the fence would not affect the risk of effective contact between cattle.
- Remove fence section with risk mitigation*:* Adding FMD serotype O to the vaccine used in cattle at crushes in high-risk border areas would offer significant added protection to these animals. Given the higher cost of using a quadrivalent vaccine rather than the standard trivalent vaccine, select crushes could be identified by Botswana's epidemiological team, in conjunction with counterparts in Namibia, to target the cattle thought to be most at risk. Active herding techniques and improved animal health in the H4H model would lower the risk of effective contact.

P5: Cattle crossing back to Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P5 in section 3.4.3.2.
- Remove fence section: See justification for P5 in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.4.3.2.

P6: Effective contact between susceptible and infected cattle after returning to Botswana

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: See justification for P6 in section 3.4.3.2.
- Remove fence section: See justification for P6 in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P6 in section 3.4.3.2.

3.4.6.3 Risk estimation of FMD serotype O outbreak in Botswana from Namibian cattle

Calculations for this risk pathway are shown in Appendix Q. The current risk of disease occurrence for FMD serotype O is **very low** with moderate uncertainty (Table 18). After fence removal alone or with risk mitigation measures in place, the risk would remain **very low** with moderate or high uncertainty. In combination with the perceived consequences (**high** magnitude with low uncertainty), the final risk estimate for FMD serotype O from cattle at the Western Border fence is **low** with moderate or high uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation.

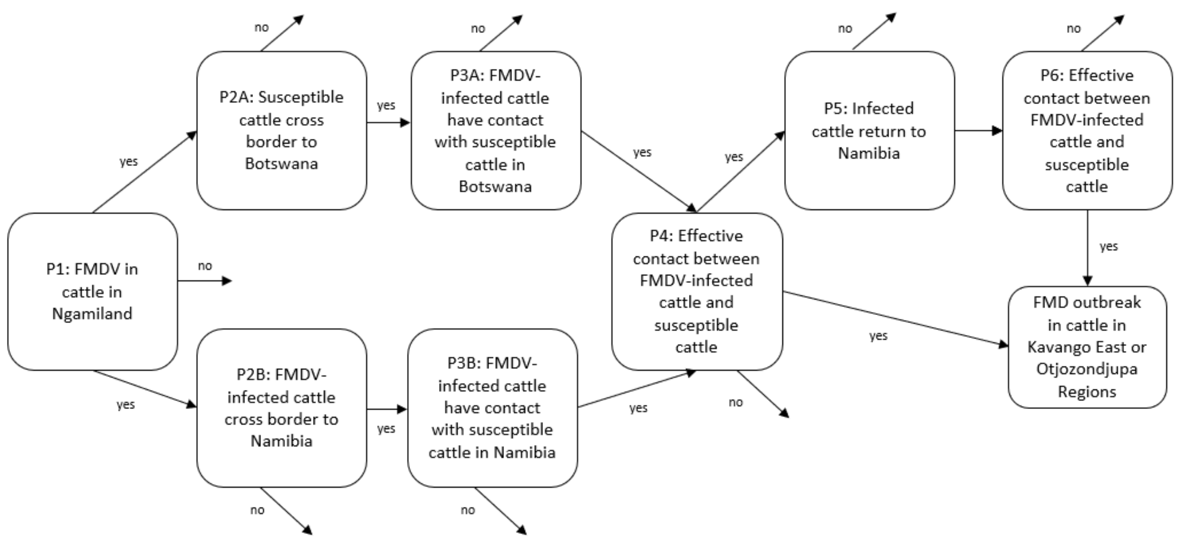
Table 18. Probability of occurrence for FMD serotype O from cattle in Namibia to cattle in Botswana along the Western Border fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
FMDV in cattle in Namibia (P1)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (high)	Very low (moderate)
Cattle cross to Botswana (P2B)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle have contact with cattle in Namibia (P3A)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle have contact with cattle in Botswana (P3B)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P4)	High (low)	High (low)	Moderate (moderate)
Cattle return to Botswana (P5)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	Moderate (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (high)**	**Very low (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**

3.4.7 Assessment of risk of SAT-type FMD outbreak in Namibia from Botswana cattle

3.4.7.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Namibia. The scenario tree (below) involves either cattle crossing the border from Botswana and having contact with cattle in Namibia, or cattle crossing the border to Botswana, having contact with cattle there, and returning to Namibia.



3.4.7.2 Probability of occurrence assessment

P1: SAT-type FMDV in cattle in Ngamiland near Western Border fence

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**

Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: Cattle vaccination rates in western Ngamiland during the October 2022 vaccination campaign were below the target of 85%, with 80% coverage in Chukumuchu and 73% in Ghani extension areas. The three fence sections proposed for removal border subzones 2a, 2b, and 2f. Subzone 2a experienced outbreaks in 2008, 2014, and 2020, while subzone 2b only experienced an outbreak in 2020. The southern-most fence section proposed for removal lies adjacent to subzone 2f, which the Government of Botswana is in the process of applying to WOAH for official FMD-free without vaccination status. No outbreaks have been recorded in zone 2f in WAHIS from 2007 to present. The subzone is sparsely populated with cattle due to the presence of *Dichapetalum cymosum* (gifblaar in Afrikaans or mogau in Setswana), which is highly toxic to cattle.
- Remove fence section: Removing sections of the fence would be unlikely to affect the risk of SAT-type FMDV in cattle near the fence.
- Remove fence section with risk mitigation: Subzone 2f will not be vaccinated under plans to convert it to a protection zone. Surveillance in the area will be an important part of maintaining its status as a protection zone. Maintaining consistent high vaccination coverage in subzones 2a and 2b with a vaccine that matches circulating strains along with PVM to confirm protection would lower the risk of FMDV.

P2A: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.3.2.
- Remove fence section: See justification for P2B in section 3.4.3.2.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step. Implementation of H4H on the Namibian side of the fence would reduce the risk of cattle crossing into Botswana.

P2B: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.4.3.2.
- Remove fence section: See justification for P2A in section 3.4.3.2.

- Remove fence section with risk mitigation: In addition to the above, active herding techniques from the H4H model would mean that cattle movements are better controlled to avoid crossing the border.

P3A: Contact between susceptible and infected cattle in Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3B in section 3.4.3.2.
- Remove fence section: See justification for P3B in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P3B in section 3.4.3.2.

P3B: Contact between susceptible and infected cattle in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: See justification for P3A in section 3.4.3.2.
- Remove fence section: See justification for P3A in section 3.4.3.2.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step. Implementing H4H on the Namibian side would reduce the risk of contact with cattle outside the herding group.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: Cattle in close proximity to the Western Border fence largely fall outside the high-risk area within 30 km of the Angolan border and are therefore not vaccinated against SAT-type FMDV, per the policy for the FMD protection zone.
- Remove fence section: Removing sections of the fence would not change the risk of effective contact after the border has already been crossed.

- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step. Even if H4H were implemented on the Namibian side, cattle in most of this area would remain unvaccinated against SAT-type FMDV based on DVS policy.

P5: Cattle return to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: If discovered, cattle that have crossed to Botswana are repatriated. Cattle that are undetected may cross or be herded back to Namibia.
- Remove fence section: Removing sections of the fence would make it marginally easier to cross the border by the lack of a fence, but cattle would still need to navigate through Khaudum National Park or Nyae Nyae Conservancy to return from contacting cattle in Botswana.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step. If H4H were implemented on the Namibian side, cattle should not be herded back to Namibia to have contact with the rest of the herding group.

P6: Effective contact between susceptible and infected cattle after returning to Namibia

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: See justification for P4 above.
- Remove fence section: Removing sections of the fence would not affect effective contact after returning from Botswana.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step. If H4H were implemented on the Namibian side of the fence, repatriated cattle should be isolated for a period after returning from Botswana because most cattle near the fence would not undergo SAT-type FMDV vaccination and would therefore be likely to have effective contact when herded and kraaled together.

3.4.7.3 Risk estimation risk of SAT-type FMD outbreak in Namibia from Botswana cattle

Calculations for this risk pathway are shown in Appendix R. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 19). After removal alone or with risk mitigation measures in place, the risk remains **very low** with moderate or high uncertainty. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for Namibia for SAT-type FMD from cattle at the Western Border fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

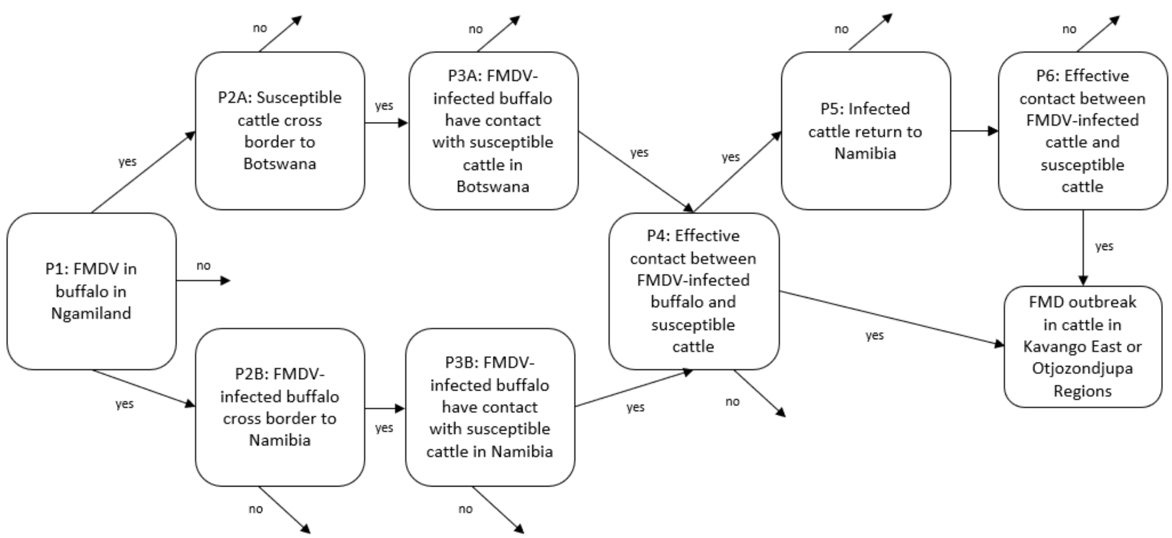
Table 19. Probability of occurrence for SAT-type FMD from cattle in Botswana to cattle in Namibia along the Western Border fence.

Pathway Step	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
		Risk (uncertainty)	
FMDV in cattle in Botswana (P1)	Very low (low)	Very low (low)	Very low (low)
Cattle cross to Botswana (P2A)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle cross to Namibia (P2B)	Low (moderate)	Low (high)	Very low (moderate)
Cattle have contact with cattle in Botswana (P3A)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Cattle have contact with cattle in Namibia (P3B)	Low (moderate)	Low (moderate)	Low (moderate)
Effective contact between cattle (P4)	High (low)	High (low)	High (low)
Cattle return to Namibia (P5)	Low (moderate)	Low (moderate)	Low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	High (low)
Risk pathway in Botswana (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**
Risk pathway in Namibia (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (high)**	**Very low (moderate)**

3.4.8 Assessment of risk of SAT-type FMD outbreak in Namibia from Botswana buffalo

3.4.8.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Namibia. The scenario tree (below) involves either buffalo crossing the Botswana-Namibia border and having contact with cattle, or cattle crossing the border, having contact with buffalo, and returning to Namibia.



3.4.8.2 Probability of occurrence assessment

P1: SAT-type FMDV excreted by buffalo in Ngamiland

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Buffalo are the natural host of SAT-type FMDV and are almost invariably serologically positive for antibodies to FMDV throughout the region but transmission from adult buffalo to cattle is considered to be inefficient (see section 3.1.3).
- Remove fence section: Removing sections of the fence will not impact the prevalence of FMDV infection in buffalo, and the risk of FMDV infection and excretion by free-ranging buffalo is considered equivalent in Botswana and Namibia.
- Remove fence section with risk mitigation: There are no practical interventions to reduce prevalence of FMDV in the free-ranging buffalo population.

P2A: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.3.2.
- Remove fence section: See justification for P2B in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.4.3.2.

P2B: Buffalo crossing to Namibia

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Buffalo were not observed in Ngamiland adjacent to Khaudum National Park or Nyae Nyae Conservancy during the KAZA Elephant Survey (Bussière and Potgieter 2023b), but they have been recorded dispersing from Bwabwata National Park through Khaudum (Naidoo et al. 2014; Ministry of Environment, Forestry and Tourism 2020). Buffalo spoor was noted during Phase 1 2020 ground surveys along the fence, although no (n = 0/12) successful fence crossings were observed

(Atkinson et al. 2022). There are occasional incursions (perhaps 2–3/yr) of buffalo from Botswana along this area of the fence (P. Beytell, personal communication).

- Remove fence section: Wildlife have been shown to return to crossing after fence removal (Arthur Albertson Consulting (Pty) Ltd 2005), so buffalo crossings would be expected to increase.
- Remove fence section with risk mitigation: Restoration of wildlife corridor connectivity is the goal of fence removal, so increased wildlife movements are to be expected and efforts to inhibit movement of buffalo would be counterproductive.

P3A: Buffalo-cattle contact in Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Contact between buffalo and cattle is usually limited and unlikely to be direct (section 3.1.4.1 provides additional information). Buffalo were not observed in Ngamiland adjacent to Khaudum National Park or Nyae Nyae Conservancy during the KAZA Elephant Survey (Bussière and Potgieter 2023b), but have been recorded dispersing from Bwabwata National Park through Khaudum (Naidoo et al. 2014; Ministry of Environment, Forestry and Tourism 2020). Buffalo would not normally be resident in this area so only dispersing animals would be occasionally expected in this region.
- Remove fence section: Removing sections of the fence would not affect buffalo-cattle contact in Botswana.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed in this step.

P3B: Buffalo-cattle contact in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: Khaudum National Park is intended to be free of cattle, although aerial surveys occasionally show cattle inside the park (Ministry of Environment, Forestry and Tourism 2020; Bussière and Potgieter 2023b). There are cattle in Nyae Nyae Conservancy, although there are few in the sections bordering the fence (Bussière and Potgieter 2023b). Occasional long-range movements of buffalo through the border have been recorded, including some which travelled from Bwabwata National Park through Botswana into Khaudum National Park, then up to Angola and down to central Namibia (Naidoo et al. 2014). It is therefore possible that buffalo could contact cattle in areas far from the fence.

- Remove fence section: Removing sections of the fence would not affect the risk of buffalo-cattle contact within Namibia.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed in this step. Implementing H4H on the Namibian side of the fence would reduce contact with buffalo.

P4: Effective contact between FMDV-infected buffalo and susceptible cattle

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Studies in the southern African region have indicated that transmission of FMDV from buffalo to cattle is relatively rare (see section 3.1.4.2).
- Remove fence section: Removing sections of the fence will not affect effective buffalo-cattle contact.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step.

P5: Cattle return to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: If discovered, cattle that have crossed to Botswana are repatriated. Cattle that are undetected may cross or be herded back to Namibia.
- Remove fence section: See justification for P5 in section 3.4.7.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.4.7.2.

P6: Effective contact between infected and susceptible cattle in Namibia

Risk (uncertainty)

Status quo: **high (low)**
Remove fence section: **high (low)**
Remove fence section with risk mitigation: **high (low)**

Justification:

- Status quo: See justification for P4 in section 3.4.7.2.
- Remove fence section: Removing sections of the fence would not affect the risk of effective contact within Namibia.
- Remove fence section with risk mitigation: See justification for P6 in section 3.4.7.2.

3.4.8.3 Risk estimation of SAT-type FMD outbreak in Namibia from Botswana buffalo

Calculations for this risk pathway are shown in Appendix S. The current risk of disease occurrence for SAT-type FMD is **very low** with moderate uncertainty (Table 20). After fence removal alone or with risk mitigation measures in place, the risk remains **unchanged**. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from buffalo at the Western Border fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

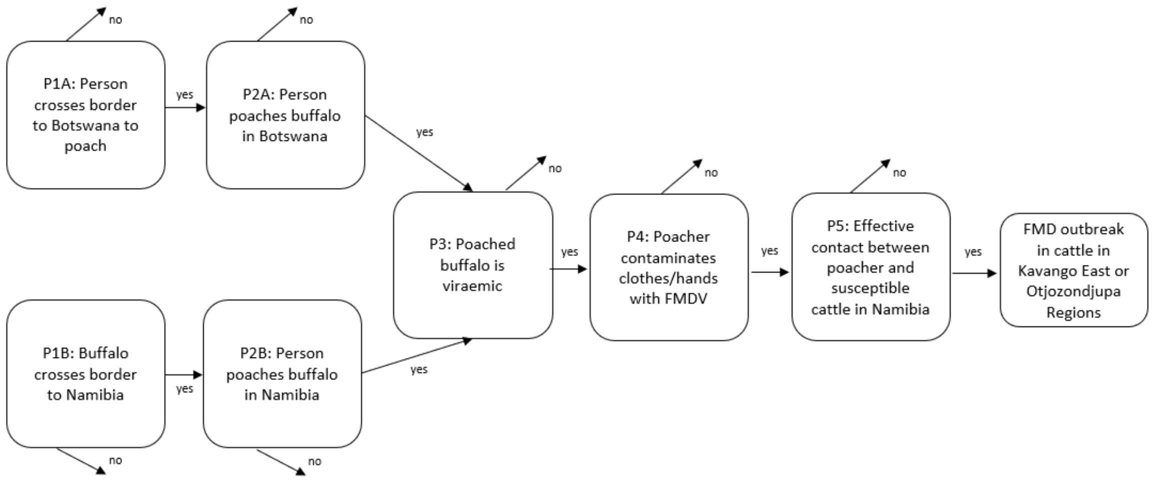
Table 20. Probability of occurrence for SAT-type FMD from buffalo in Botswana to cattle in Namibia along the Western Border fence.

Pathway Step	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Risk (uncertainty)		
FMDV excretion by buffalo (P1)	Low (moderate)	Low (moderate)	Low (moderate)
Cattle cross to Botswana (P2A)	Very low (low)	Very low (moderate)	Very low (moderate)
Buffalo cross to Namibia (P2B)	Very low (moderate)	Low (moderate)	Low (moderate)
Buffalo have contact with cattle in Botswana (P3A)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Buffalo have contact with cattle in Namibia (P3B)	Low (moderate)	Low (moderate)	Low (moderate)
Effective contact between buffalo and cattle (P4)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle return to Namibia (P5)	Low (moderate)	Low (moderate)	Low (moderate)
Effective contact between cattle (P6)	High (low)	High (low)	High (low)
Risk pathway in Botswana (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**
Risk pathway in Namibia (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**

3.4.9 Assessment of risk of SAT-type FMD outbreak in Namibia from poaching

3.4.9.1 Hazard identification and scenario tree

The hazards for this assessment are SAT-1, SAT-2, and SAT-3 serotypes of FMDV causing FMD in cattle in Namibia. The scenario tree (below) involves either a poacher crossing the Botswana-Namibia border and poaching a buffalo in Botswana or poaching a buffalo after it crossed the Botswana-Namibia border, followed by the poacher having contact with cattle in Namibia.



3.4.9.2 Probability of occurrence assessment

P1A: Poacher crossing to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: There is a low density of human settlements near the border fence, and there is little incentive to cross to Botswana to hunt buffalo, as buffalo would not generally be resident in this area of Ngamiland. There has been little evidence of bushmeat poaching in Ngamiland from Namibia.
- Remove fence section: See justification for P1A in section 3.4.5.2.
- Remove fence section with risk mitigation: See justification for P1A in section 3.4.5.2.

P1B: Buffalo crossing to Namibia

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.8.2.
- Remove fence section: See justification for P2B in section 3.4.8.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.4.8.2.

P2A: Buffalo being poached in Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.5.2.
- Remove fence section: See justification for P2B in section 3.4.5.2.
- Remove fence section with risk mitigation: See justification for P1A in section 3.4.5.2.

P2B: Buffalo being poached in Namibia

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: Free-ranging buffalo would not be expected in this area of Namibia, making them an unlikely target for a poacher.
- Remove fence section: Removing sections of the fence will not impact the risk of a buffalo being poached in Namibia.
- Remove fence section with risk mitigation: No specific risk mitigation is proposed for this step.

P3: Buffalo being viraemic

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: See justification for P1 in section 3.4.8.2. Also, viraemia in buffalo is of short duration and under natural conditions only likely to occur in calves infected after maternally derived immunity has waned (see section 3.1.5.1).
- Remove fence section: See justification for P3 in section 3.4.5.2.
- Remove fence section with risk mitigation: See justification for P3 in section 3.4.5.2.

P4: Contamination of poacher with FMDV

Risk (uncertainty)

Status quo: **moderate (moderate)**

Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **moderate (moderate)**

Justification:

- Status quo: Spread of FMDV as a result of contamination is unlikely (see section 3.1.5.2).
- Remove fence section: Removing sections of the fence will not impact the risk of a poacher becoming contaminated with virus.
- Remove fence section with risk mitigation: There are no practical interventions to improve hygiene during and after poaching.

P5: Effective contact between poacher and cattle

Risk (uncertainty)

Status quo: **negligible (moderate)**
Remove fence section: **negligible (moderate)**
Remove fence section with risk mitigation: **negligible (moderate)**

Justification:

- Status quo: Infection by handling cattle is not considered probable according to previous risk assessments (see section 3.1.5.3).
- Remove fence section: Removing sections of the fence will not impact the risk of effective contact between a poacher and cattle.
- Remove fence section with risk mitigation: There are no practical interventions to improve hygiene during and after poaching.

3.4.9.3 Risk estimation of SAT-type FMD outbreak in Namibia from poaching

Calculations for this risk pathway are shown in Appendix T. The current risk of disease occurrence for SAT-type FMD is **negligible** with moderate uncertainty (Table 21). After fence removal alone or with risk mitigation measures in place, the risk would remain **negligible**. In combination with the perceived consequences (**moderate** magnitude with low uncertainty), the final risk estimate for SAT-type FMD from poaching at the Western Border fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation. If the outbreak were caused by a virus strain not covered by the vaccine, the consequences are considered **high** with low uncertainty and the overall risk estimate **moderate**.

Table 21. Probability of occurrence for SAT-type FMD from poaching to cattle in Namibia along the Western Border fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
Poacher crosses to Botswana (P1A)	Very low (low)	Very low (moderate)	Very low (moderate)
FMD host crosses to Namibia (P1B)	Very low (moderate)	Low (moderate)	Low (moderate)
Poaching in Botswana (P2A)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Poaching in Namibia (P2B)	Very low (low)	Very low (low)	Very low (low)
Poached animal is viraemic (P3)	Very low (low)	Very low (low)	Very low (low)
Contamination of poacher with FMDV (P4)	Moderate (moderate)	Moderate (moderate)	Moderate (moderate)
Effective contact with cattle (P5)	Negligible (moderate)	Negligible (moderate)	Negligible (moderate)
Risk pathway in Botswana (P1, P2A, P3, P4, P5)	**Negligible (moderate)**	**Negligible (moderate)**	**Negligible (moderate)**
Risk pathway in Namibia (P1B, P2B, P3, P4, P5)	**Negligible (moderate)**	**Negligible (moderate)**	**Negligible (moderate)**

3.5 Assessment of risk of CBPP outbreak in Botswana from Namibian cattle

A majority (65%) of Namibia's CBPP cases have occurred in the North Central Regions of the country (Figure 25), and these are attributed to uncontrolled movement of cattle between northern Namibia and southern Angola where CBPP is endemic (Mbiri et al. 2020). A CBPP outbreak in 2003 in the Zambezi Region, which was the first in the region in over 60 years, was thought to have originated in Zambia (Namibia Directorate of Veterinary Services 2022). No CBPP outbreaks have occurred in the Zambezi Region in the last decade. There have been outbreaks in Kavango East Region in 2014 and 2015, but no outbreaks in the last 10 years have occurred in the areas that border the Zambezi or Western Border fences.

Botswana suffered a single incursion of CBPP in 1995, more than 50 years after the disease had been eradicated there (Amanfu et al. 1998), and it was eliminated using a combination of permanent cordon fences and stamping out of all the cattle (320,000) in Ngamiland (Marobela-Raborokgwe 2011). The incursion was attributed to cattle having been taken into Namibia for grazing and later returning, after becoming infected, to Botswana (Amanfu et al. 1998; Marobela-Raborokgwe 2011). Botswana is currently officially free from CBPP but the disease occurs sporadically in Namibia. This risk assessment applies to the Zambezi Border fence and the Western Border fence.

In Namibia, overall CBPP occurs at very low sporadic levels, and cases are often only discovered at slaughter. Outbreaks are largely attributed to movement of cattle between Angola and Namibia. Cultural links that pre-date international borders drawn during colonization result in shared grazing between Angola and Namibia, particularly in Ohangwena, Omusati, Kavango West and Kavango East (Namibia Directorate of Veterinary Services 2022).

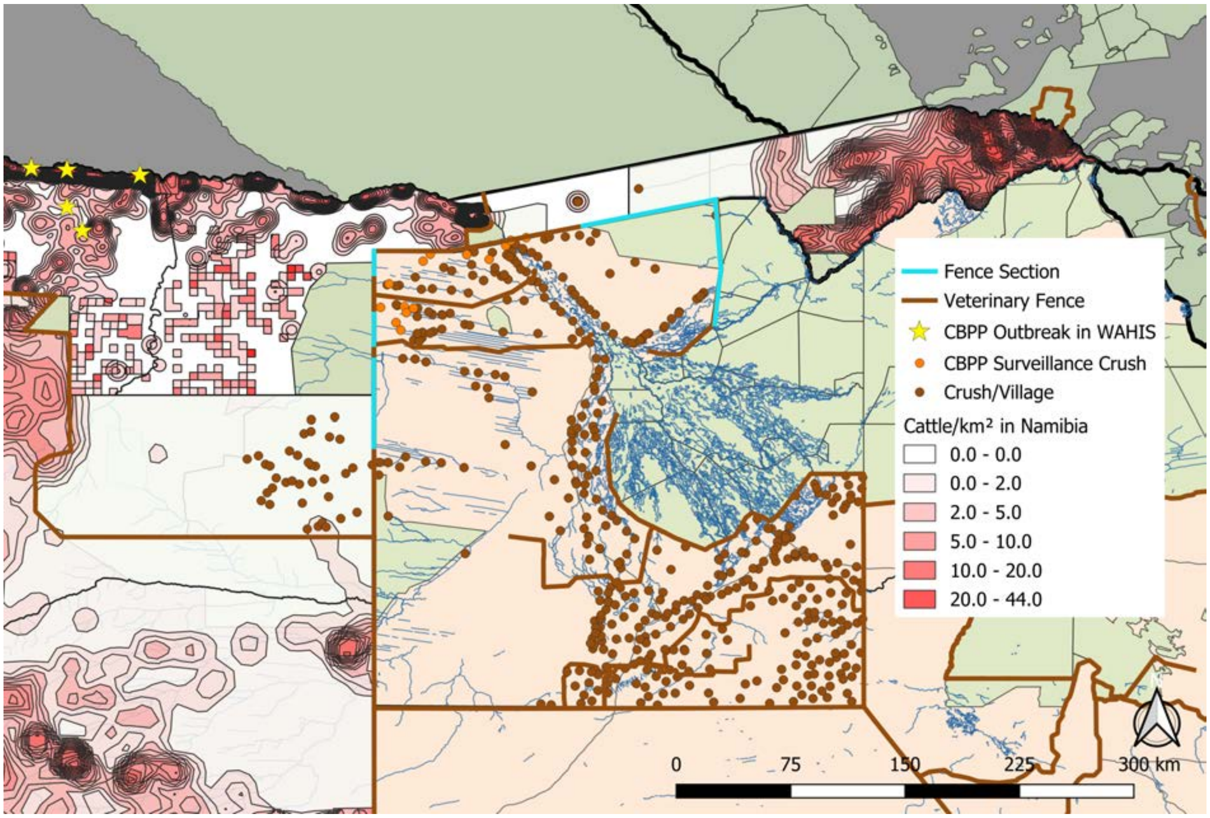


Figure 25. Map of high-risk crushpens selected for active CBPP surveillance in Botswana DVS Surveillance Plan in relation to CBPP outbreaks in Namibia recorded in WAHIS from 2007–present. Note: one surveillance crush, Rikonga II, is not shown as coordinates were not available. Crushpen geodata were not available for Namibia so only select villages and publicly available cattle density data (2012 data for former Kavango Region, 2002 Atlas of Namibia Project data otherwise) are plotted to give an indication of where cattle are most prevalent.

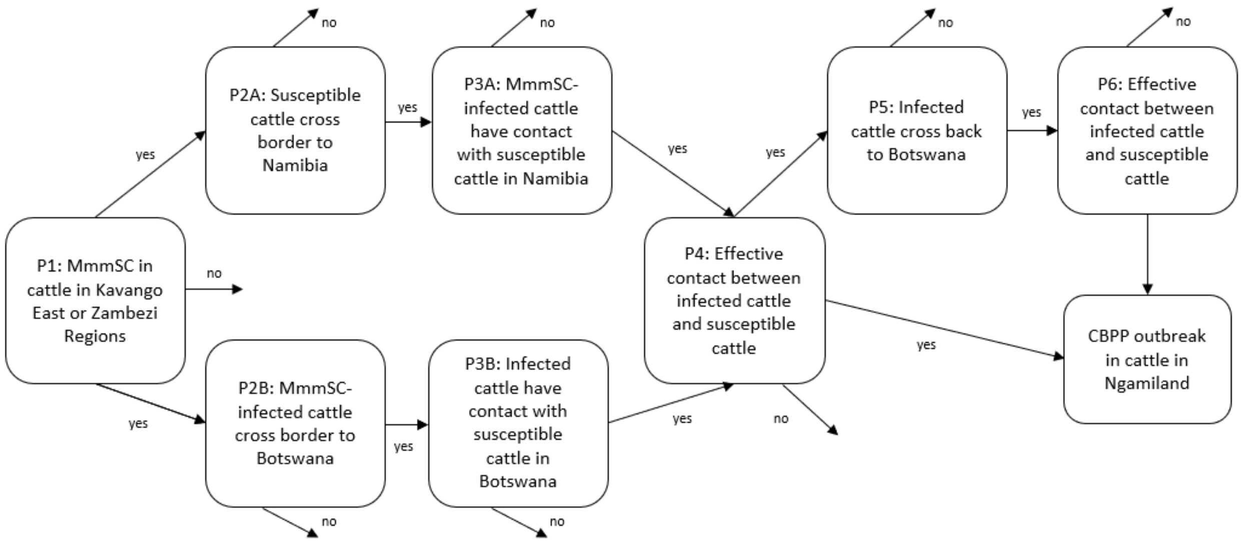
3.5.1 Hazard identification

The hazard for this assessment is *Mycoplasma mycoides* subsp. *mycoides* small colony variant (MmmSC), endemic in parts of southern Africa, causing CBPP in cattle.

As part of its WOAH CBPP-free status, Botswana does not vaccinate against CBPP or allow importation of cattle from countries or zones where vaccination is practiced. Risk-based surveillance for CBPP takes place biannually during FMD vaccination campaigns in high-risk areas that border Namibia and Zambia (i.e. zones 2a and 2b where CBPP entered Ngamiland during the 1995 outbreak, and Chobe District). Approximately 3,300-3,500 serosurveillance samples from zones 1 (Chobe District) and 2 (Ngamiland) are collected and analysed at BNVL annually. Clinical and abattoir surveillance are also employed. Control of cattle movements is essential to control of CBPP.

3.5.2 Assessment of risk of CBPP in Botswana via Zambezi Border fence (east of the Okavango River)

The scenario tree (below) involves either cattle crossing the border from Namibia and having contact with cattle in Botswana, or cattle crossing the border to Namibia, having contact with cattle there, and returning to Botswana.



3.5.2.1 Probability of occurrence assessment

P1: CBPP in cattle in Kavango East or Zambezi Regions

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: There was a CBPP outbreak in 2003 in Zambezi Region, which was the first in the region in over 60 years, thought to have originated in Zambia (Namibia Directorate of Veterinary Services 2022). No CBPP outbreaks have occurred in Zambezi Region in the last decade. Kavango East Region has experienced several CBPP outbreaks in the last decade (Figure 25), although these have been relatively small (2014 – 3 cases, 2 deaths; 2015 – 20 cases, 10 deaths; 2017 – 16 cases, 4 deaths). Uncontrolled movement of cattle apparently does not occur in Zambezi Region (Mbiri et al. 2020), although there may be informal trade of cattle from Angola through Bwabwata National Park (D. Jooste, personal communication). In 2022, 244,730 CBPP vaccines were administered in Kavango East. CBPP vaccination does not offer complete protection; in one study, protection at 3 months post vaccination ranged from 33–67% (Thiaucourt et al. 2000).

- Remove fence section: Removing the eastern section of the fence would not affect the risk of CBPP in cattle in Kavango East or Zambezi Regions.
- Remove fence section with risk mitigation: Removal of cattle from Bwabwata National Park would remove the risk of resident cattle across from NG13 which could be infected. Active herding techniques from the H4H model would lower the risk of cattle having contact with cattle outside their herding group. Cattle are also required to be vaccinated under the H4H model.

P2A: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.2.3.2.
- Remove fence section: See justification for P2A in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.2.3.2.

P2B: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: See justification for P2B in section 3.2.3.2.
- Remove fence section: See justification for P2B in section 3.2.3.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.2.3.2.

P3A: Contact between susceptible cattle from Botswana and infected cattle in Namibia

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **negligible (low)**

Justification:

- Status quo: Because cattle in Bwabwata National Park are concentrated around Omega settlement ~15 km from the border, Botswana cattle would need to travel well into the park to make contact with other cattle.
- Remove fence section: Removing the eastern section of the fence would not change the risk of contact after the border has already been crossed.

- Remove fence section with risk mitigation: Removal of cattle from Bwabwata National Park would eliminate the risk of having contact with resident cattle anywhere near the fence section.

P3B: Contact between infected cattle from Namibia and susceptible cattle in Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P3A above. Contact with cattle in Ngamiland would be most likely around the Tovera crushes at the western aspect of the section proposed for removal, although past ground and aerial surveys have observed these cattle further west or south rather than near the fence in NG13 (Atkinson et al. 2022, A. Songhurst, unpublished data). Based on Botswana's surveillance plan, which identifies crushes determined to be at high risk of CBPP, crushes this far east along the Zambezi Border fence are not considered high risk (Figure 25).
- Remove fence section: See justification for P3A above.
- Remove fence section with risk mitigation: Active herding techniques under H4H would limit contact with any stray cattle from Namibia.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (moderate)**
Remove fence section: **high (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: Cattle in Botswana are not vaccinated against MmmSC and are therefore completely susceptible to the agent. The primary source of infection is thought to be respiratory droplets from coughing, clinically ill animals (Masiga et al. 1996). Adults are more susceptible than calves (Masiga et al. 1996). Susceptible animals generally need immediate direct contact (or contact over short distances) for transmission to occur (Masiga et al. 1996). Transmission of MmmSC rarely occurs over distances and is generally a result of close contact, as in co-housing (Di Teodoro et al. 2020). Indirect transmission does not appear to play a role (Di Teodoro et al. 2020). A modelling study estimated effective contact rates in pastoral herds in southern Sudan at 0.07–0.13, with R_0 ranging from 3.2–4.6 (Mariner et al. 2006).
- Remove fence section: Removing the eastern section of the Zambezi Border fence would not affect the risk of effective contact between susceptible and infected cattle.
- Remove fence section with risk mitigation: Under the H4H model, cattle are actively herded and avoid contact with cattle outside their herding group.

P5: Cattle returning to Botswana

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: If discovered, cattle that have crossed to Namibia are destroyed rather than repatriated to avoid the risk of diseases. Cattle that are undetected may cross or be herded back to Botswana, although there is a high density of predators. The fence is semi-permeable and could be crossed if cattle were able to return through Bwabwata National Park.
- Remove fence section: Removing the eastern section of the fence would make it easier to cross the border, but cattle would still need to navigate through Bwabwata National Park to return from contacting cattle in Namibia
- Remove fence section with risk mitigation: Cattle under H4H should not be herded back to Botswana to have contact with the rest of the herding group.

P6: Effective contact between susceptible and infected cattle after returning to Botswana

Risk (uncertainty)

Status quo: **high (moderate)**
Remove fence section: **high (moderate)**
Remove fence section with risk mitigation: **high (moderate)**

Justification:

- Status quo: See justification for P4 above.
- Remove fence section: Removing the eastern section of the fence would not affect effective contact after returning to Botswana.
- Remove fence section with risk mitigation: Improved animal health in the H4H model would raise individual immunity.

3.5.2.2 Risk estimation of CBPP outbreak in Botswana from Namibian cattle in Zambezi or Kavango East Regions

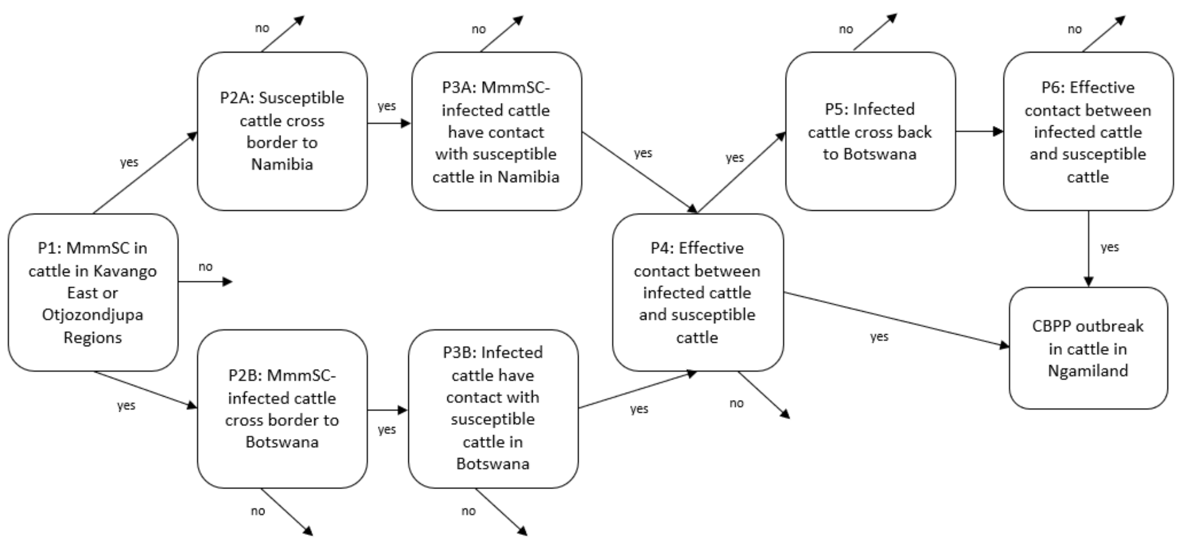
Calculations for this risk pathway are shown in Appendix U. The current risk of disease occurrence for CBPP is **very low** with moderate uncertainty (Table 22). After fence removal alone, the risk would remain **unchanged**. After removal with risk mitigation measures in place – specifically removal of cattle from Bwabwata National Park – the risk decreases to **negligible** with moderate uncertainty. In combination with the perceived consequences (**high** magnitude with low uncertainty), the final risk estimate for CBPP from cattle at the Zambezi Border fence (east of Okavango River) is **moderate** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation.

Table 22. Probability of occurrence for CBPP from cattle in Namibia to cattle in Botswana along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
MmmSC in cattle in Namibia (P1)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (moderate)	Very low (moderate)
Cattle cross to Botswana (P2B)	Very low (moderate)	Very low (moderate)	Negligible (low)
Cattle have contact with cattle in Namibia (P3A)	Very low (moderate)	Very low (moderate)	Negligible (low)
Cattle have contact with cattle in Botswana (P3B)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective contact between cattle (P4)	High (moderate)	High (moderate)	Very low (moderate)
Cattle return to Botswana (P5)	Low (moderate)	Low (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (moderate)	High (moderate)	High (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Negligible (moderate)**

3.5.3 Assessment of risk of CBPP in Botswana via Western Border fence

The scenario tree (below) involves either cattle crossing the border from Namibia and having contact with cattle in Botswana, or cattle crossing the border to Namibia via the Western Border fence line, having contact with cattle there, and returning to Botswana.



3.5.3.1 Probability of occurrence assessment

P1: MmmSC in cattle in Kavango East or Otjozondjupa Regions

Risk (uncertainty)

Status quo: **low (low)**
Remove fence section: **low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: Kavango East has experienced several CBPP outbreaks in the last decade (Figure 25), although these have been relatively small (2014 – 3 cases, 2 deaths; 2015 – 20 cases, 10 deaths; 2017 – 16 cases, 4 deaths). Outbreaks are largely attributed to movement of cattle from Angola into Namibia. Cattle in the region are vaccinated against CBPP although the annual coverage can be highly variable (e.g. 85,712 vaccines administered in Kavango East in 2021 vs. 244,730 vaccines administered in 2022). CBPP vaccination does not offer complete protection; in one study, protection at 3 months post vaccination ranged from 33–67% (Thiaucourt et al. 2000).
- Remove fence section: Removing sections of the fence would not affect the risk of CBPP in cattle in Kavango East or Otjozondjupa Regions. Cattle in Angola are the source of MmmSC infection to Namibian cattle, and this fence does not inhibit movement of cattle between Angola and Namibia.
- Remove fence section with risk mitigation: If Namibian cattle farmers were to adopt H4H, planned grazing would limit the long range movements of cattle into Angola while active herding techniques would lower the risk of cattle having contact with cattle outside their herding group. Cattle are also required to be vaccinated under the H4H model.

P2A: Cattle crossing border to Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (high)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2A in section 3.4.3.2.
- Remove fence section: See justification for P2A in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P2A in section 3.4.3.2.

P2B: Cattle crossing border to Botswana

Risk (uncertainty)

Status quo: **very low (moderate)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: See justification for P2B in section 3.4.3.2.
- Remove fence section: See justification for P2B in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P2B in section 3.4.3.2.

P3A: Contact between susceptible cattle from Botswana and infected cattle in Namibia

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**

Remove fence section with risk mitigation: **low (moderate)**

Justification:
- Status quo: See justification for P3A in section 3.4.3.2.
- Remove fence section: See justification for P3A in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P3A in section 3.4.3.2.

P3B: Contact between infected cattle from Namibia with susceptible cattle in Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:
- Status quo: See justification for P3B in section 3.4.3.2.
- Remove fence section: See justification for P3B in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P3B in section 3.4.3.2.

P4: Effective contact between susceptible and infected cattle

Risk (uncertainty)

Status quo: **high (moderate)**
Remove fence section: **high (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:
- Status quo: See justification for P4 in section 3.5.2.1.
- Remove fence section: Removing sections of the fence would not affect the risk of effective contact between cattle.
- Remove fence section with risk mitigation: Under the H4H model, cattle are actively herded and avoid contact with cattle outside their herding group.

P5: Cattle returning to Botswana

Risk (uncertainty)

Status quo: **moderate (moderate)**
Remove fence section: **moderate (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:
- Status quo: See justification for P5 in section 3.4.3.2.
- Remove fence section: See justification for P5 in section 3.4.3.2.
- Remove fence section with risk mitigation: See justification for P5 in section 3.4.3.2.

P6: Effective contact between susceptible and infected cattle after returning to Botswana

Risk (uncertainty)

Status quo: **high (moderate)**
Remove fence section: **high (moderate)**
Remove fence section with risk mitigation: **high (moderate)**

Justification:

- Status quo: See justification for P4 in section 3.5.2.1.
- Remove fence section: Removing sections of the fence would not affect effective contact after returning to Botswana.
- Remove fence section with risk mitigation: Improved animal health in the H4H model would raise individual immunity.

3.5.3.2 Risk estimation of CBPP outbreak in Botswana from Namibian cattle, Western Border fence

Calculations for this risk pathway are shown in Appendix V. The current risk of disease occurrence for CBPP is **low** or **very low** with moderate uncertainty (Table 23). After fence removal alone, the risk would remain **low** or **very low** with moderate or high uncertainty. With risk mitigation measures, the risk would decrease to or remain **very low**. In combination with the perceived consequences (**high** magnitude with low uncertainty), the final risk estimate for CBPP from cattle at the Western Border fence is **moderate** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation.

Table 23. Probability of occurrence for CBPP from cattle in Namibia to cattle in Botswana along the Western Border fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
MmmSC in cattle in Namibia (P1)	Low (low)	Low (low)	Very low (low)
Cattle cross to Namibia (P2A)	Low (moderate)	Low (high)	Very low (low)
Cattle cross to Botswana (P2B)	Very low (moderate)	Very low (moderate)	Very low (moderate)
Cattle have contact with cattle in Namibia (P3A)	Low (moderate)	Low (moderate)	Low (moderate)
Cattle have contact with cattle in Botswana (P3B)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P4)	High (moderate)	High (moderate)	Very low (moderate)
Cattle return to Botswana (P5)	Moderate (moderate)	Moderate (moderate)	Very low (moderate)
Effective contact between cattle (P6)	High (moderate)	High (moderate)	High (moderate)
Risk pathway in Namibia (P1, P2A, P3A, P4, P5, P6)	**Low (moderate)**	**Low (high)**	**Very low (moderate)**
Risk pathway in Botswana (P1, P2B, P3B, P4)	**Very low (moderate)**	**Very low (moderate)**	**Very low (moderate)**

3.6 Assessment of risk of PPR outbreak in Botswana from Namibian small stock

3.6.1 Hazard identification

The hazard for this assessment is peste des petits ruminants virus (PPRV) of the *Morbillivirus* genus in family *Paramyxoviridae*, causing PPR in small ruminants.

It is important to note that Namibia is recognised as free of PPR south of the VCF and is in the process of conducting surveillance to gain PPR-free status for the entire country; there is no evidence of current PPR infection in the country. The NCA is considered at high risk of PPR given the proximity to Angola (Britton et al. 2019), which has previously reported PPR near its border with Democratic Republic of Congo. Zambia also borders Namibia and has never had a clinical outbreak of PPR, although antibodies to PPR were detected near its border with Tanzania in 2010 and 2014 and attributed to vaccinated animals from neighbouring countries. Botswana is free of PPR, but sampling for PPR surveillance at high risk crushes (Figure 26) was not done during the June 2022 FMD vaccination campaign due to a lack of sampling supplies.

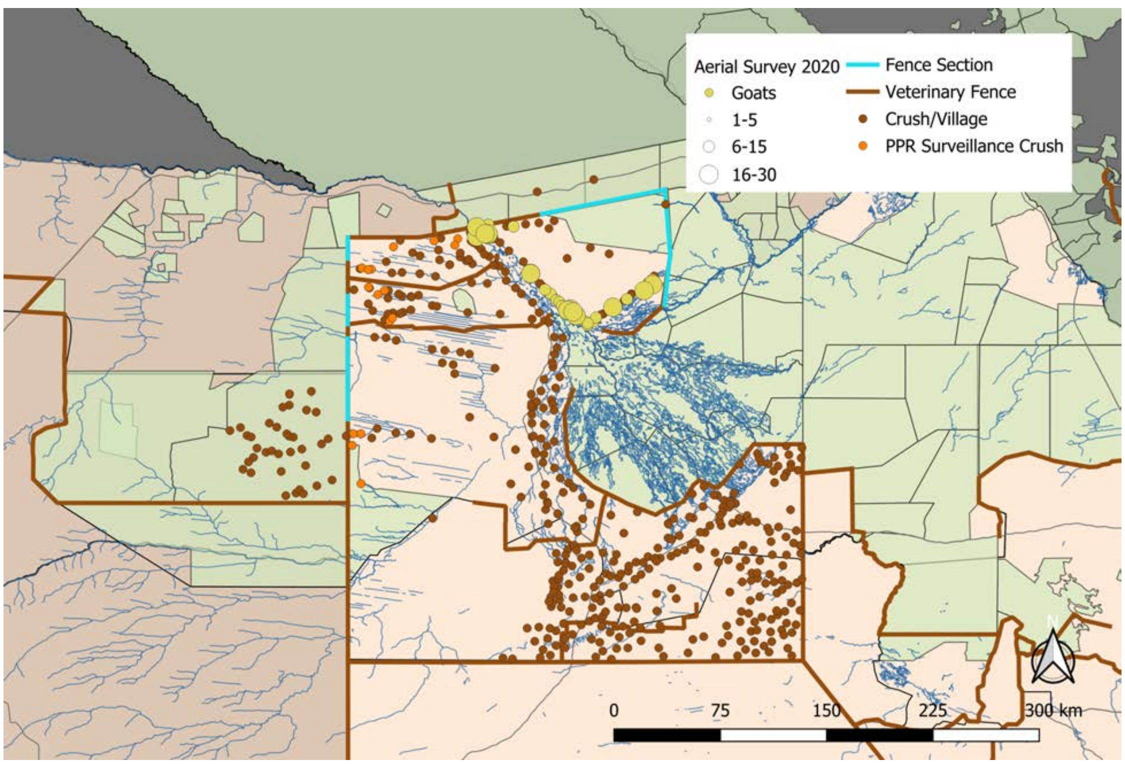


Figure 26. Map of Ngamiland showing presence of goats in eastern panhandle of the Okavango Delta as observed during a 2020 aerial survey as well as designated PPR surveillance crushes.

3.6.2 Assessment of risk of PPR in Botswana from Namibia via Zambezi Border fence (east of the Okavango River)

3.6.2.1 Probability of occurrence assessment

Entry assessment

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- Status quo: There are ~18,000 people living in the southern section of Luengue-Luiana National Park in Angola, raising primarily cattle but some small stock as well (D. Jooste, personal communication). There is virtually no presence of Angola veterinary services in this area and livestock are not being vaccinated, branded, or monitored for diseases (D. Jooste, personal communication). For both Angola and Zambia, initial outbreaks of PPR would be very unlikely to occur in the southern parts of the countries, close to Namibia, unless infected small stock were moved very long distances. There were few small stock observed in the Bwabwata Multiple Use Area during the KAZA Elephant Survey (Figure 27; Bussière and Potgieter 2023a). Crushpens in Botswana east of the Okavango River are not considered to be at the highest risk for possible incursion of PPRV, according to Botswana's disease surveillance plan (high risk crushes shown in orange in Figure 26). In addition, small stock have a limited capacity to travel long distances on foot compared to cattle. Illegal movement of small stock poses the greatest entry risk for PPR, and while the lack of a fence would make it marginally easier to move livestock illegally, terrain and predators in this area would make it challenging to move small stock long distances on foot.
- Remove fence section: Removing the eastern section of the fence would likely not affect the risk of PPRV entering Botswana. There is no likely source of PPRV within hundreds of kilometres of the fence and sheep and goats have more limited capacity to travel long distances on foot than cattle. Illegal movement of small stock poses the greatest entry risk for PPR, and while the lack of a fence would make it marginally easier to move livestock illegally, terrain and predators in this area would make it challenging to move small stock long distances on foot.
- Remove fence section with risk mitigation: Illegal movement of small stock poses the greatest entry risk for PPR, and the risk mitigation strategies outlined at the beginning of this document do not directly address these movements.

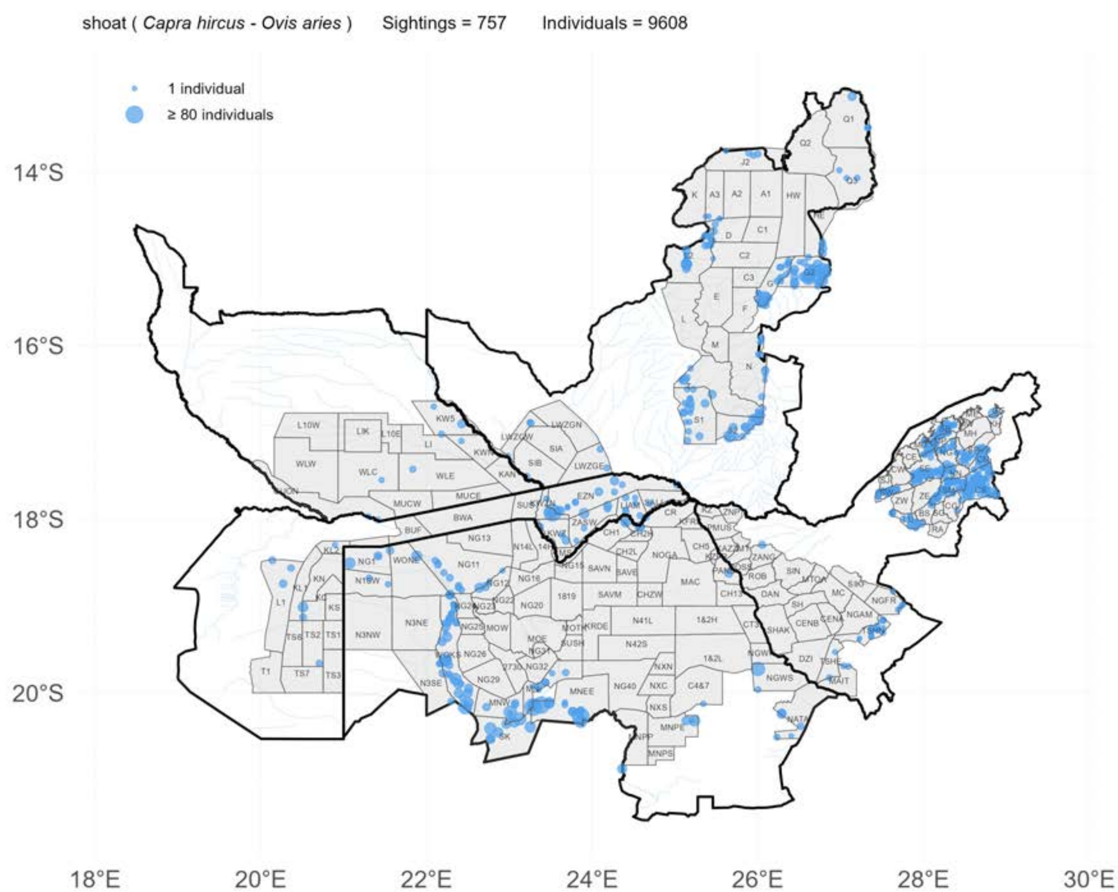


Figure 27: Map of small ruminants observed during 2022 KAZA Elephant Survey. Source: KAZA Elephant Survey Report Volume I (Bussière and Potgieter 2023a)

Exposure assessment

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (low)**
Remove fence section with risk mitigation: **very low (low)**

Justification:

- Status quo: PPR is transmitted through close contact, with inhalation considered an important route of transmission (Spickler et al. 2010b). Fomites, aerosol, and environmental transmission are unlikely to play a significant role (Spickler et al. 2010b). Because Botswana has PPR-free status, vaccination is not practised and small ruminants are therefore susceptible to the virus. Aerial surveys from 2020 show that goats occur in relatively low densities in the eastern panhandle and northern delta, with group sizes observed not exceeding 30 goats (A. Songhurst, unpublished data). Small stock do not roam as far as cattle on a daily basis and generally remain close to villages, with the highest grazing/browsing impact being within a ~2–3 km radius from their homestead of origin, up to a maximum of ~5 km (J. van Rooyen, personal communication). Goats would be very unlikely to traverse NG13 to the eastern panhandle or the northern delta.

- <u>Remove fence section</u>: Removing the eastern section of the fence would not affect the risk of exposure to PPRV if it had already entered the country.
- <u>Remove fence section with risk mitigation:</u> The risk mitigation tools for preventing FMD and CBPP do not translate as well to PPR. Vaccination is not practiced in Botswana given its freedom from disease status, and while the H4H model can be implemented for small stock, controlling cattle movements is the primary objective.

3.6.2.2 Risk estimation of PPR outbreak in Botswana from Namibian small stock

Calculations for this risk pathway are shown in Appendix W. The current risk of disease occurrence for PPR is **very low** with low uncertainty (Table 24). Removing the fence section without or with risk mitigation measures in place would not be expected to change the risk of disease occurrence; the risk would remain **unchanged**. In combination with the perceived consequences (**moderate** magnitude with moderate uncertainty), the final status quo risk estimate for PPR in Botswana from Namibian small stock at the Zambezi Border fence line (east of Okavango River) is **low** with low uncertainty. Under both removal and removal with risk mitigation measures in place, the overall risk would remain **low** with moderate uncertainty.

Table 24. Probability of occurrence for PPR from small stock in Namibia to small stock in Botswana along the Zambezi Border fence (east of Okavango River).

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
		Risk (uncertainty)	
Entry assessment	Very low (low)	Very low (moderate)	Very low (moderate)
Exposure assessment	Very low (low)	Very low (low)	Very low (low)
Probability of occurrence	**Very low (low)**	**Very low (moderate)**	**Very low (moderate)**

3.6.3 Assessment of risk of PPR in Botswana via Western Border fence

3.6.3.1 Probability of occurrence

Entry assessment

Risk (uncertainty)

Status quo: **very low (low)**
Remove fence section: **very low (moderate)**
Remove fence section with risk mitigation: **very low (moderate)**

Justification:

- <u>Status quo</u>: The most likely risk pathway for PPR near the Western Border fence is through small ruminants straying or being moved illegally across the border from Angola. At the time of a risk analysis in 2012, entry of PPRV into Namibia was considered a low risk given that there were no known sources of the virus close by (Thomson and Venter 2012), which remains the case.

Nyae Nyae Conservancy has few small stock (approximately 51 sheep, 475 goats; L. Hanssen, unpublished data.). No small stock were observed in the strata closest to the Western Border fence during the KAZA Elephant Survey (Figure 27; Bussière and Potgieter 2023b). Botswana considers certain crushes in northwest Ngamiland at high risk for PPR – these include crushes in the far northwest corner of Ngamiland, as well as in the west near Dobe, opposite Nyae Nyae Conservancy (Figure 26). Entry of small stock would be most likely to occur through Nyae Nyae Conservancy, where there are small stock close to the border.

- Remove fence section: Removing sections of the fence would likely not affect the risk of PPRV entering Botswana. There is no likely source of PPRV within hundreds of kilometres of the fence and sheep and goats have more limited capacity to travel long distances than cattle. Illegal movement of small stock poses the greatest entry risk for PPR, and while the lack of a fence would make it marginally easier to move livestock illegally, terrain and predators in this area would make it challenging to move small stock long distances on foot.
- Remove fence section with risk mitigation: Illegal movement of small stock poses the greatest entry risk for PPR, and the risk mitigation strategies outlined at the beginning of this document do not directly address these movements.

Exposure assessment

Risk (uncertainty)

Status quo: **low (moderate)**
Remove fence section: **low (moderate)**
Remove fence section with risk mitigation: **low (low)**

Justification:

- Status quo: The high-risk crushes identified in the 2022-2025 surveillance plan for Botswana have relatively few goats and no sheep according to numbers in the plan. For instance, four crushes near Nyae Nyae Conservancy have 45–77 goats each. The high-risk crushes adjacent to Khaudum National Park have 3–105 goats each.
- Remove fence section: Removing sections of the fence would not affect the risk of exposure to PPRV if it had already entered the country.
- Remove fence section with risk mitigation: The risk mitigation tools for preventing FMD and CBPP do not translate as well to PPR. Vaccination is not practiced in Botswana given its freedom from disease status, and while the H4H model can be implemented for small stock, controlling cattle movements is the primary objective.

3.6.3.2 Risk estimation of PPR outbreak in Botswana from Namibian small stock

Calculations for this risk pathway are shown in Appendix X. The current risk of disease occurrence for PPR is **very low** with low uncertainty (Table 25). After fence removal alone or with risk mitigation measures in place, the risk would remain **unchanged**. In combination with the perceived consequences (**moderate** magnitude with moderate uncertainty), the final risk estimate for PPR from small stock at the Western Border fence is **low** with moderate uncertainty under all three scenarios. In other words, there is no change in the risk estimation whether the fence is left as is (status quo) or is removed without or with risk mitigation.

Table 25. Probability of occurrence for PPR from small stock in Namibia to small stock in Botswana along the Western Border fence.

Pathway Step	Status Quo	Fence Removal	Fence Removal with Risk Mitigation
	Risk (uncertainty)		
Entry assessment	Very low (low)	Very low (moderate)	Very low (moderate)
Exposure assessment	Low (moderate)	Low (moderate)	Low (moderate)
Probability of occurrence	**Very low (low)**	**Very low (moderate)**	**Very low (moderate)**

4. SUMMARY OF FINDINGS AND RECOMMENDATIONS

4.1 Summary of findings

This assessment was conducted to inform national, bilateral and KAZA-level planning efforts on veterinary fences and includes delineation of risks at each fence line under three different scenarios assuming that (i) no changes are made, i.e. status quo, (ii) the fence section is removed and (iii) the fence section is removed with specific risk mitigation in place. While veterinary fences have a long-standing role in disease control in southern Africa, there is growing recognition that the time has come to consider alternative disease control methods in some parts of the region. This risk assessment offers a look at how key fence sections might be removed in areas deemed critical for wildlife and habitat connectivity, while maintaining low levels of risk for transboundary diseases. Although land use and livestock density around each fence contribute to its unique risk profile, there are some commonalities in the risks assessed at each fence. These include:

- **The veterinary fence sections of interest are currently in variable condition, making them semi-permeable under the status quo.** Some fence sections remain upright and fully intact, while others have deteriorated as a result of inadequate resources for maintenance and persistent elephant damage. In some cases, fence sections are completely destroyed or lying on the ground, making it possible for animals to cross.

- **The risks for disease outbreaks remained the same under proposed fence section removals.** Removing fence sections can increase the risk at certain steps in a risk pathway, but in all cases, the probability of disease occurrence and overall risk estimate were the same under both the status quo and proposed removal. In some cases, the probability of disease occurrence decreased with the addition of risk mitigation measures.

- **Effective implementation of risk mitigation can reduce the probability of disease occurrence below the status quo risk.** In some pathways, particularly for the Zambezi Border fence east of the Okavango River, implementing risk mitigation produced a lower estimated probability of disease occurrence than under the fencing status quo scenario. Removal of cattle from Bwabwata National Park lowers the risk of FMD and CBPP to Botswana cattle to negligible by removing the most likely source population. Risks to Namibia would also be reduced by removing the host population nearest to the fence.

- **Removing fence sections impacts risks at some but not all steps in the risk pathway.** Removing a fence section can increase the risk of animal movement across that fence line, depending on the location. Removing a fence section does not impact all of the steps in a risk pathway; for example, the risk of effective contact between livestock within a country or the risk of a free-ranging buffalo being viraemic are not impacted by the presence of fences.

- **Removing fence sections can affect the risk of a pathogen entering a country or zone, but risk mitigation measures can be applied to reduce both the risk of entry and exposure.** Fences may limit the entry of a pathogen into a country, but once a pathogen has entered, border fences will not limit exposure of susceptible animals. Risk mitigation measures, in contrast, may be applied in different ways to limit entry and/or exposure. For instance, removal of cattle from Bwabwata National Park reduces the risk of livestock pathogens entering through the border. Controlled livestock movements under H4H (a model of strategic active herding and kraaling by skilled herders implementing planned grazing through collective action at village level) reduces the risk of exposure to pathogens outside a herding group.

- **Intentional illegal movement of livestock across international borders remains a major risk for the spread of CBPP and PPR, and to a lesser degree FMD.** Fences have some capacity to control livestock movements but are always susceptible to deliberate destruction, as has been noted in fence patrols and questionnaire responses. As such, fences have limited capacity as a preventive measure against illegal movement of livestock. It would be impossible to maintain constant patrolled surveillance across hundreds of kilometres of fences to prevent all border crossings.

- **The fences have a limited impact on the risk of poaching in general.** The presence or absence of a fence does not necessarily factor strongly into the risk of poaching. Poaching happens regardless of fences and other factors in the poaching scenarios are more strongly tied to the likelihood of disease transmission. There are limited risk mitigation measures to reduce the risks from poaching, other than to increase anti-poaching efforts.

- **The extremely low probability of FMD viraemia in adult buffalo is a critical "risk bottleneck" in the risk pathways for poaching.** Poachers are far more likely to target adult buffalo than juveniles when poaching, and adults are not the demographic in which virus is most likely to be actively circulating. Even if a poacher was grossly contaminated with blood, the blood of an adult buffalo is not likely to contain FMDV, which would still need to be transmitted to cattle via fomites to result in an outbreak. This pathway is therefore unlikely to contribute much to the occurrence of FMD outbreaks, given the negligible likelihood of virus being present in adult buffalo meat or blood.

The subsequent sub-sections summarise the findings and key recommendations per fence, with a full list of **recommendations from the livestock disease control perspective** provided in section 4.2. As a reminder, these recommendations do not yet take into account community perspectives – that Phase 3 work still needs to be undertaken.

4.1.1 Zambezi Border fence (east of the Okavango River)

Perhaps the most significant disease risk at this fence is that of FMD serotype O, which has a very low probability of occurrence but the overall risk is elevated to moderate based on the high consequences. This disease has the potential to enter Botswana along the border with Zambezi Region, where the previous outbreak in Namibia occurred. However, Namibia DVS is now vaccinating against FMDV serotype O in Zambezi Region and sensitised to the risk in this area. It would seem unlikely that another outbreak of FMD serotype O would occur near the Zambian border, move unchecked into Bwabwata National Park, and spread across the border to Botswana. The fence section bordering Bwabwata National Park represents less risk than elsewhere along the Zambezi Border fence (east of the Okavango River), given the absence of cattle along much of it. The removal of cattle from Bwabwata National Park would mark a major reduction in risk, while the small number of cattleposts near the fence on the Botswana side would be excellent targets for implementation of H4H to further protect cattle from cross-border infections in this region. The crush at Seshokora represents an epidemiologically isolated unit of cattle, and in the event of an outbreak here, these cattle are geographically isolated from others in Ngamiland, making spread beyond the crush unlikely.

This area of Ngamiland is not considered at high risk of CBPP or PPR under Botswana's disease surveillance plan, and Zambezi Region across the border has not experienced a CBPP outbreak in the last 10 years.

For scenarios with buffalo in the Zambezi Region, it is important to note that SAT-type FMDV is endemic in free-ranging buffalo on both sides of the fence, therefore movement of buffalo from one country to another arguably does not change the risk of the disease occurring. Similarly, there is no difference in the disease risk – which has a very low probability of occurrence – from poaching a buffalo in one country versus the other. All scenarios with buffalo and poaching near the Zambezi Border fence were considered to have a low overall risk. It should be noted that FMDV serotype O is a Eurasian serotype that evolved in cattle, unlike SAT-type FMDV. Studies in East Africa, where serotype O has a long history including in areas where cattle and buffalo co-exist, have shown that buffalo remained seronegative for serotype O even when it has caused outbreaks in cattle in the same area.

Table 26. Zambezi Border fence (east of Okavango River) risk scenarios summary of findings. Note that for SAT-type FMD outbreaks caused by a strain not covered by the vaccine, the overall risk estimate is moderate.

Zambezi Border fence			
Risk Scenario Disease/Route/Country	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Probability of Occurrence / Risk Estimate		
SAT-FMD/cattle/Botswana	Very low / Low	Very low / Low	Negligible / Low
SAT-FMD/buffalo/Botswana	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/poaching/Botswana	Negligible / Low	Negligible / Low	Negligible / Low
FMD type O/cattle/Botswana	Very low / Moderate	Very low / Moderate	Negligible / Moderate
SAT-FMD/cattle/Namibia	Very low / Low	Very low / Low	Negligible / Low
SAT-FMD/buffalo/Namibia	Very low / Low	Very low / Low	Negligible / Low
SAT-FMD/poaching/Namibia	Negligible / Low	Negligible / Low	Negligible / Low
CBPP/cattle/Botswana	Very low / Moderate	Very low / Moderate	Negligible / Moderate
PPR/small ruminants/Botswana	Very low / Low	Very low / Low	Very low / Low

4.1.2 Northern Buffalo fence

While the Northern Buffalo fence is intended to keep buffalo and cattle separated, given its poor condition, it is not fulfilling this goal. Aerial survey data presented in this report documents the presence of buffalo in zone 2 in two consecutive years, although they were largely concentrated at the southernmost aspect of the fence which is not proposed for removal. Flooding in that area routinely damages the fence and makes maintenance challenging during the rainy season. Despite the presence of buffalo near livestock along the eastern panhandle and northern delta, this area has not experienced FMD outbreaks.

Because the Northern Buffalo fence is an internal fence in Botswana and there are only cattle resident on one side of the fence, it presents the simplest set of scenarios in terms of disease risks. The probability of FMDV transmission to cattle from buffalo or poaching was deemed to be very low. When combined with the consequences of an outbreak, which were calculated as moderate, the overall risk estimate for all scenarios was low. Overall, this fence presents the fewest risks associated with removal.

The Phase 1 report (focused on impacts on wildlife) recommended removal of the northern section (80 km) of the Northern Buffalo fence bordering land use zones NG13, NG11 and the top of NG12. The northern part of the fence along NG13 presents the least risk in terms of fence removal. The cattle at Seshokora are the only ones close to this fence section and are epidemiologically isolated from all other cattle in the event of an outbreak there. Removing this section of fence would allow movement of wildlife, particularly elephants, out of subzone 2a. Because there are no cattle resident in zone 16, there is no increased risk of cattle-cattle contact if the fence were removed here. The risk of FMDV from either buffalo contact or poaching of buffalo was considered to be very low, and the risk of buffalo-cattle contact would be further mitigated if H4H were implemented to promote active avoidance of buffalo.

The southern aspect of the Northern Buffalo fence that borders NG11 and NG12 is associated with a higher risk of cattle-buffalo contact, given the number of cattle along the northern delta and the density of buffalo in the delta, although the overall risk of disease transmission from buffalo appears to be very low. There is already implementation of H4H in Eretsha and in some neighbouring areas, and further adoption of H4H would likely help to mitigate the risk of human-wildlife conflict, including livestock disease transmission, if buffalo move out of the delta into these areas.

Table 27. Northern Buffalo fence risk scenarios summary of findings. Note that for SAT-type FMD outbreaks caused by a strain not covered by the vaccine, the overall risk estimate is moderate.

Northern Buffalo fence			
Risk Scenario Disease/Route/Country	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Probability of Occurrence / Risk Estimate		
SAT-FMD/buffalo/Botswana	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/poaching/Botswana	Negligible / Low	Negligible / Low	Negligible / Low

4.1.3 Western Border fence

Although SAT-type FMD is endemic in both Botswana and Namibia, the consequences of an outbreak of FMD may be higher in the future in the areas around the Western Border fence. Botswana is in the process of converting subzone 2f, which currently has no WOAH official status, into an FMD-free without vaccination zone, with plans to apply for freedom status from WOAH in 2024. An outbreak in subzone 2f would then require additional resources to create a containment zone, as with the 2022 FMD outbreak near Francistown. Similarly, Namibia plans to eventually stop vaccination against FMD in its protection zone. If the current protection zone also gains official freedom without vaccination status, then an outbreak there has similar repercussions.

The current risk of CBPP at the Western Border fence was calculated as very low. The risk is arguably higher than that at the Zambezi Border fence (east of the Okavango River), given the closer proximity to recent outbreaks and the regions where cattle are routinely taken to Angola for grazing.

The Western Border fence is perceived to have lower FMD risk to Botswana associated with buffalo and poaching than the other fences, as the only buffalo nearby in Namibia are FMD-free. There are no or limited resident buffalo in Botswana near the fence, although dispersing animals from Botswana do occasionally move across the border. This is problematic in that dispersing buffalo will be naturally infected with SAT-type FMDV while the only buffalo in Namibia's protection zone west of Zambezi Region are those in Tsumkwe, all of which are FMD-free (and notably, fenced-in). Plans for wildlife reintroductions into Khaudum National Park also need to be carefully considered in decision making about this fence. The park's management plan states that buffalo as well as white rhinoceros (*Ceratotherium simum*) and black rhinoceros (*Diceros bicornis*) may be established in the park. If the buffalo population in the park were to be FMD-free, then cattle and buffalo incursions from Botswana could jeopardise the FMD-free status of such animals. The threat of poaching for rhino horn makes border security for the park an utmost priority.

Table 28. Western Border fence risk scenarios summary of findings. Note that for SAT-type FMD outbreaks caused by a strain not covered by the vaccine, the overall risk estimate is moderate.

Western Border fence			
Risk Scenario Disease/Route/Country	**Status Quo**	**Fence Removal**	**Fence Removal with Risk Mitigation**
	Probability of Occurrence / Risk Estimate		
SAT-FMD/cattle/Botswana	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/buffalo/Botswana	Negligible / Low	Negligible / Low	Negligible / Low
SAT-FMD/poaching/Botswana	Negligible / Low	Negligible / Low	Negligible / Low
FMD type O/cattle/Botswana	Very low / Moderate	Very low / Moderate	Very low / Moderate
SAT-FMD/cattle/Namibia	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/buffalo/Namibia	Very low / Low	Very low / Low	Very low / Low
SAT-FMD/poaching/Namibia	Negligible / Low	Negligible / Low	Negligible / Low
CBPP/cattle/Botswana	Very low or low / Moderate	Very low or low / Moderate	Very low / Moderate
PPR/small ruminants/Botswana	Very low / Low	Very low / Low	Very low / Low

4.1.4 Benefits and consequences of management strategies

The consequences of individual disease outbreaks have been explored earlier in this report, but the broader consequences of different management strategies have not.

In the transboundary landscape of KAZA, there is a need to re-evaluate the status quo of veterinary fencing policies in light of a fundamental conflict between fences and connectivity. Veterinary services departments or directorates have a mandate to control veterinary diseases, particularly those of economic importance. To that end, the KAZA Treaty includes "harmonisation…in the area of transboundary animal disease prevention, surveillance and control" (KAZA TFCA Treaty 2011). Veterinary fences have been a standard approach to disease control for decades but have far-reaching consequences outside the veterinary sector, standing in stark contradiction to other objectives of the KAZA Treaty, namely to "support healthy and viable populations of wildlife species" and "promote and facilitate the development of a complementary network of Protected Areas within the KAZA TFCA linked through corridors to safeguard the welfare and continued existence of migratory wildlife species" (KAZA TFCA Treaty 2011). The evolution of CBT now offers a non-geographic management alternative (i.e. with less reliance on fencing) for producing beef with negligible risk of FMDV.

Fences have benefitted farmers by preventing livestock from straying and reducing livestock theft (McGahey 2011). Fences have the ability to separate populations of animals to prevent transmission of transboundary diseases and associated economic impacts on farmers and governments. However, fences require continuous maintenance against elephant damage, human interference, and wear and tear to function as intended. Repairing damaged fences is costly and particularly challenging to implement in remote areas with difficult terrain which can be inaccessible during the rainy season. The growth of elephant populations in the KAZA region has placed unsustainable pressure on fencing infrastructure, with damages exceeding the maintenance budgets of veterinary departments or directorates.

Fences are not infallible in preventing disease transmission as intended. The construction of veterinary fences in 1995 failed to contain the CBPP outbreak in Ngamiland, though the country has remained free of the disease since then. Border fences have certainly limited (but not completely excluded) cattle movements from Namibia into Botswana and vice versa. It is important to note, however, that the overall risk of CBPP from Namibia has decreased after Namibia intensified its mass vaccination efforts in the NCA in 1997 and reduced CBPP incidence to very low sporadic levels (Namibia Directorate of Veterinary Services 2022).

Veterinary fences have had negative effects on wildlife populations through entanglements, restriction of natural seasonal migration routes, overpopulation of certain species due to inhibited dispersal, lack of access to historical water sources and restriction of gene transfer (Taylor and Martin 1987; Mbaiwa and Mbaiwa 2006; Osofsky 2019; Smith et al. 2020). Any benefit that fences provide as a possible deterrent to poaching is likely outweighed by the fact that fencing material is easily and frequently repurposed for wildlife snares (Taylor and Martin 1987). Veterinary fences also have negative impacts on subsistence livestock farmers by reducing accessible grazing and water points for cattle (Darkoh and Mbaiwa 2009). Local communities note a decline in wild herbivores since the construction of CBPP fences, which has resulted in an accumulation of dead biomass, leading to more bushfires (McGahey 2011). Fences limit wildlife presence in community lands and associated community-based natural resource management opportunities for alternative livelihoods (McGahey 2010). The multi-ethnic population in the Okavango Delta and in northwestern Ngamiland have variable preferences for different livelihoods, with a broad spectrum of land use priorities and opinions on veterinary fences (Darkoh and Mbaiwa 2009; McGahey 2010).

Removing fence sections has, as its most obvious benefit, the restoration of habitat connectivity in a part of the world where migration is crucial for the long-term viability of many wildlife populations and species. Connectivity is particularly vital given climate change's impacts on, for example, the availability of grazing and water resources over space and time. Removal of some fence infrastructure also removes the risk of fence entanglements at these sections, some of which are already in poor condition where loose wires may pose additional hazards, including the risk of fencing wire being repurposed for wildlife snares. Zebra (*Equus burchelli antiquorum*) movements from the Okavango Delta to Makgadikgadi recorded after removal of the Nxai Pan fence suggest that long range movements across ancient migration routes can resume within a few years of fence removal even after decades of physical barriers being in place (Bartlam-Brooks et al. 2011). Much remains to be understood about how wildlife movements might change if the fence sections studied here were removed. Restoration of wildlife movement patterns will be impacted by a complex set of interactions among ecological communities, climate change, hydrological cycles, availability of preferred habitat or prey species, proximity to human settlements and other factors.

While the intent of removing fence sections is to restore connectivity in KAZA's Wildlife Dispersal Areas and lower densities of wildlife such as elephants in areas of intense human-wildlife conflict by allowing for dispersal out of Ngamiland, it will be important to engage communities on both sides of fences during Phase 3 of this analysis should any fence sections be deemed acceptable candidates for removal based on the combined findings of Phase 1 and Phase 2.

4.1.5 Risk mitigation implementation

Implementing disease risk mitigation measures stands to benefit farmers and livestock. The H4H model is built on a One Health premise, with planned grazing to prevent overgrazing rangelands and use of mobile kraals to strategically fertilise soils with manure from the herd. In addition, fewer animals are likely to be lost and animal health should improve as a result of closer monitoring for signs of disease, better nutrition from planned grazing, and better immunity from improved body condition and routine vaccinations. In addition, farmers in compliance with H4H have access to better markets through CBT.

Risk mitigation has associated costs, particularly in terms of supplies such as vaccines and DVS manpower to conduct vaccination campaigns and surveillance. A cost-benefit comparison of these estimated costs versus the business-as-usual fencing maintenance and repair budget could prove beneficial in decision making. Relatedly, the stipends for ecorangers at existing H4H pilot sites have been subsidised as part of pilot efforts to date, raising the question of who will pay for these stipends in the future. There is an expectation that local communities will pay to support ecorangers, but the practicality of this remains to be seen. One potential solution would be to redirect some funds previously allocated for infrastructure such as cordon fencing into community-led risk mitigation such as H4H.

The H4H model depends on “bottom up” engagement from communities which are invested in implementing it. The percentage threshold of H4H adoption by farmers within a local community needed for it to be successful has not yet been formally established, but it appears that approximately 80% of farmers must agree to use these practices for the benefits to be realised (J. van Rooyen, personal communication). Lessons learned from successes and failures under the current implementations of H4H, particularly at pilot sites in Habu and Eretsha in Botswana, should be applied to future applications of the model at other sites in Botswana and Namibia.

Fully implementing CBT in Botswana and continuing to develop markets for CBT beef will be crucial steps for promoting improved herding practices. Partnerships between wildlife tourism entities and local beef producers stand to influence the mindset regarding management of cattle. The past prolonged closures of beef trade during FMD outbreaks in Ngamiland and the inability of farmers in the red zone to reach more lucrative export markets has cultivated an attitude of apathy among farmers. By improving marketing support for red zone farmers and offering a financial incentive for producing higher quality beef in co-existence with wildlife, compliance with H4H and better herding practices can become the norm.

It is clear that the status quo for FMD control measures in Ngamiland has gaps that must be filled to allow for effective risk mitigation. The risk mitigation strategy relies on a DVS having the capacity to carry out vaccination, surveillance and response measures that fall under its mandate. A 2023 European Commission audit of Botswana DVS FMD control found poor implementation of planned serosurveillance and subsequent planning of FMD vaccination campaigns, as well as challenges in filling vacancies for veterinarians (European Commission 2023). Other constraints also hinder surveillance efforts; for instance, in the April-June 2022 vaccination campaign, sampling for PPR surveillance was not done due to a shortage of supplies, and sampling for post incursion FMDV surveillance in subzones 2a and 2b was less than intended due to poor information dissemination to farmers and few cattle being presented.

The Botswana Vaccine Institute has experienced challenges in meeting production demand, and BNVL has lacked essential reagents needed to conduct PVM. The ability to acquire vaccine in a timely manner and ensure that the vaccine has provided adequate protection is heavily dependent on these regional entities being fully capacitated. Sharing of PVM data must also occur within DVS to allow for adaptation of vaccination programmes as needed. The vaccination coverage figures provide only a crude measure of the overall proportion of cattle that have been vaccinated; they do not provide any measure of the immunity induced by the vaccine or an overall estimate of herd immunity. Without these data, it is difficult for DVS to accurately assess the efficacy of their vaccination efforts and the existing level of protection in cattle in Ngamiland. Further, ongoing FMD outbreaks in Ngamiland despite regular vaccination campaigns demonstrate that this strategy alone is insufficient to control FMD. Given the cost of bi-annual vaccination campaigns, in terms of both personnel time and other resources, it is critical to analyse the effectiveness of these campaigns in the context of an overall FMD management strategy.

If fence sections are removed, conducting regular patrols of the former fence lines should be a part of the overall risk mitigation strategy. There are current patrols by Botswana DVS and regular bilateral NAMBOT patrols. The Botswana Defence Force camp, situated at the corner composed of the Zambezi Border and Northern Buffalo fences, also represents a resource for ensuring border security.

4.1.6 Limitations

There are limitations to this analysis. Botswana and Namibia are part of the greater KAZA landscape, and in close proximity to countries where CBPP exists, namely Angola and Zambia. Including data from these countries was beyond the scope of this assessment, but the risk from movements of animals from Angola and Zambia is acknowledged. That said, the risk mitigation factors recommended in this report are still effective in reducing the risks related to these countries as well.

Botswana and Namibia DVS staff were unavailable for significant periods of time during this study due to other commitments, including FMD outbreaks in both Botswana and Namibia, a CBPP outbreak in Namibia, and major audits in both countries. Minimal information was received from Namibia DVS, including geodata on crushpens or cattleposts. Older publicly available geodata have been used to provide an estimate of cattle densities but these data may not accurately reflect the current situation.

The available data have important limitations. The European Commission audit noted inconsistences in Botswana's Animal Identification and Traceability System (BAITS), including many dead animals still registered as alive. Traceability allows for improved outbreak management and while BAITS tagging is intended to be implemented on all cattle in Botswana, in reality BAITS coverage is far below 100%. For example, only 40% of cattle presented for vaccination in the April-June 2022 vaccination campaign were tagged with BAITS ear tags, and the BAITS system was not functional at the start of the April-June 2022 campaign and there was no network connectivity later on. BAITS records are therefore inadequate for estimating the true cattle population. Instead, cattle numbers are typically estimated from vaccination records. However, although required to present their cattle for vaccination by Botswana legislation, some farmers fail to do so, and vaccination numbers do not represent the entire cattle population as a result.

The vaccination coverage numbers for Botswana can be skewed upwards in two ways. Expected numbers are reportedly based on the number of cattle presented at the previous vaccination plus 15%, although this could not be replicated using numbers from sequential vaccination campaigns. Vaccination coverage is calculated by dividing the number of cattle presented for vaccination by the number of cattle expected. Given the poor turnout for vaccination in some areas of Ngamiland, the number of cattle presented may be well below the true population, artificially inflating vaccination coverage figures. In other cases, more cattle are presented for vaccination than the expected number, leading to vaccination coverage rates in excess of 100%. More current and accurate data on cattle numbers are needed to effectively implement vaccination and surveillance programmes.

FMD and CBPP were identified as the diseases of interest when this disease risk assessment was first being designed, given their reportable nature and economic impact, but there are obviously other cattle diseases which have the potential to spread under a fence removal scenario. The unique risk to each country must be assessed based on its current situation and that of its neighbours. PPR was identified as a disease of particular interest late in the course of the project and it did not receive the same level of discussion or data gathering as the cattle diseases. In general, small stock are more likely to remain closer to cattleposts rather than roam long distances as cattle do. Illegal movement of livestock is likely the biggest risk factor for PPR, against which fences offer only limited protection.

4.2 Recommendations based on qualitative risk assessment (prior to validation meeting)

The results of this disease risk assessment provide qualitative estimates of risks for various diseases at three fence lines, and the findings based on these risks are presented in Table 29. Overall, the risk assessment indicated that removing the specific fence sections evaluated would not increase the risk from that of maintaining the status quo. In some cases, the probability of disease occurrence under the fence removal scenario decreased with the addition of risk mitigation measures.

The fence sections recommended for community engagement (Phase 3) on potential removal or re-evaluation in the future are shown in Figure 28. Ultimately, any decision to remove one or more fence sections from a DVS perspective relies on a determination of an acceptable level of risk in terms of livestock diseases and must be informed by relevant data from the region and scientific understanding of the diseases themselves. This study was of course monosectoral in nature, being focused only on the perspective of the livestock sector. The impacts of veterinary fences on wildlife populations in Botswana and KAZA more broadly were the subject of the Phase 1 fencing study carried out with Defra support (Atkinson et al. 2022), and neither that Phase 1 analysis nor this Phase 2 report fully capture the overall benefits and costs of current fencing policies versus those of potential scenarios involving some removal. Such a need for holistic decision making is the raison d'être for Botswana having a “whole of government” National Committee on Cordon Fences.

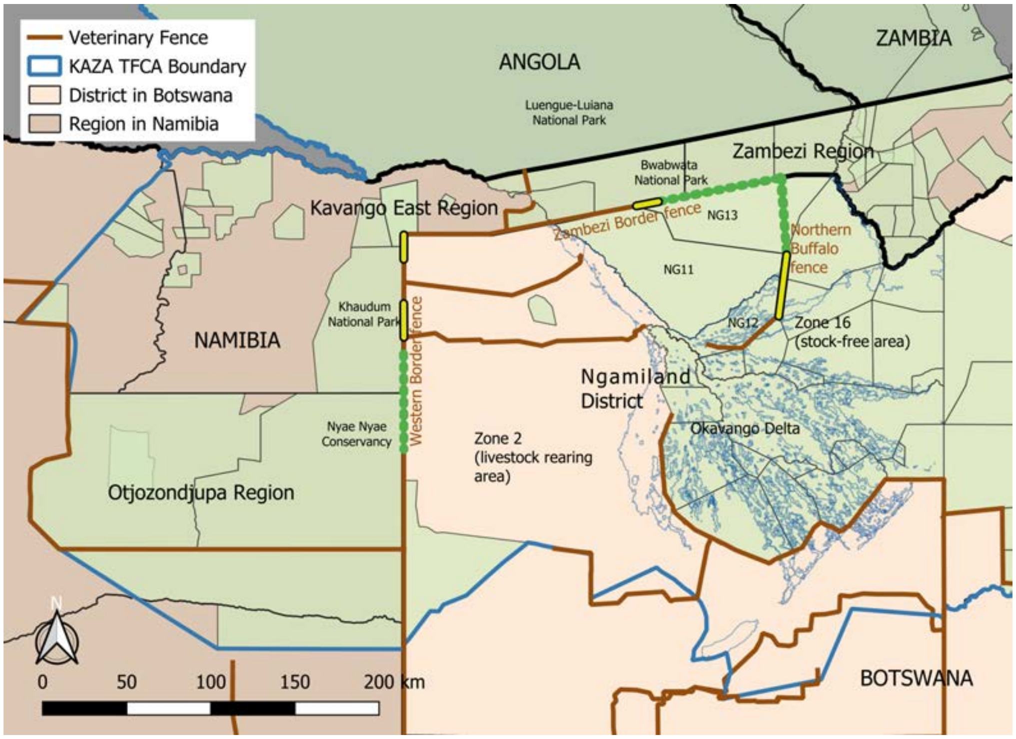


Figure 28. Fence sections recommended for Phase 3 community consultations on potential removal (green) or re-evaluation in future (yellow) based on livestock disease risk.

Table 29. Recommended actions for key fence sections based on livestock disease risk.

Fence	Recommendations
Zambezi Border (east of the Okavango River) - eastern section (90 km) in NG13	**Community consultation (Phase 3) on potential removal of eastern section (75km) in NG13** The greatest overall risks were those from CBPP and FMDV serotype O, given their high consequences. If fence removal with additional risk mitigation was the desired option, the removal of cattle from Bwabwata National Park is the most important of the proposed risk mitigation factors at this fence, because doing so removes the nearest source of transmission of pathogens from Namibia. Removal of these cattle reduces the risk of disease transmission to cattle in Botswana to negligible, and similarly lowers the risk of disease in Namibia if there are no cattle to which to transmit. While both CBPP and FMDV serotype O had a very low probability of occurrence in this area, the high consequences associated with an outbreak of either elevate the risk estimate to moderate. Otherwise, the risks of SAT-type FMD and PPR were considered very low, and when combined with moderate consequences, the overall risk estimate was low. Leaving a section of fence at the western end of NG13 would restrict potential movement of animals from Tovera settlement in Botswana. **Re-evaluate western section in NG13 (15km) after risk mitigation implementation** If cattle were removed from Bwabwata National Park and H4H implementation around Tovera were successful, the remainder of the fence along NG13 could be considered for removal.
Northern Buffalo – northern section (80 km) in NG13,	**Community consultation (Phase 3) on potential removal of northern section (45 km) in NG13** The probability of SAT-type FMD from buffalo or poaching occurring was very low, and the overall risk estimate was low. Although effective contact between buffalo and cattle

NG11 & top of NG12	is believed to be rare, the large number of buffalo in the delta and the density of cattle along the southern part of the Northern Buffalo fence may pose a higher risk than the mostly uninhabited section of NG13. Notably, aerial survey data show that buffalo are already present despite the presence of the fence, but FMD has not been reported in this area of subzone 2a. Farmers in this region have also long been sensitized to the potential disease risk from buffalo and may be more reluctant to have fences around them removed unless results of Phase 1 and Phase 2 can be clearly shared with them. However, there has been a successful H4H pilot running in Eretsha for several years, so the local communities are familiar with this model and its benefits. **Re-evaluate southern section in NG11 & NG12 after risk mitigation implementation** If H4H implementation in the northern delta were successful, the remainder of the fence section along NG11 and NG12 could be considered for removal.
Western Border – sections along northeast Khaudum National Park, north of Ikoga fence, south of Ikoga fence to Dobe	**Community consultation (Phase 3) on potential removal of southernmost (55 km) section bordering Nyae Nyae Conservancy and southern Khaudum National Park** The greatest risk to Botswana along this fence line is an outbreak of CBPP and loss of Botswana's free status. Although considered very low, this risk is perceived to be highest at the more northern sections proposed for removal in the Phase 1 analysis, given their closer proximity to the border with Angola, which is the source of CBPP infections in Namibia, and the lack of recent history of CBPP in Namibia further south. Botswana's surveillance plan identifies specific crushes in the extreme northwest of Ngamiland as high risk for CBPP. The southernmost section proposed for removal in this Phase 2 analysis largely borders Otjozondjupa; there are no high-risk surveillance crushes in this area and CBPP has not been reported this far south. The FMD-free buffalo, limited number of cattle and lack of recent FMD outbreak history on the Namibian side of the fence make the risk of SAT-type FMD to Botswana very low. **Re-evaluate northern sections bordering Khaudum National Park pending continued absence of CBPP cases in Kavango East Region** If CBPP cases in Namibia remain sporadic and Kavango East remains free of cases, the other fence sections bordering central and northern Khaudum National Park could be considered for removal.

4.3 Recommendations based on special considerations identified at validation meeting

In May 2024, a meeting of the core team, the majority being Botswana DVS and Namibia DVS stakeholders, was held in Maun, Botswana to validate the results of the report and allow for bilateral discussions between the Governments of Botswana and Namibia on the fence sections proposed for Phase 3. Group discussions during the validation meeting (also see Appendix Y) brought to light several special considerations:

- Although the probability of occurrence for FMD serotype O at the Zambezi Border fence was very low and group discussions noted that FMD serotype O was likely more of a risk to Chobe District than to Ngamiland, based on proximity to Zambia, the moderate overall risk estimate for this disease was an overriding factor in decision making for this fence line.

- Fence patrols that are already in place help with detection of illegal movement of livestock or cattle theft. These patrols should be an explicit part of risk mitigation if fence sections were to be removed. The Botswana Defence Force camp at the junction of the Zambezi Border and

Northern Buffalo fences provides some confidence for considering removal of sections of either fence.

- The severity of the consequences of stamping out of the 1995 CBPP outbreak in Botswana has resulted in lingering apprehension about the recurrence of the disease in Botswana. Although meat other than lung is still considered safe for trade regardless of CBPP status, trade of live cattle would be affected in the event of an outbreak.

- One important limitation of the analysis was that it did not account for the complete extent of cattle mobility in the region; farmers may move cattle seasonally to different grazing areas. In addition, borehole rights may be owned but not yet developed and could represent future areas of livestock presence not shown on existing maps.

- Although fences do not represent barriers impermeable to all movement, removal of fence sections entirely could facilitate illegal movement of animals and people and possible spread of transboundary animal diseases and poaching. While the attendees agreed that the risk of an FMD outbreak from poaching was minimal, there was concern about poaching of wildlife resources in general, particularly if animals move into areas with higher relative poaching pressure. This could act as a deterrent to animal migration (e.g. if there were significant poaching pressure in Angola, elephants might avoid leaving the eastern panhandle in Botswana to disperse to this area). That said, poaching pressure in northern Botswana itself is not insignificant. In the KAZA context, fence removal decisions would benefit from consultations between, for example, the Animal Health Sub Working Group and the Elephant Sub Working Group.

- Complete data on cattle incursions had not been provided to assist in understanding the risks for the Western Border fence, as there was anecdotal knowledge of more cattle movement than what was documented in the report. However, some of these incursions may have occurred further south in areas not proposed for fence section removal.

As a result of the Maun May 2024 validation meeting, the final recommendations are more conservative than the initial suggestions based purely on the qualitative risk assessment. The final recommendations based on these special considerations and further discussion are presented in Table 30, below. The fence sections recommended for community engagement (Phase 3) on potential removal or re-evaluation in the future are shown in Figure 29, below.

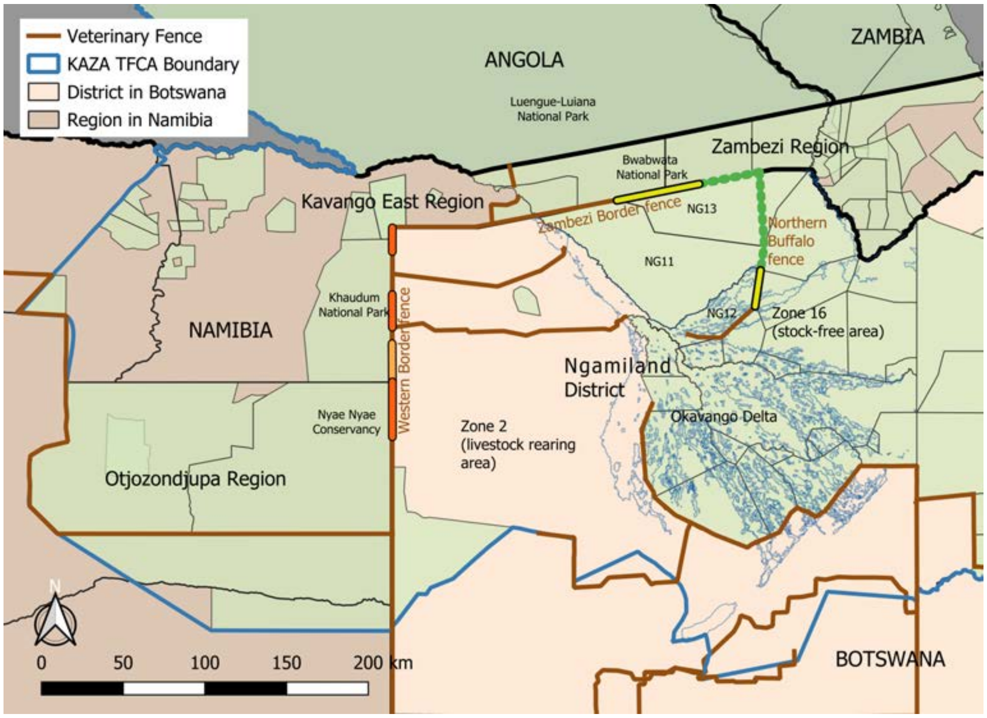


Figure 29. Fence sections recommended for Phase 3 community consultations on potential removal (green) with risk mitigation or re-evaluation in future (yellow) based on bilateral consideration. Sections of the Western Border fence (dark and light orange) were not recommended for removal at this time, though one 23 km section (light orange) was highlighted as being a potential candidate in the future pending further information.

Table 30. Recommended actions for key fence sections agreed upon during validation meeting.

Fence	Recommendations
Zambezi Border (east of the Okavango River) - eastern section (90 km) in NG13	**Community consultation (Phase 3) on eastern 35 km section, subject to risk mitigation measures** Fence removal would be done in phases, starting with the 35 km easternmost section, furthest from Tovera and Omega settlements. Risk mitigation would involve actions on the part of both Botswana and Namibia. Removal of the cattle from Bwabwata National Park is a key risk mitigation step for fence removal, particularly to minimise the risk of FMD serotype O. Namibia would need to improve the existing 15 km buffalo fence that separates the western multiple use area from the rest of the park and extend the fence westward to run along the Namibia-Angola border to the park boundary at the Okavango River. This would restrict movement of cattle into the park from settlements along the western border of Bwabwata. In Botswana, the farmer at Seshokora crush would also need to be resettled and compensated, to avoid the presence of cattle in NG13, or participate in H4H. **Re-evaluate western section in NG13 (55km) after risk mitigation implementation** If cattle were removed from Bwabwata National Park and H4H implementation around Tovera were successful, the remainder of the fence along NG13 could be considered for removal.
Northern Buffalo – northern section (80 km) in NG13,	**Community consultation (Phase 3) on potential removal of section to Selinda Gate (62 km), subject to risk mitigation measures**

NG11 & top of NG12	The disease risks along the Northern Buffalo fence were perceived to be the most limited, given the fact that it is an internal fence. However, the greatest concern with potential removal of this fence was the risk of increased cattle-buffalo contact in the eastern panhandle. Fence removal would be done in phases, starting with the northernmost 62 km section from Xhoroma to Selinda Gate. Risk mitigation for this fence would involve two related actions. The farmer at Seshokora crush would need to be resettled and compensated, to avoid the presence of cattle in NG13, or participate in H4H. In addition, H4H would need to be implemented at cattleposts in the eastern panhandle. Controlling cattle movement and limiting cattle-buffalo contact under H4H would serve to mitigate the risk of buffalo moving into the area. **Re-evaluate southern section in NG11 & NG12 after risk mitigation implementation** If H4H implementation in the eastern panhandle were successful, the southern sections closer to the cattleposts could be re-evaluated for removal.
Western Border – sections along northeast Khaudum National Park, north of Ikoga fence, south of Ikoga fence to Dobe	**Pause consideration of community consultations until further information gathered and harmonised animal health controls in place** Additional information on cattle incursions was requested to form a more complete picture of the disease risk along this fence, as was other information on elephant migration and human-wildlife conflict. Border security was also noted to be of interest. Given the perceived higher risks, particularly for CBPP, both countries felt there was a need for better harmonised animal health controls throughout KAZA, with specific emphasis on CBPP and PPR, before further consideration of potential removal of parts of this fence in a phased approach. A 23 km section, south of the Ikoga fence, bordering Khaudum National Park, was tentatively identified as a possible future candidate for consideration, depending on the success of risk mitigation measures elsewhere in Ngamiland.

4.4 Way forward

This report is the second of a three-part project evaluating veterinary fences in Botswana's component of KAZA, some of which border Namibia, and their impact on the overall vision for an ecologically and economically successful TFCA. The first phase, completed in 2022, evaluated the fences based on their impacts on wildlife movements and recommended the removal of sections of several fences (Appendix A) from a wildlife conservation perspective. The recommendations from Phase 1 are shown in light blue in Figure 30. The second phase (this report) goes on to analyse how the risk of important livestock diseases might change if these sections were removed to promote habitat connectivity across the greater KAZA landscape. The initial recommendations from Phase 2, based on livestock disease risk as assessed prior to the validation meeting, are shown in green ellipses in Figure 30. A third and final phase would entail consultations with communities that could be impacted, positively or negatively, by the removal of any specific fence or fence section as proposed by the first two phases and associated deliberations. Cumulatively, the three phases of work will inform national, bilateral and KAZA-level planning efforts within the context of regional collaboration and cooperation in the areas of disease risk management, natural resource use and management, and community development.

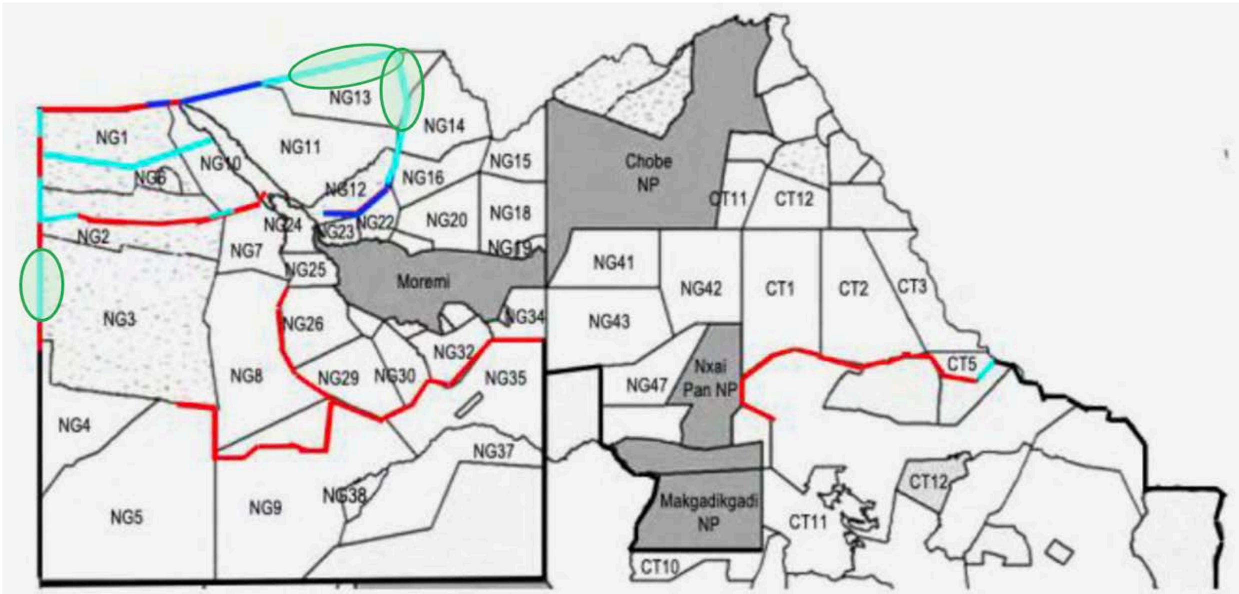


Figure 30. Three sections of fences (green ellipses) in northern Botswana initially recommended for Phase 3 review (community consultations on potential removal), which represent a smaller span of fencing than originally identified for potential removal in the Phase 1 report. Phase 1 had evaluated the fences based on their impacts on wildlife movements, as per this map derived from the Phase 1 report's Figure A, wherein dark blue and pale blue had indicated fences that were most negatively impacting wildlife that merited further analysis, a process now beginning to be addressed via this Phase 2 report. Note that the Samochima and Ikoga fences were not evaluated in the Phase 2 analysis, but they are still important to consider due to their impacts on wildlife movements, as per the Phase 1 analysis findings.

The potential impact of fence removal on local communities and the importance of considering their perspectives and concerns in decision making is not to be underestimated. Communities have often been excluded from decision making on addition or removal of fences, despite being directly impacted by these fences. Community acceptance of H4H implementation is central to much of the approach to risk mitigation described in this report, and disease risks cannot be effectively mitigated if livestock movements are largely uncontrolled. The H4H model is one that can only be effective in self-motivated communities that are amenable to adopting these practices, and it will not be successful if made compulsory by a top-down approach without community buy-in. It should also be noted that the costs of implementing H4H broadly in Ngamiland may compare favourably with the expenses associated with the constant need for fencing repairs due to elephant damage and other causes. To our knowledge, no one has compared these types of investments and their associated returns on genuine risk mitigation (and improved livelihoods as associated with CBT in the case of H4H).

Risk mitigation such as vaccination cannot be effectively implemented without a fully capacitated DVS. Botswana DVS in particular has experienced funding setbacks, and at the time of its 2022 EU audit, had a 31% vacancy rate in veterinary posts (European Commission 2023). Botswana DVS has experienced further losses since then. It is imperative for there to be a strong business case to support acquisition of adequate funding to support DVS risk management activities. Similarly, collaboration among neighbours is imperative to regional disease control. The safety of livestock in Botswana and Namibia depends in part upon the disease control efforts of the other KAZA Partner States and neighbours. Harmonisation of disease control among countries, particularly in high-risk border areas, is essential to optimise these efforts, and is an ongoing priority for the KAZA Animal Health Sub Working Group.

Evidence from Chobe District in Botswana supports the possibility of effective control of livestock diseases without veterinary fences, even along international borders. Chobe District has not had an FMD outbreak reported in WAHIS since 2015, and Botswana has plans to eventually declare zone 1 in Chobe District FMD-free with vaccination. Chobe's high vaccination coverage (~99% in 2022 vs. 82% in Ngamiland) and tri-annual vaccination schedule, in addition to its active herding and kraaling practices, have resulted in better prevention of FMD outbreaks than in Ngamiland. That in and of itself provides an incentive to look very closely at historical fencing policies in Ngamiland and elsewhere in KAZA, and the actual returns on that investment.

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APPENDIX A: Executive summary from Phase 1 report

Veterinary Fences in Botswana's Portion of the KAZA TFCA: Assessment of Status and Impacts on Wildlife

Executive Summary – April 2022

AHEAD (Animal & Human Health for the Environment And Development) Programme
Cornell University

Citation

Atkinson, S. J., Albertson, A., Naidoo, R., Ramsden, N., Songhurst, A. & Osofsky, S. A. (2022).
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This report is dedicated to the memory of our colleague Mr Gareutlwane Gaopatwe,
Chief Scientific Officer, DVS.

EXECUTIVE SUMMARY OF RECOMMENDATIONS

This report provides an assessment of the impacts of veterinary fences in Botswana's component of the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) on wildlife, with a special focus on KAZA's Wildlife Dispersal Areas (WDAs). This initial analysis is not designed to evaluate fences in terms of disease control aspects or socioeconomic perspectives - that work still needs to be undertaken. Instead, this report serves as a steppingstone to inform national and KAZA-level planning efforts.

The findings and recommendations are based on analyses of ~10 years of data from GPS collared wildlife from both Botswana and Namibia, observations from aerial surveys and data collected via ground surveys that provided close visual inspection of fence damage and animal-fence encounters (inferred from spoor). Under the AHEAD programme (Cornell University) umbrella, an assembled team undertook the work between November 2020 and March 2021, a timeframe that was admittedly compressed due to COVID and related challenges.

The key fences considered were the Zambezi Border (both east and west of the Okavango River), Western Border, Northern Buffalo, Samochima, Ikoga and Ngwasha. All six (i) are considered major fences, (ii) have veterinary control as their primary function and (iii) fall within one of the three WDAs where fences have been identified as impacting wildlife movement, namely the Kwando River, Khaudum-Ngamiland and Hwange-Makgadikgadi-Nxai Pan WDAs. Other fences briefly touched on include the Southern Buffalo, Setata, Zimbabwe-Botswana Border and Proposed Elephant Proof fence. The overall summary of findings that informed these recommendations are outlined in Section 6 of the report.

Recommendations

The fence sections recommended for removal or removal pending further evaluation are shown in Figure A. This analysis did not focus on issues such as modifications of fencing designs.

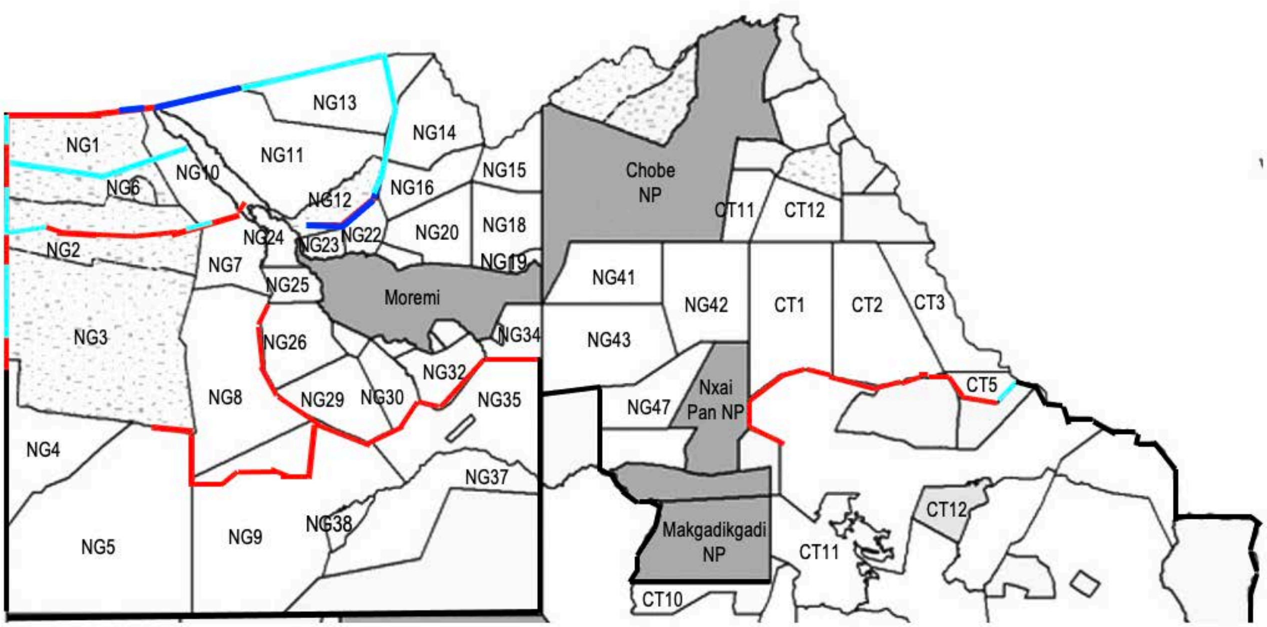

Figure A. Fences sections recommended for removal (pale blue lines) or removal pending further evaluation (dark blue lines). Additional surveyed fences (red lines) and other major fences (thick black lines) are indicated.

The list of recommendations delineated in Table A below have been marked for their level of urgency. Those listed as 'high' are considered critical from the perspective of enabling wildlife movement and WDA functionality, but also have a bearing on the state of human wildlife conflict (HWC) levels and coexistence.

Table A. Recommended actions for key fences from the wildlife perspective. Fences marked as high in terms of urgency level have been approved for the phase 2 disease risk assessment as of 2022, except for the proposed Elephant Proof fence as it never progressed to being included in the approved National Elephant Management Plan.

Fence	Recommendations	Urgency
Zambezi Border (east of Okavango River)	**Remove east section of fence in NG13** Despite its dilapidated status in many places, the fence is substantially restricting elephant and other wildlife movement from the eastern Panhandle into areas of suitable habitat in Namibia and Angola. Human elephant conflict (HEC) is also high, due in part to the fence 'bottling up' this population. To alleviate these impacts, removal of the east section of the fence is required. This area (NG13) is devoid of cattle in close proximity to the fence on the Botswana side, however, cattle exist in Bwabwata National Park (NP) on the Namibia side. Removal of cattle in Namibia will need to take place prior to fence removal to create a livestock-free buffer zone – the consultative process for which is already underway. Note: realignment is not recommended as this would restrict elephant movement out of NG11 into NG13 during the wet season and preclude the alleviation of pressure on people in NG11 during that time.	High
	Re-evaluate west half of fence in NG11 pending review of livestock movement Elephant movement/build-up is also occurring closer to the Okavango side in NG11. This section of fence is, however, characterised by continuous livestock presence, cattleposts and settlements on the Botswana side. A review of these in relation to future recommendations on fence removal is required, particularly given differing land use on the Namibia side.	Medium
Northern Buffalo	**Remove north section of fence (80 km) in NG13, NG11 & top of NG12** This fence, which adjoins the Zambezi Border fence, is similarly restricting elephant and other wildlife movement from the eastern Panhandle to the east and then north across the WDA. Likewise, HEC is high, due in part to the fence 'bottling-up' this population. To alleviate these impacts, removal of the north part of fence is required. This section is largely devoid of cattle in close proximity to the fence, with only 1 cattlepost at Shishikora in NG13 (a wildlife management area). No cattle are present east of the fence. Note: realignment is not recommended as this would restrict elephant movement out of NG11 into NG13 during the rains and preclude the alleviation of pressure on people in NG11 during that time.	High
	Retain south end in NG12 while reviewing its necessity for disease control The extreme south end of the fence has likely contributed to protecting the northern delta from cattle incursion and to reducing foot and mouth disease (FMD) risk. However, due to periodic flooding and ongoing elephant/human damage, it is very porous. Many wildlife species, including buffalo, now move back and forth. It is therefore recommended that the necessity of this fence section be reviewed. Tourism operators and communities are collaboratively exploring opportunities to optimise the value of the wildlife resource through removal of this portion of the fence. Cattle herding practices in NG12 would, however, need to be improved to keep cattle away from core delta wildlife areas and from further interacting with buffalo (south of NG12 in NG22/NG23).	Medium
Zambezi Border (west of Okavango River)	**Re-evaluate fence after reviewing holistic strategies for connecting east end with Mahango/ Bwabwata NP** The fence is well maintained and clearly a priority to DVS in terms of protecting Botswana from the cross-border spread of animal disease. Wildlife movement is, however, significantly restricted at both ends. **East end**. Although this section is limiting wildlife movement across the border (into Mahango/ Bwabwata NP), there is a need to minimise HWC on the Botswana side. Mohembo-West and Shakawe both lie in close proximity and ideally transboundary wildlife movements should be encouraged away from human settlements. Slightly further west however ecotourism is proposed in	Medium

Fence	Recommendations	Urgency
	the Shaikarawe Forest Conservation Area and farmers have expressed interest in turning cattle boreholes over to wildlife. Some wildlife does move across the fence in this area. Strategies to connect protected areas here should be developed, whilst considering the need to address HWC. This may include fence modifications at strategic locations. Consultation with Namibia is required in order to agree to the same with regards to their fencing. **West end.** It is possible that impacts on wildlife movement could be mitigated without removing the west end of the fence. That is, if a segment of fence along the Western Border fence close to the top of Khaudum NP is opened up, animals could funnel down to the gap and cross there.	
Western Border	**Remove sections of fence at strategic locations along border with Khaudum NP/Nyae Nyae** The fence is substantiality restricting cross-border wildlife dispersal, critical to WDA functionality. To alleviate ongoing impacts, exacerbated by recent repair work, removal of sections at strategic locations within NG1, NG2 and NG3 is required. Locations include: (i) first 15 km section [from north] adjacent to the north-east corner of Khaudum NP, (ii) a ~20 km section immediately north of the Ikoga junction and (iii) a ~60 km section beginning 10 km south of the Ikoga junction in Xaudum valley to 6 km south of Xaranxago village. Facilitating wildlife movement and population rehabilitation in NG1, NG2 & NG3 is also essential to existing wildlife-related income generation (e.g. in Xaranxago & Nxau-Nxau) and expected income streams (e.g. KAZA-supported Heritage Trail). Livestock presence is limited along the fence and communities with small numbers of cattle in NG3 are actively herding. In other areas, models like Herding for Health that promote active herding and community-level monitoring can be implemented. Consultation with Namibia is recommended in order to agree to the same with regards to their fencing.	High
Samochima	**Remove entire fence** This fence has the least impact on wildlife and WDA functionality. Nevertheless, in its current state there is no rationale why this fence should be retained.	Low
Ikoga	**Remove western most section (20 km) adjoining Namibia border** This area close to the border is largely devoid of livestock in close proximity to the fence and is being used for north-south movement of wildlife. Removal of this section, if aligned with a section left open on the Western Border fence, could facilitate movement across the Ikoga fence and into neighbouring Khaudum NP. The remaining western half of the Ikoga fence may merit further evaluation should it be repaired.	Medium
	Remove short segments between 30-45 km point (from east) around NG2/NG7 boundary Wildlife concentration/build-up is evident along this recently repaired section (only elephants appear able to cross, on occasion). Cattleposts are concentrated to the west of this point, i.e. along the central portion of the fence. Removing short segments of the fence either side of the NG2/NG7 boundary (creating gaps) would alleviate impacts and enable north-south movement.	Medium
Ngwasha	**Remove eastern most section (17 km) adjoining Zimbabwe border** The fence appears quite porous with many breakages along this section and lots of wildlife movement occurring between Ngwasha and Sepako. Removal of this section would facilitate movement between Ngwasha/Sepako/Hwange.	Medium
	Lower height of top wire at strategic locations along fence This fence forms the boundary between the FMD-endemic 'red' zone to the north and FMD-free 'green' zone to the south. Because elephants and giraffe are clearly crossing or trying to cross the fence and there are a number of damaged sections along the fence, future evaluation of potential modifications is likely indicated unless removal is ever deemed possible.	Medium
Proposed Elephant Proof	**Retain original alignment within Hwange-Makgadikgadi-Nxai Pan WDA** A thorough environmental impact assessment is required before this proposed fence alignment is finalised. Altering the alignment, for example, to track north to join the Ngwasha fence would have notable repercussions from a wildlife perspective, negatively impacting functionality of the WDA.	High

APPENDIX B: Risk assessment methodologies document

Methodological Options for Exploring Potential Changes in Livestock Disease Transmission Risk for Scenarios Involving Partial Decommissioning of Specific Veterinary Cordon Fences

Prepared by Laura Rosen, DVM, PhD
On Behalf of the Kavango-Zambezi Animal Health Sub Working Group
12 September 2022

Executive Summary of Recommendations

This draft document provides a compilation of options for assessing the disease risk associated with decommissioning veterinary fences in Botswana's component of the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA). Previous work organized by the AHEAD programme (Cornell University), in partnership with the KAZA Secretariat and Botswana's National Committee on Cordon Fences, made recommendations for consideration of removal of key portions of veterinary fences in Botswana based on their perceived impact on wildlife, supported by wildlife GPS collar data and observations from aerial and ground surveys. These fences are depicted in Figure A, and the three fences for which partial removal was recommended as a high priority are further described in Table A.

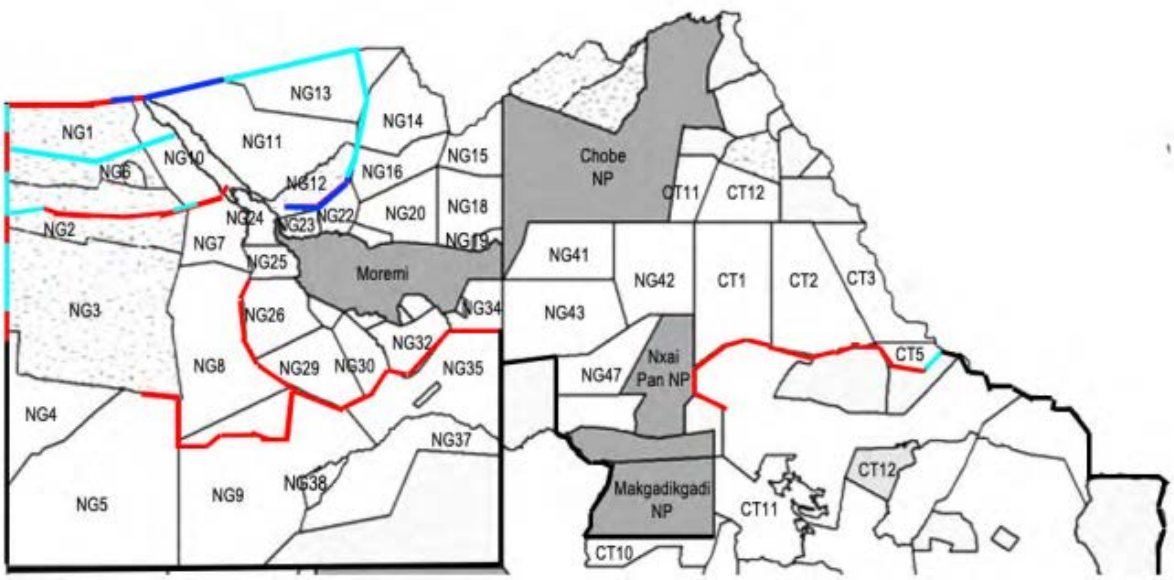

Figure A. Veterinary fences in Botswana, with fence sections recommended for removal from the wildlife perspective in pale blue, those recommended for removal pending further evaluation in dark blue, other surveyed fences in red, and other major fences in black (1)

Table A. Abridged recommendations for key fences based on impacts on wildlife (1)

Fence	Recommendations
Zambezi Border (east of Okavango River)	**Remove east section of fence in NG13** Despite its dilapidated status in many places, the fence is substantially restricting elephant and other wildlife movement from the eastern Panhandle into areas of suitable habitat in Namibia and Angola. Human elephant conflict (HEC) is also high, due in part to the fence 'bottling-up' this population. To alleviate these impacts, removal of the east section of the fence is required. This area (NG13) is devoid of cattle in close proximity to the fence on the Botswana side, however, cattle exist in Bwabwata National Park (NP) on the Namibia side. Removal of cattle in Namibia will need to take place prior to fence removal to create a livestock-free buffer zone – the consultative process for which is already underway. Note: realignment is not recommended as this would restrict elephant movement out of NG11 into NG13 during the wet season and preclude the alleviation of pressure on people in NG11 during that time.
Northern Buffalo	**Remove north section of fence (80 km) in NG13, NG11 & top of NG12**

	This fence, which adjoins the Zambezi Border fence, is similarly restricting elephant and other wildlife movement from the eastern Panhandle to the east and then north across the WDA. Likewise, HEC is high, due in part to the fence 'bottling-up' this population. To alleviate these impacts, removal of the north part of fence is required. This section is largely devoid of cattle in close proximity to the fence, with only 1 cattlepost at Shishikora in NG13 (a wildlife management area). No cattle are present east of the fence. Note: realignment is not recommended as this would restrict elephant movement out of NG11 into NG13 during the rains and preclude the alleviation of pressure on people in NG11 during that time.
Western Border	**Remove sections of fence at strategic locations along border with Khaudum NP/Nyae Nyae** The fence is substantiality restricting cross-border wildlife dispersal, critical to WDA functionality. To alleviate ongoing impacts, exacerbated by recent repair work, removal of sections at strategic locations within NG1, NG2 and NG3 is required. Locations include: (i) first 15 km section [from north] adjacent to the north-east corner of Khaudum NP, (ii) a ~20 km section immediately north of the Ikoga junction and (iii) a ~60 km section beginning 10 km south of the Ikoga junction in Xaudum valley to 6 km south of Xaranxago village. Facilitating wildlife movement and population rehabilitation in NG1, NG2 & NG3 is also essential to existing wildlife-related income generation (e.g. in Xaranxago & Nxau-Nxau) and expected income streams (e.g. KAZA-supported Heritage Trail). Livestock presence is limited along the fence and communities with small numbers of cattle in NG3 are actively herding. In other areas, models like Herding for Health that promote active herding and community-level monitoring can be implemented. Consultation with Namibia is recommended in order to agree to the same with regards to their fencing.

Prior to any decommissioning of veterinary fences, it is essential to evaluate the potential change in animal disease risks versus the status quo. Some fences are currently in a state of disrepair, and therefore are not effective as intended in completely restricting the movement of animals. The risk assessment will encompass the following evaluations:

- comparison of risk of FMD to cattle under current Zambezi Fence versus risk of FMD under proposed fence decommissioning approach
- comparison of risk of CBPP to cattle under current Zambezi Fence versus risk of CBPP under proposed fence decommissioning approach
- comparison of risk of FMD to cattle under current Northern Buffalo Fence versus risk of FMD under proposed fence decommissioning approach
- comparison of risk of FMD to cattle under current Western Border Fence versus risk of FMD under proposed fence decommissioning approach
- comparison of risk of CBPP to cattle under current Western Border Fence versus risk of CBPP under proposed fence decommissioning approach

General Approach

The general approach towards the risk assessment is modelled after the WOAH's guidelines for import risk analysis, and can be summarized as the following steps:

- identify hazards of interest (*What could go wrong?*)
- develop scenario tree that defines events necessary for a hazard to occur (*What steps have to happen for the disease outcome to occur?*)

- collect relevant data sources (*What do existing data tell us about the risk, and how certain are we about this information?*)
- elicit expert opinions (*If we don't have data, what do experts think about the risk, and how certain are they about their opinions?*)
- perform risk assessment (*Combine data, expert opinion, and the level of certainty to generate a final estimate of risk*)
- prepare report on risk assessment (*Report the findings and document how we arrived at them*)
- risk communication to stakeholders (*Throughout the process and ensuing management decisions, communicate with fencing stakeholders*)

Risk Assessment Options

The risk assessment can be conducted by a variety of methods, which are broadly categorized as qualitative, semi-quantitative, or quantitative. No single approach is universally recommended for all scenarios, and the availability of data is key to determining the most appropriate type of risk assessment for a given scenario. Data sources can include disease reporting systems, published research or risk assessments, livestock movement records, and historical disease occurrence data. When data availability is insufficient to determine risk, expert opinions are often elicited to provide an informed estimate of risk. All risk analyses are only as accurate as the data underlying them. The different approaches are summarized in Table B.

Table B. Summary of risk assessment approaches that could potentially be used for the veterinary fencing situation in Botswana, along with the resources needed to complete each.

Method	Description	Needs
Qualitative risk assessment	The most common type of risk assessment performed, and appropriate in the absence of numerical data on which to base probability calculations. Risks are represented as defined categories such as "low", "moderate", and "high". All the risks in the scenario tree are combined using defined matrices, resulting in a qualitative final risk estimate. Uncertainty about each risk is also characterized.	Data for each step in scenario tree Expert opinions Defined risk categories Defined risk matrix/matrices Uncertainty estimates
Semi-quantitative risk assessment	A combination of qualitative and quantitative approaches. Risks are first described in qualitative categories, then converted to pre-determined numerical probability ranges to calculate numerical probabilities. The final calculated risk may then be converted back to a qualitative risk category. Uncertainty about each risk is also characterized.	Data for each step in scenario tree Expert opinions Defined risk categories Quantitative risk ranges Software for calculating probabilities (e.g., R)
Quantitative risk assessment	The most complicated type of risk assessment performed, where risks are calculated as mathematical probabilities based on models informed by numerical data. Referenced numerical data are required for each step in the scenario tree, as is a model that describes the overall risk. Uncertainty can also be incorporated into the model. This option is the most time and data-intensive to complete.	Data for each step in scenario tree Expert opinions Software specific to analysis (e.g., @RISK, R, GeNIE)

Abbreviations

AHSWG	Animal Health Sub Working Group
BBN	Bayesian Belief Network
CBPP	Contagious Bovine Pleuropneumonia
CBT	Commodity-Based Trade
DAG	Directed Acyclic Graph
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus
IPPC	International Plant Protection Committee
KAZA	Kavango Zambezi Transfrontier Conservation Area
OIE	Office International des Épizooties (World Organization for Animal Health; now WOAH)
SPS	Sanitary and Phytosanitary Measures
TAHC	Terrestrial Animal Health Code
TFCA	Transfrontier Conservation Area
WDA	Wildlife Dispersal Area
WOAH	World Organisation for Animal Health
WTO	World Trade Organization

Suggested Definitions

Important terms in animal health risk analysis and their suggested definitions: (2)

Risk analysis: the process which includes risk assessment, risk management and risk communication
Risk assessment: the process of identifying a hazard and evaluating the risk of a specific hazard, either in absolute or relative terms. This process includes estimates of uncertainty and is objective, repeatable and scientific. Quantitative risk assessment characterises the risk in numerical representations.
Hazard: elements or events which represent potential harm; an adverse event or adverse outcome. In risk analysis, hazard is specified by describing what might go wrong and how this might happen.
Risk: the likelihood and magnitude (of the consequences) of occurrence of an adverse event; a measure of the probability of harm and the severity of the adverse effects. Objective measurement and scientific repeatability are hallmarks of risk. In risk studies, it is common – especially in oral communication – to use "risk" synonymously with the likelihood (probability or frequency) of occurrence of a hazardous event. In such instances, the magnitude of the event is assumed to be significant.

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1. Context

Veterinary cordon fencing in the Kavango-Zambezi (KAZA) Transfrontier Conservation Area (TFCA) presents a major impediment to the overall connectivity of the KAZA landscape (3,4) and runs counter to the KAZA Treaty objective of “development of a complementary network of Protected Areas…linked through corridors to safeguard the welfare and continued existence of migratory wildlife species” (5). Veterinary fences in KAZA include both long-term structures intended to control foot and mouth disease (FMD) until areas could be declared free of the disease and “emergency” fences erected with the intent of containing the spread of highly contagious diseases such as contagious bovine pleuropneumonia (CBPP) (6). However, existing fences may no longer serve their initial purpose in controlling animal diseases (7); for instance, the disease threat that prompted construction of an emergency fence may no longer exist, or fences may have fallen into disrepair or be partly dismantled by illegal removal of fence components (6), allowing for uncontrolled movement of animals. More sustainable control options than fencing for FMD have been proposed for southern Africa, including commodity-based trade of beef along with improved vaccination and herding practices, development of commercial livestock production in areas with natural barriers to wildlife-livestock contact, a more participatory approach to veterinary service delivery, and expansion of community conservancies (8), and some of these are already being implemented.

When fences are erected as a temporary measure in response to an outbreak or when fences have been abandoned, decommissioning and removal merit consideration (6). Removal of fencing to re-establish wildlife corridors would allow dispersal of hoofed stock, elephants, and large carnivores into unoccupied areas of KAZA and, for example, permit movement of elephants from Botswana north into Namibia, Zambia and Angola, reducing pressures resulting from Ngamiland region’s growing elephant population, with thousands of elephants bottled-up between villages and vast livestock disease control fences (6,7). A recent assessment of fences within key wildlife dispersal areas (WDAs) identified fences for which partial or full decommissioning would mitigate the most severe wildlife impacts (1). These fences include the Zambezi (formerly Caprivi) Border Fence, the Northern Buffalo Fence, and the Western Border Fence with Namibia (1). However, to date no assessment has been made regarding the potential changes in risks of livestock disease transmission that could result from proposed fence decommissioning (as per Figure A.).

An important underlying assumption of any such risk assessment is the baseline level of disease risk that currently exists. Fences erected for disease control purposes are often not adequately maintained over time; fences between Botswana and Namibia are no longer electrified and have numerous gaps and breakages (1,9). Fences are only effective as disease control measures when adequately maintained, and fences in Ngamiland have deteriorated as a result of breakages by people and wildlife, theft of fencing materials, and poor maintenance due to periodic inaccessibility due to flooding and limited resources (1,10). Both livestock and wildlife have been documented crossing damaged fencing (1), although they may utilize different areas of damaged fences (11). Illegal movement of animals across the Botswana/Namibia border is another risk factor for disease transmission (12). Therefore it will be critical to document what is currently known about the integrity of existing fences and animal disease status on either side of the fences of interest to inform the assessment of increased risks, if any, from fence segment decommissioning.

For given fences of focus, we propose conducting risk assessments comparing the risk of livestock disease under the status quo fencing situation versus a partially or fully decommissioned fence. Even in data-scarce environments, formal risk assessments on animal disease risk mitigation measures can be conducted (13,14). The objectives of the proposed risk assessments are:

1. To evaluate whether the Zambezi Border, Northern Buffalo, and Western Border fences are currently effective in controlling livestock disease according to their original intent.
2. To compare the risks of livestock disease in Botswana and Namibia and the potential consequences for animal health under the status quo fencing situation versus the risks of livestock disease under partial decommissioning of the Zambezi Border, Northern Buffalo, and Western Border fences (as per Figure A.).

2. Introduction to Risk Analysis

2.1 Major Regulatory Frameworks for Risk Analysis

The World Trade Organization (WTO) administers the Sanitary and Phytosanitary Measures (SPS) Agreement, which allows for sanitary measures to protect human, animal, and plant health. Under the SPS Agreement, WTO members must base their sanitary measures on international standards, guidelines, and recommendations, or on a higher level of protection if there is a scientific justification. Under those circumstances, increased measures should be based on a risk assessment. The World Organization for Animal Health (formerly OIE, now WOAH) is the international organization responsible for development and promotion of international standards, guidelines, and recommendations for animal health and zoonoses under the SPS Agreement, while the sister organization governing plant health is the International Plant Protection Committee (IPPC).

The IPPC has guidelines for pest risk analyses that determine whether pests are of potential economic significance in areas where they are not present or controlled (15), and similarly, the OIE has a developed a framework for import risk analysis based on work by Covello and Merkhofer (16). While this framework was designed for use in decision-making regarding the import of live animals, animal or biological products, and commodities intended for human consumption, animal feed, or agricultural use (17), it has been applied in risk analysis studies on a variety of animal disease scenarios outside of live animal or animal product importation (13,14,18–20). Transparency and objectivity are important components of a risk analysis, with appropriate documentation of methods, data sources, and assumptions (17).

2.1.1 Import Risk Analysis

Import risk analyses are a method for assessing disease risks associated with importation of animals, animal products, or pathological material (17). Import risk analyses comprise four components: hazard identification, risk assessment, risk management, and risk communication (Figure 1). In the case of veterinary fencing within KAZA, the risk of a potential increase in livestock disease transmission across areas if some or all of an existing fence line were to be removed would be assessed (noting that the most significant animal diseases of concern are FMD and CBPP).

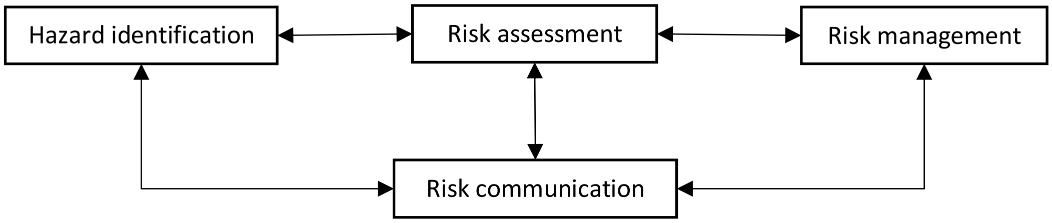

Figure 1: OIE risk analysis components, as detailed in (17)

2.1.1.1 Hazard Identification

At the outset, it is important to identify specific hazards (such as pathogens) of interest and to conduct a risk assessment for each hazard. In Botswana (responsible for all of the fences under discussion), specific veterinary cordon fences have been erected to prevent transmission of FMD or CBPP— these are thus the diseases Botswana DVS stakeholders have agreed to focus on for this risk assessment given that these are the diseases of concern behind fencing decisions.

2.1.1.2 Risk Assessment

The goal of the risk assessment is to address what might go wrong, how likely it is to happen, and the magnitude of the consequences (21). The OIE has developed handbooks outlining the approach for both qualitative (17) and quantitative (22) risk assessments. Prior to conducting the risk assessment, drawing a scenario tree (Figure 2) for each hazard is recommended (17). It is important to include all events necessary for a hazard to occur in the scenario tree to produce a transparent assessment of likelihood (23).

A risk assessment comprises four parts:

- entry assessment, which describes the likelihood of a hazard entering a country or zone, and the risk pathways necessary for each hazard to be introduced into the country or zone;
- exposure assessment, which describes the risk pathways necessary for the exposure of susceptible animals to each hazard;
- consequence assessment, which describes the biological, environmental, and economic consequences of spread of each hazard;
- the risk estimation, which is a summary of results or conclusions that arise from the previous assessments.

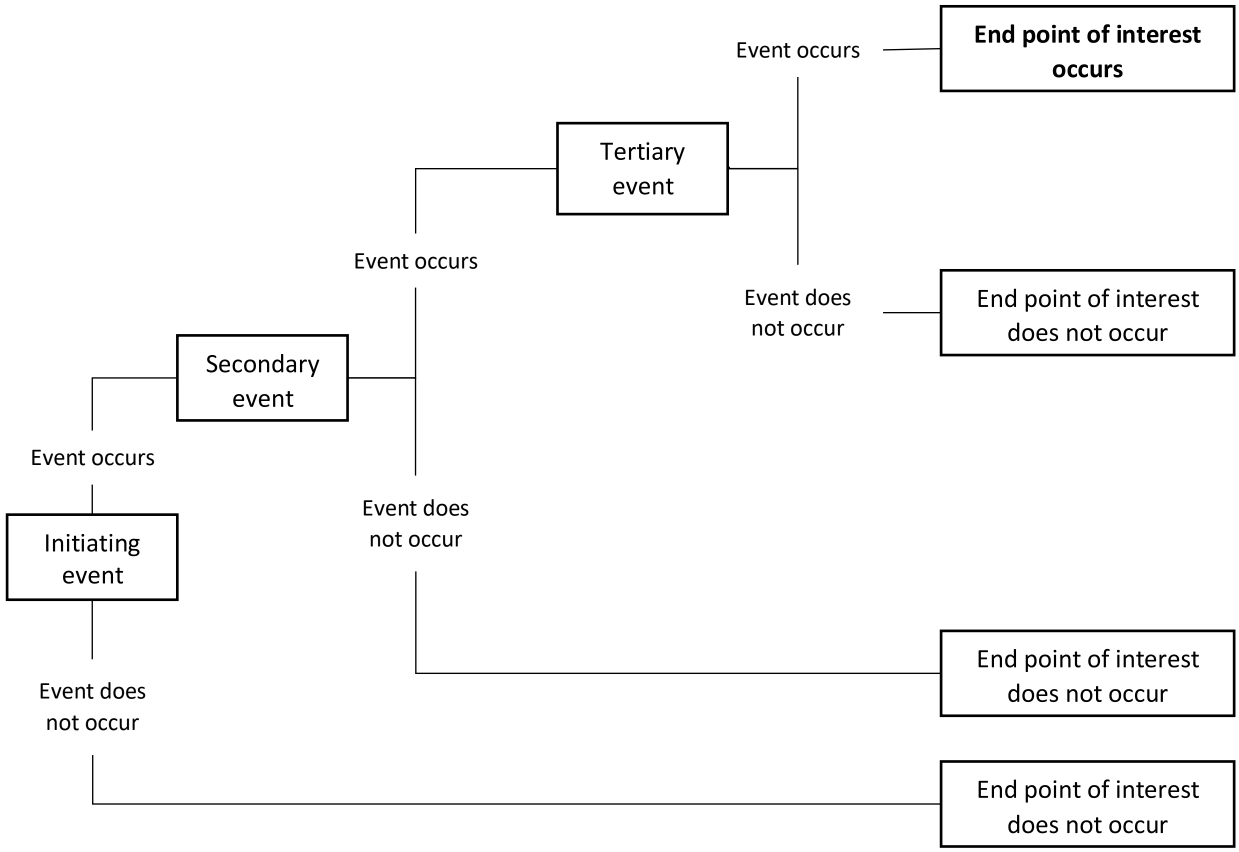

Figure 2: Generalised scenario tree framework for use in risk assessment, as detailed in (17)

Published animal disease import risk analyses often omit the consequence assessment (24,25), but doing so does not fulfil SPS requirements. The consequence assessment should be included as a holistic evaluation of the effects on multiple sectors (23). Direct consequences include the morbidity and mortality from disease, decreased animal welfare, production losses, and any human health consequences (26). A variety of indirect consequences must also be considered; these may include economic factors such as surveillance costs and reduced tourism, as well as broader environmental implications, such as effects on other species and ecological community structure and ecosystem processes (26,27). However, no specific methodology for assessing consequences is suggested (23).

2.1.1.3 Risk Management

The stage of risk management involves making decisions on sanitary measures to manage the risks posed by hazards in the analysis (17). The results of the risk assessment must be interpreted in a meaningful way to suggest risk management strategies, and with an understanding of what level of risk is considered acceptable (28). Risk management includes comparison of the estimated risk with importing country's acceptable risk and identification, evaluation, and selection of sanitary measures to manage risks in line with the acceptable risk (17).

The Hazard Analysis and Critical Control Point (HACCP) system for identifying and controlling hazards at each stage in a process can be a useful tool for risk management (28). HACCP has traditionally been used in food safety practices (28,29) and is a fundamental component of the commodity-based trade approach for managing FMD in beef (10), but can also be applied to disease control programmes (30).

The HACCP approach was the basis for a comparative analysis of the risk of diseases and their control by different options for veterinary cordon fences in a previous environmental impact assessment of fencing in Ngamiland (12).

2.1.1.4 Risk Communication

Risk communication involves a transparent exchange of information on the hazards of interest and their risks, along with risk mitigation measures (17). Relevant stakeholders in this process include the Competent Authority of the county which is responsible for developing a risk communication strategy, producer and consumer organisations, academic and scientific institutions, and the media (17). Local communities should be involved in decision making on risk management when It comes to fences, as fencing decisions directly impact their livelihoods, positively or negatively.

2.2 Other Formats for Risk Assessment

Not all animal health risk analyses relate to import of animals, animal products or commodities, and not all strictly follow the OIE import risk analysis outline. Some opt for a quantitative approach that focuses on modelling scenarios that may lead to disease outbreaks and may exclude other components of the OIE framework. Risk assessors in these studies often conduct quantitative risk analyses built on simulation modelling. Bayesian Belief Network (BBN) models represent another approach for use in modelling the risk of disease outbreaks, even when some data are not available (31). Other approaches can include an economic assessment of control measures for diseases, such as cost-benefit analysis, which is often used for long-term disease control programs at regional or national levels, or decision analysis, which may be used for diseases of sporadic or epidemic occurrence (32). A study in which reviewers audited and scored 22 veterinary import risk analyses did not find differences in reviewer scores between import risk analyses that adhered to OIE guidelines versus those that did not (25). However, this study assessed risk analyses published between 1997 and 2008, with most published prior to 2004, and neither newer approaches nor all approaches described above were included.

3. Proposed Risk Assessment Outline for This Study

The OIE offers the following summary of the steps involved in an animal health import risk analysis, regardless of which type of analysis is performed:

1. Determine the scope of the risk analysis
2. State clearly the purpose of the risk analysis
3. Develop a risk communication strategy
4. Identify sources of information for the risk analysis
5. Identify the hazards likely to be associated with the commodity under consideration
6. Determine whether or not the *Codes* provide sanitary measures for the hazard in the commodity under consideration
7. Conduct a risk assessment for each hazard:
   a. Identify the populations of interest
   b. Draw a scenario tree to identify the various biological (risk) pathways leading to the commodity harbouring the hazard when imported animals that are susceptible and/or exposed, and potential outbreak scenarios

c. Conduct an entry assessment to estimate the likelihood of the commodity introducing the hazard into the country
d. Conduct an exposure assessment to estimate the likelihood of susceptible animals and/or humans being exposed to the hazard
e. Conduct a consequence assessment to estimate the likely magnitude of potential biological, environmental and economic consequences associated with the entry, establishment or spread of the hazard, and the likelihood of their occurrence
f. Summarise the conclusions of the release, exposure and consequence assessments to provide an overall estimate of the risk (risk estimation)

8. Determine whether sanitary measures are warranted (risk management):
   a. Evaluate the risk to determine whether the risk estimate is greater than the country's acceptable risk level
   b. Evaluate the animal health options to effectively manage the risks posed by each hazard and ensure that the options chosen are consistent with the country's obligations under the SPS Agreement
   c. Undertake a scientific peer review of the analysis
   d. Implement the sanitary options by notifying the WTO as appropriate and making a final decision on the measures selected
   e. Monitor and review factors that could impact on the conclusions of the risk analysis and/or the implementation of the sanitary measures (17)

For the purposes of this study, steps 1–7 are most relevant and will be developed further. The results of the risk assessment will be presented to Botswana and Namibia stakeholders. While any decisions on Botswana fence decommissioning are of course up to Botswana, the disease issues of focus are of relevance to both sides of the international borders in question, and sustainable decisions will require earnest, transparent bilateral dialogue.

Previous work on behalf of the KAZA Secretariat and in partnership with the Government of Botswana conducted via AHEAD programme (Cornell University) umbrella made recommendations for removal of key fences / fence segments in Botswana based on their perceived impact on wildlife, supported by wildlife GPS collar data and observations from aerial and ground surveys (1). These fences are depicted in Figure 3, and the three highest priority fences that involve sections recommended for removal are further described in Table 1.

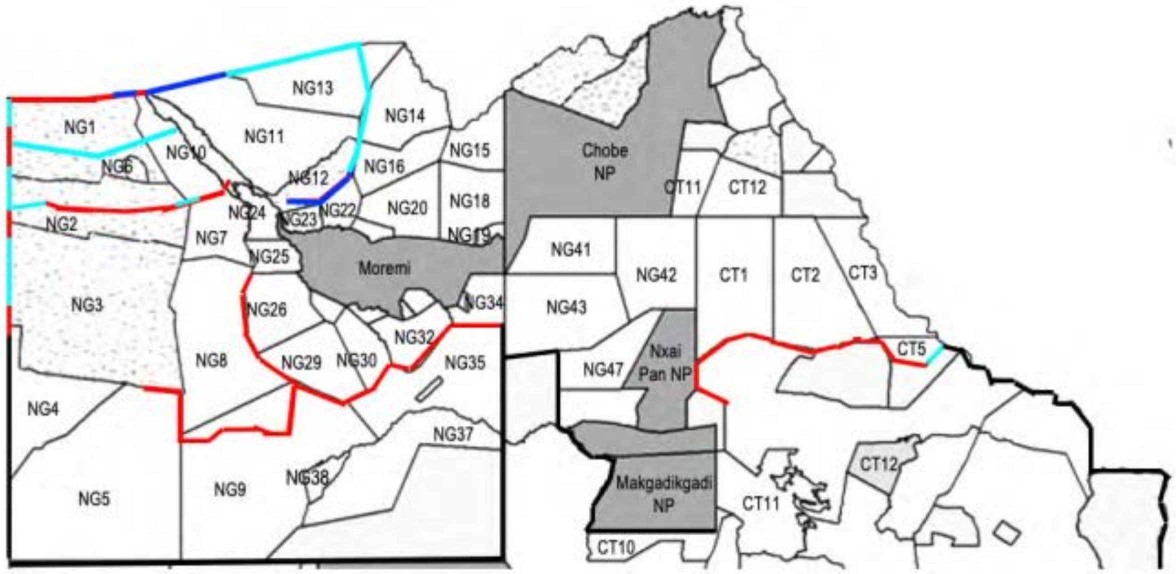

Figure 3. Veterinary fences in Botswana, with fence sections recommended for removal from the wildlife perspective in pale blue, those recommended for removal pending further evaluation in dark blue, other surveyed fences in red, and other major fences in black (1)

Table 1. Abridged recommendations for key fences based on impacts on wildlife (1)

Fence	Recommendations
Zambezi Border (east of Okavango River)	**Remove east section of fence in NG13** Despite its dilapidated status in many places, the fence is substantially restricting elephant and other wildlife movement from the eastern Panhandle into areas of suitable habitat in Namibia and Angola. Human elephant conflict (HEC) is also high, due in part to the fence 'bottling-up' this population. To alleviate these impacts, removal of the east section of the fence is required. This area (NG13) is devoid of cattle in close proximity to the fence on the Botswana side, however, cattle exist in Bwabwata National Park (NP) on the Namibia side. Removal of cattle in Namibia will need to take place prior to fence removal to create a livestock-free buffer zone – the consultative process for which is already underway. Note: realignment is not recommended as this would restrict elephant movement out of NG11 into NG13 during the wet season and preclude the alleviation of pressure on people in NG11 during that time.
Northern Buffalo	**Remove north section of fence (80 km) in NG13, NG11 & top of NG12** This fence, which adjoins the Zambezi Border fence, is similarly restricting elephant and other wildlife movement from the eastern Panhandle to the east and then north across the WDA. Likewise, HEC is high, due in part to the fence 'bottling-up' this population. To alleviate these impacts, removal of the north part of fence is required. This section is largely devoid of cattle in close proximity to the fence, with only 1 cattlepost at Shishikora in NG13 (a wildlife management area). No cattle are present east of the fence. Note: realignment is not recommended as this would restrict elephant movement out of NG11 into NG13 during the rains and preclude the alleviation of pressure on people in NG11 during that time.
Western Border	**Remove sections of fence at strategic locations along border with Khaudum NP/Nyae Nyae** The fence is substantiality restricting cross-border wildlife dispersal, critical to WDA functionality. To alleviate ongoing impacts, exacerbated by recent repair work, removal of sections at strategic locations within NG1, NG2 and NG3 is required. Locations include: (i) first 15 km section [from

north] adjacent to the north-east corner of Khaudum NP, (ii) a ~20 km section immediately north of the Ikoga junction and (iii) a ~60 km section beginning 10 km south of the Ikoga junction in Xaudum valley to 6 km south of Xaranxago village. Facilitating wildlife movement and population rehabilitation in NG1, NG2 & NG3 is also essential to existing wildlife-related income generation (e.g. in Xaranxago & Nxau-Nxau) and expected income streams (e.g. KAZA-supported Heritage Trail). Livestock presence is limited along the fence and communities with small numbers of cattle in NG3 are actively herding. In other areas, models like Herding for Health that promote active herding and community-level monitoring can be implemented. Consultation with Namibia is recommended in order to agree to the same with regards to their fencing.

3.1 Scope of Risk Analysis

Prior to any decommissioning of veterinary fences as described in Table 1, it is essential to evaluate the potential change in animal disease risks versus the status quo. Some fences are currently in a state of disrepair, and therefore are not effective as intended in completely restricting the movement of animals. The risk assessment will encompass the following evaluations:

- comparison of risk of FMD to cattle under current Zambezi Fence versus risk of FMD under proposed fence decommissioning approach
- comparison of risk of CBPP to cattle under current Zambezi Fence versus risk of CBPP under proposed fence decommissioning approach
- comparison of risk of FMD to cattle under current Northern Buffalo Fence versus risk of FMD under proposed fence decommissioning approach
- comparison of risk of FMD to cattle under current Western Border Fence versus risk of FMD under proposed fence decommissioning approach
- comparison of risk of CBPP to cattle under current Western Border Fence versus risk of CBPP under proposed fence decommissioning approach

3.2 Purpose of Risk Analysis

To identify and assess the likelihood of change in risk of FMD and CBPP in Botswana and Namibia and the likely magnitude of the potential consequences for animal health as a result of decommissioning the eastern portion of the Zambezi Fence, the northern portion of the Northern Buffalo Fence, and/or sections of the Western Border Fence.

3.3 Risk Communication Strategy

Stakeholders in the risk analysis include Botswana's Department of Veterinary Services, Namibia's Directorate of Veterinary Services, Namibia's Ministry of Environment, Forestry and Tourism, and Botswana Department of Wildlife and National Parks. Local communities living in the areas around fences are also stakeholders, as are the KAZA Secretariat and the KAZA Animal Health Sub Working Group.

Initial consultative meetings with stakeholders from Botswana and Namibia are being scheduled for 2022, with a plan for a bilateral meeting as follow-up. After the risk assessment has been conducted, final consultative meetings with Botswana and Namibia stakeholders will be scheduled in 2023, again followed by a bilateral meeting. Stakeholder feedback from these meetings will be incorporated into the final report.

3.4 Sources of Information for Risk Analysis

Regardless of whether a qualitative or quantitative risk assessment is applied, data are required to inform the risk assessment at each step. For instance, relevant information for a risk assessment on FMD would include the following for the geographical areas of interest: epidemiology of FMD virus (FMDV), livestock husbandry systems, population and density of susceptible livestock, historical and recent prevalence/incidence of FMD, volume of unofficial (illegal) animal movement, seasonal changes in livestock movements and outbreaks, survival of FMDV in the environment, and likelihood of FMDV-infected animals showing clinical signs (33).

Potential sources of information to be used in the risk assessment include, but are not limited to:

- Disease reporting systems, e.g., OIE (WOAH).
- OIE (WOAH) Terrestrial Animal Health Code.
- Historical disease occurrence data from veterinary departments.
- Disease surveillance data from veterinary or wildlife departments.
- Published risk assessments and original research.
- Livestock movement records.
- Expert opinions (opinions of veterinary, livestock, and wildlife officials working in the areas under study).
- Visits to access knowledge / experiences local community members may be willing to share (*sensu* 19).

3.5 Hazard Identification

Hazards to be assessed could include the following. Hazard identification should be supported by a referenced discussion (22); Table 2 below could represent the basis for discussion of potential hazards to Botswana:

Table 2: Example of potential hazards to Botswana associated with fence decommissioning

Common name	Scientific name	Exotic?	Free zones or compartments, or official control programmes	More virulent strains in other countries	Identified as a hazard?
Foot and mouth disease	Family *Picornaviridae*, genus *Apthovirus*, FMD virus O, SAT1, SAT2, SAT3	No (SAT1/2/3) Yes (type O)	Yes (free zones)	O has been found in cattle in Namibia; not in Botswana	
Contagious bovine pleuropneumonia	*Mycoplama mycoides* subsp. *mycoides*	Yes	N/A	N/A	

3.6 Sanitary Measures

The OIE (WOAH) TAHC contains sanitary measures regarding both FMD and CBPP. With its implications for potential fence decommissioning, commodity-based trade (CBT) is, as of a 2015 change in the FMD chapter of the TAHC, an accepted alternative to the geographic (fence-based) trade standards for FMD (10). Under CBT, the risk of FMD in beef is managed at various points along the value chain (34). It is noteworthy that the TAHC also recognizes milk and milk products, hides and skins, and meat and meat products as safe commodities for export, regardless of CBPP status of the cattle population of the exporting country.

3.7 Risk Assessment for Each Hazard

Once the data sources available for the risk assessment have been clearly identified, the type of risk assessment to be undertaken should be selected. If performing a qualitative risk assessment, the definitions of risk levels and matrices to be used for combining probabilities should be defined prior to conducting the assessment. If performing a semi-quantitative risk assessment, the probabilities associated with each risk category should be defined prior to conducting the assessment.

3.7.1 Populations of Interest

All potentially susceptible species should be identified to ensure that all biological pathways are considered in the risk assessment.

3.7.2 Scenario Trees

Scenarios trees showing consequences for various outcomes after an animal exposure should be constructed for each hazard. Figure 3 shows an example of a simple scenario tree for CBPP.

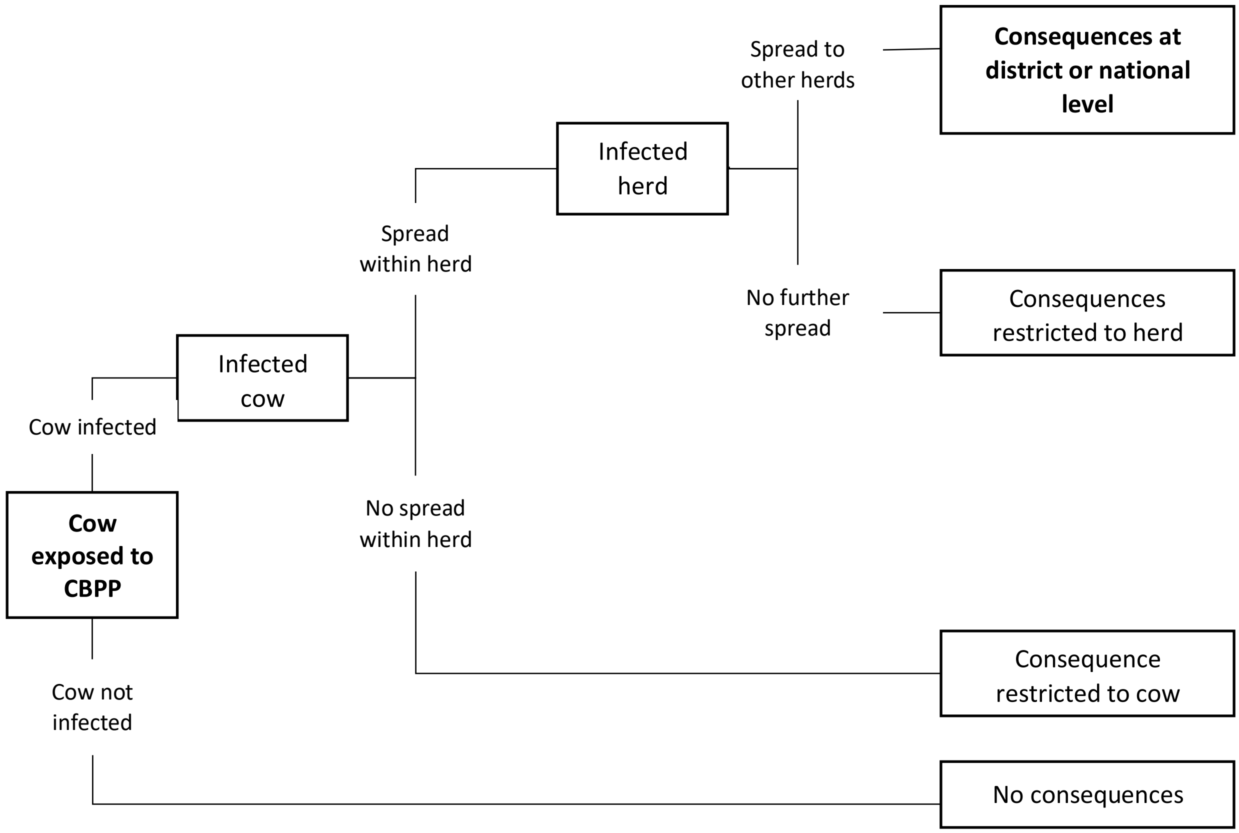

Figure 4: Example of a simple scenario tree framework for use in risk assessment

3.7.3 Entry Assessment

Factors to consider:

- Susceptibility by species, breed, age, and sex
- Transmission: horizontal, direct, indirect, vertical
- Infectivity, virulence, and stability of hazard
- Routes of infection
- Outcome of infection (e.g., carrier state, latent infection)
- Impact of vaccination, testing, treatment, quarantine
- Incidence/prevalence
- Existence of disease-free areas and areas of low prevalence
- Animal demographics
- Husbandry practices
- Animal movement practices (legal and illegal)

3.7.4 Exposure Assessment

The exposure assessment covers two different steps: exposure to a pathogen and whether or not a susceptible animal becomes infected (17). Probabilities for these stages should be assessed individually by describing biological pathways for exposure, estimating likelihood of exposure to individual animals, and estimating the likelihood of a population-wide exposure occurring (17).

Factors to consider in the exposure assessment include:

- Means of exposure
- Stability and virulence of hazard
- Route of exposure
- Susceptibility by species, age, sex
- Presence of intermediate hosts
- Animal demographics
- Husbandry practices
- Geographic and environmental characteristics

3.7.5 Consequence Assessment

Consequences to be assessed include the biological, environmental, and economic impacts associated with the proposed fence decommissioning. In alignment with the principle of One Health (35), a cross-sectoral assessment that includes indirect impacts on other industries (27) is recommended. A number of scenarios under which consequences vary may be described (17). For each hazard, estimate the likelihood of at least one animal becoming infected, identify biological, environmental, and economic consequences associated with entry or spread of the hazard and their magnitude, and estimate the likelihood of consequences occurring (17).

Factors to consider in the consequence assessment include:

- The outcome of exposure in domestic animal populations, including biological factors (e.g., morbidity and mortality, latent infection) and production losses
- Outcome of exposure in wildlife populations
- Public health consequences
- Environmental consequences as side effects of control measures (including fences)
- Impact on biodiversity and other species
- Control and eradication costs
- Compensation costs
- Surveillance and monitoring costs
- Reduced tourism and loss of social amenity

Unlike other risk assessments which examine the disease risks associated with importing animals or animal products, this scenario of fencing changes has the potential to result in some positive outcomes. For instance, removal of fences would allow more elephants to move out of Ngamiland, reducing human-elephant conflict, which has very real costs. Increased wildlife-based tourism opportunities also offer livelihood diversification for communities.

3.7.6 Risk Estimation

Each hazard should be summarised individually, based on the conclusions resulting from entry, exposure, and consequence assessments.

4. Proposed Options for Risk Assessment

The availability of data is key to determining the most appropriate type of risk assessment for a given scenario. All risk analyses are only as useful as the data underlying them, and it is possible to make biased recommendations from inaccurate probabilities used in the determination of risk. Depending on what data are available, the risk assessments may be conducted according to the following options:

1. **Option 1: Perform a qualitative risk assessment.** Qualitative risk analyses are the most common type of risk assessment performed, and appropriate in the absence of good data on which to base probability calculations. Qualitative risk analyses may require prospectively seeking expert opinions in order to fill knowledge gaps. The risk levels and the matrices to be used for combining probabilities must be decided upon.
2. **Option 2: Perform a semi-quantitative risk assessment.** Semi-quantitative analyses offer a mathematical component to calculating risk rather than relying solely on risk calculation matrices. The associated quantitative risk levels that correspond to qualitative risk categories must be decided.
3. **Option 3: Perform a quantitative risk assessment.** Quantitative risk analyses produce numerical estimates of risk for a given scenario. However, the accuracy of such estimates depends entirely on the quality of the data used to construct the model and the accuracy of the model itself in representing a complex biological environment.

5. Methodological Approaches to Risk Assessment

No single method of risk assessment is applicable for all situations (17). Risk assessments are defined by the methods assessors use to define risks, which fall into three categories. Qualitative risk assessments use descriptive scales such as "low," "medium," and "high" rather than numerical values to define risk levels (17,28). Quantitative risk assessments represent likelihoods expressed as mathematical probabilities of an event occurring over a specific time period (28). Semi-quantitative risk assessments are an amalgam of qualitative and quantitative risk assessments. In a semi-quantitative risk assessment, qualitative risk categories such as "very low" or "low" are assigned to probability ranges or ordinal scales (36) in order to calculate a probability for all steps in the assessment. This probability value is then transformed back into a qualitative risk category based on the same range or scale (17). In the same comparison study of veterinary import risk analyses mentioned previously, reviewers tended to rank quantitative analyses more highly than qualitative analyses, although this may have been biased by the fact that most of the quantitative analyses were published in peer-reviewed journals while most qualitative analyses had only been published as agency reports (25). Each method is discussed in further detail below.

5.1 Qualitative Risk Assessment

Qualitative risk assessments are used in several scenarios: as an initial evaluation, when the perceived risk does not warrant a more detailed study, or where there is insufficient information to quantify parameters (21). They are considered suitable for a majority of import risk analyses and are the most common type of assessment (17). Examples of published qualitative assessments include risk of FMD outbreaks in cattle in the lower Okavango Delta due to interaction with buffalo (19), risk of rabies reintroduction into low-risk areas of Bhutan (37), risk of factors contributing to FMD in cattle along the western boundary of Kruger National Park (18), and comparison of risk under current and proposed control measures for African swine fever in Trans Caucasus countries and Russia (14).

Qualitative risk assessments use descriptive scales for defining risks at each step in the scenario tree. There is no single standard scale for characterising qualitative risks. As few as four categories, ranging from “negligible” to “high” may be used (Table 3) (14), while other studies opt for six levels, from “negligible” to “very high” (Table 4), but as many as ten categories, ranging from “null” to “very high” have been suggested (36).

Table 3: Qualitative probability definitions from Zepeda-Sein (21)

Risk Probability	Definition
Negligible	The occurrence probability is small enough not to be taken into account; the occurrence of the event would be possible only in exceptional circumstances
Low	the occurrence probability is not high, but a possibility in some cases
Moderate	the occurrence probability is a possibility
High	the occurrence probability is clearly a possibility

Table 4: Qualitative probability definitions used by European Food Safety Authority (EFSA) (38), adapted from OIE handbook on import risk analysis (17)

Risk Probability	Definition
Negligible	Event is so rare that it does not merit consideration
Very low	Event is very rare but cannot be excluded
Low	Event is rare but does occur
Medium	Event occurs regularly
High	Event occurs very often
Very high	Event occurs almost certainly

The OIE handbook does not define any specific method to combine the qualitative likelihoods from each step of the scenario tree or risk pathway (23). Qualitative assessments generally use combination matrices to determine the level of risk that would result from two events occurring within a risk pathway. As an example, Table 5 shows a combination matrix for combining two events recommended by the regional standard for the formulation of animal health risk analyses (21).
The same document recommends a slightly different table for calculating the overall impact of a disease incursion, based on its probability of occurring and perceived impact (Table 6) (21). This variation demonstrates the subjectivity inherent in these matrices, as the level of risk assessed for any given combination varies across matrices used in different studies. In certain scenarios, experts have assessed matrices as too severe in their estimates of risk and modified the combination rules for a specific scenario (39). For instance, mathematically, multiplying two probabilities should result in a number less than or equal to the lowest probability, thus matrices may be updated accordingly (39,40). In some assessments, different matrices are used depending on whether the probabilities being combined are conditional or unconditional (14,19). Some have suggested that matrices be used in summarizing data but not as calculators of likelihood (23).

Table 5: Combination matrix for calculating overall impact of a disease incursion (21)

Probability of dissemination	**Economic impact and health impact**			
	Negligible	**Low**	**Moderate**	**High**
Negligible	Negligible	Low	Low	Moderate
Low	Low	Low	Moderate	Moderate
Moderate	Low	Moderate	Moderate	High
High	Moderate	Moderate	High	High

Table 6: Combination matrix for calculating overall classification of risk (21)

Occurrence probability	**Impact of the disease**			
	Negligible	**Low**	**Moderate**	**High**
Negligible	Negligible	Low	Low	Moderate
Low	Low	Low	Moderate	Moderate
Moderate	Low	Low	Moderate	Moderate
High	Moderate	Moderate	High	High

While the results of these risk assessments are expressed as qualitative values, decision-making for qualitative risk assessments is based on numerical data sources wherever possible. Some parameters may be estimated using published data or internal government records on disease prevalence, trade volume in animals or animal products, and survival capacity of infectious agents in the environment. However, even these data may be scarce in some environments, and important relevant factors such as uncontrolled movements of livestock may be impossible to quantify.

Expert opinions may be solicited to estimate risks, particularly in data-scarce environments (13,14,41). This can be through individual consultation, a formal Delphi conference[1] (28), or other structured approaches to elicitation (42). A participatory epidemiology approach involving stakeholders such as local community members in interviews can also be used to gather data on risks (19). As with risk levels, there is no single standard method for combining expert opinions into a single risk probability. Some methods may aim for experts to reach a consensus on an estimate (42). In situations where experts assign an ordinal value to risk probability (e.g., score 1–4 representing negligible, low, moderate, or high risk), a variety of methods can be applied, including median, mean, uncertainty-weighted median, expertise-weighted median, and linear opinion pooling (43).

Uncertainty is another factor which may be explicitly included in risk assessment, particularly in data-scarce environments. The OIE handbook defines uncertainty as "the lack of precise knowledge of the input values which is due to measurement error or to lack of knowledge of the steps required, and the pathways from hazard to risk, when building the scenario being assessed" – or more informally, a measure of the incompleteness of our knowledge about a particular thing (17). The level of uncertainty may be assessed using qualitative levels (example shown in Table 7) and included into the study

[1] The modified Delphi method recommended in the OIE handbook (22) is carried out over two or three days. Experts fill out a questionnaire individually and anonymously, and the responses are analyzed and presented to the group. A facilitated discussion among the experts follows, and the questionnaire is given again to allow for changes in opinions following the group discussion.

(13,14,19,44). In addition to uncertainty, inherent variability in biology also exists, though this is not typically explicitly assessed in qualitative studies.

Table 7: Qualitative probability values for uncertainty about data (43)

Uncertainty	Definition
High	Scarce or no data available; evidence is not provided in references but rather in unpublished reports, based on observations, or personal communications; authors report conclusions that vary considerably between them
Moderate	Some but no complete data available; evidence provided in small number of references; authors report conclusions that vary from one another
Low	Solid and complete data available; strong evidence provided in multiple references; authors report similar conclusions

Although risk matrices have been widely adopted in a variety of fields for risk management, there is a lack of empirical research evaluating their performance in improving risk management decision-making (45). Criticisms include range compression (i.e., having only a few possible categories to which very different risk levels may be assigned) and errors associated with negative correlations between probability of an outcome and associated consequences, among others (45). Despite these criticisms, qualitative risk assessments are widely used and accepted – see examples in Table 8.

Table 8: Examples of qualitative risk assessments

Disease(s)	Situation	Year (Ref)
Foot and mouth disease	Risk of introduction to Russia and Europe from Georgia, Armenia, and Azerbaijan	2001 (37)
Classical swine fever	Spread into and within Finland	2002 (46)
Foot and mouth disease	Risk factors for outbreaks in cattle on western boundary fence of Kruger National Park	2009 (18)
Selected exotic diseases	Feral wild boar and incursions into England	2010 (47)
Vector-borne viruses	Impact of climate change in the European Union	2010 (40)
African swine fever	Impact of control measures on spread in Trans Caucasus Countries and Russian Federation	2011 (14)
Selected exotic diseases	Wild deer and incursion into England	2012 (48)
Zoonotic and other pathogens	Visual-only post-mortem meat inspection of cattle, sheep, goats and farmed/wild deer	2014 (49)
Peste des petits ruminants	Introduction from Tanzania into Northern Zambia	2014 (50)
Nipah virus	Establishment in Australian flying-foxes	2015 (43)
Transboundary diseases	Risk from importing sable antelope from Zambia into South Africa	2015 (51)
Capripoxviruses	Risk of entry into Great Britain from European Union through importation of ruminant hides, skins and wool	2016 (52)
Japanese encephalitis virus	Risk of introduction in the United States	2019 (53)
Rabies	Dog-mediated rabies from high-risk to low-risk zone in Bhutan	2020 (13)

Foot and mouth disease	Spatial risk analysis in Tunisia	2021 (41)
Foot and mouth disease	Risk of outbreak in cattle in lower Okavango Delta due to interaction with buffalo	2022 (19)
Bluetongue and African horse sickness	Risk of entry and exposure at a UK zoo	2022 (14)

Two relevant studies using qualitative approaches are described here. In the first, the risk of rabies reintroduction from a rabies endemic area to a low-risk area of Bhutan was evaluated (13). The assessment included three risk pathways through which rabies might be reintroduced – stray dogs, pet dogs, or cattle – and compared the current control measures as compared to no control measures (13). The risk assessment was conducted using existing data sources and through elicitation of expert opinions, and included qualitative assessments of uncertainty at each step (13). Qualitative assessments of uncertainty were made for each step in each risk pathway (13).

In the second study, the risk of an FMD outbreak in cattle in the lower Okavango Delta due to interaction with buffalo was assessed (19). The assessment included one scenario tree with two possible entry/release routes, and relied on existing data sources, expert opinion, and structured interviews from community members, with qualitative assessments of uncertainty for each step (19).

5.2 Quantitative Risk Assessment

Quantitative risk assessments are a specialised approach to assessing risk, and are sometimes undertaken to gain further insight after an initial qualitative assessment (17). Quantitative assessments require data in order to accurately inform model parameters, but should not necessarily be considered more objective or more precise than qualitative methods (17). Developing quantitative models is inherently challenging because there is usually a lack of quantitative data for precise estimation of probability and magnitude of potential consequences (28), and these models' quality depends on the quality of the data on which they are based (21). If most data for an import risk analysis are missing, the resulting confidence intervals for outputs of quantitative analysis may be so wide that they are not more informative than a qualitative assessment (23).

Quantitative assessments often use simulation models to create results for defined scenarios. Simulation models can be either deterministic or stochastic. Deterministic models use single inputs and provide point estimates of risk, while stochastic models account for inherent variability by using probability distributions for each variable and produce ranges of probability values for risk (28). In stochastic models, probability distributions such as binomial, Poisson, or hypergeometric must be selected for each variable. To then produce ranges of probability values, there are three options: by fitting empirical data (if they exist), a subjective approach based on expert opinion, and a Bayesian approach combining empirical data and expert opinion (22). Sampling values from probability values is typically undertaken by either Monte Carlo sampling or Latin hypercube sampling (22). The Monte Carlo method involves sampling with replacement, while Latin hypercube sampling is without replacement and requires fewer iterations than Monte Carlo sampling (22). The Microsoft Excel add-in @Risk (Palisade Corporation, Raleigh, North Carolina, USA), a commercial risk analysis software, is used for simulation throughout the OIE quantitative handbook on import risk analysis and in numerous risk assessment studies (54–57). Licenses for @Risk start at approximately US $2,000 for a one-year license, with longer terms licenses offered at a lower yearly rate.

Variability and uncertainty can both be explicitly incorporated into quantitative models (22,28). Sensitivity analysis is recommended to evaluate the effects of uncertainty in parameter values and model structure on the results (25). In sensitivity analysis, the most influential variable(s) in determining the output are identified by calculating the degree of correlation between input and output variables (22).

Scenario pathway (or scenario tree) models have been commonly used in published quantitative risk analyses (58), such as the assessment of FMD risk to cattle from buffalo in wildlife conservancies in Zimbabwe (54), the analysis of risk of FMD to cattle in Ngamiland (59), and risk of classical swine fever entering the European Union (55). In the scenario pathway or event tree, each event has two possible outcomes (e.g., that infected animals are or are not identified as infected, or that infected wildlife have contact or do not have contact with susceptible livestock) (58), and probabilities can be assigned to each event to develop overall probabilities for each pathway (60).

As an example, the assessment of FMD risk to cattle from buffalo in wildlife conservancies in Zimbabwe examined five transmission scenarios: buffalo escaping from a conservancy, cattle entering and leaving a conservancy, small ruminants entering and leaving a conservancy, antelope jumping over the conservancy perimeter fence, and aerosol transmission across the perimeter fence (54). Each scenario included a specialized tree of events, with estimation of various parameters using literature, where available, and expert opinion otherwise (54). The Scott Wilson assessment of veterinary fences adapted this quantitative framework to the specific situation in Ngamiland.

In contrast, Bayesian Belief Network (BBN; also known as belief network or Bayesian network) models represent a different approach of hierarchical relationships among variables, and can be used to estimate the probability of infectious disease outbreaks (31). The joint distribution of all variables is reflected visually in a directed acyclic graph (DAG), and probabilities can be calculated for all nodes within the DAG (31). BBN models are constructed by first identifying relevant variables, creating the model structure and identifying links between variables, specifying the conditional probability table, and validating and testing the model. These models have generally been used in risk assessments that do not fully conform to the OIE framework, such as the likelihood of a farm becoming infested with specific ticks (61) or the probability of porcine diseases occurring in swine production facilities based on biosecurity practices in use (62).

Other techniques incorporate economic components into the broader epidemiological context. Economic impact assessments of animal diseases measure costs as the sum of direct and indirect losses and control expenditures (32). Decision (or decision tree) analysis is used when making decisions under uncertain conditions (63) by modelling epidemiological consequences and calculating resulting direct and indirect costs (64). Decision analysis considers events over which there is control, probability of chance events, and the value of various outcomes (32). Decision analysis can be used to compare different control strategies, such as diagnostic tests and herd management strategies for control of paratuberculosis on commercial dairies (65), or no preventive measures versus different strategies for prevention of thromboembolic meningoencephalitis in feedlot cattle (66). Cost-benefit analysis incorporates economic, environmental, biological, and medical costs and benefits from specific choices, and is often used to compare different strategies of disease control (32). Cost-benefit (or benefit-cost) analysis combines simulation modelling for epidemiological analysis and a model or estimate of economic costs. The effectiveness of different interventions can be compared; for instance, comparison of on-farm *Salmonella* control strategies (67) or ranking control options for tropical theileriosis in Tunisian dairy cattle (68). Cost-benefit analysis models are heavily data-dependent, may be sensitive to changes in assumptions, and costs and benefits such as changes in annual mortality probabilities can be difficult to quantify (32,69). This may make quantifying an economic model extremely difficult; for instance, studies of FMD impacts on smallholders are mostly on decreased output in milk systems rather than pastoral or meat producing systems (70). Examples of the wide variety of quantitative assessments and methods are shown in Table 9.

Table 9: Examples of quantitative risk assessments

Disease(s)	**Situation**	**Method**	**Year (Ref)**
Thromboembolic meningoencephalitis	Control measures in feedlot cattle	Decision analysis	1981 (66)
Foot and mouth disease	Introduction through deboned beef importation	Scenario tree/stochastic simulation	1997 (71)
Foot and mouth disease	Risk from African buffalo in wildlife conservancies to cattle in Zimbabwe	Scenario tree/stochastic simulation	2000 (54)
Foot and mouth disease	Control measures early in an epidemic	Decision analysis	2002 (64)
Gyrodactylus salaris	Inter-river transmission by migrating Atlantic salmon smolts	Scenario tree/stochastic simulation	2003 (72)
Classical swine fever	Introduction into European Union	Scenario tree/stochastic simulation	2004 (55)
Paratuberculosis	Control in commercial dairy herds	Decision analysis	2006 (65)
Foot and mouth disease	Risks from illegally imported meat to Great Britain	Scenario tree/stochastic simulation	2007 (57)
Bovine viral diarrhoea	Control options in dairy industry in New Zealand	Decision analysis	2008 (73)
Tropical theileriosis	Control options for dairy cattle in Tunisia	Benefit-cost analysis	2011 (68)
Contagious bovine pleuropneumonia	Risk of entry through live cattle from northwestern Ethiopia	Scenario tree/stochastic simulation	2015 (74)
Foot and mouth disease	Transmission at the wildlife/livestock interface of Kruger National Park	Scenario tree/stochastic simulation	2016 (75)
Foot and mouth disease	Control alternatives in Ethiopia	Benefit-cost analysis	2016 (76)
Porcine diseases	Biosecurity practices in Canada	Bayesian Belief Network	2016 (62)
Murray Valley encephalitis virus	Risk in Western Australia	Bayesian Belief Network	2016 (77)
Dengue virus	Emergence in Western Australia	Bayesian Belief Network	2017 (78)

Rabies	Introduction in Japan through importation of dogs and cats	Scenario tree/stochastic simulation	2017 (79)
Salmonella	Control strategies in pigs reared in the United Kingdom	Benefit-cost analysis	2018 (67)
Rhipicephalus microplus	Introduction into farms by cattle movement in Uruguay	Bayesian Belief Network	2019 (61)
Foot and mouth disease	Introduction into FMD-free without vaccination zone of Argentina through trade in bone-in beef and unvaccinated animals	Scenario tree/stochastic simulation	2019 (80)

5.3 Semi-Quantitative Risk Assessment

Semi-quantitative risk assessments are sometimes considered more objective than purely qualitative assessments because they include a numerical component (17). However, the rankings used in semi-quantitative assessments are often arbitrary and therefore do not necessarily add the intended benefit of greater objectivity (28). While this approach may seem to provide more objectivity by introducing a numerical component, it may be flawed from a statistical viewpoint (81) and is not recommended by the OIE for conducting import risk analyses (17).

Nevertheless, some researchers opt for a semi-quantitative approach, and several governments have developed generic semi-quantitative tools for rapid risk assessments (46,82–84), as in response to outbreaks of transboundary diseases in neighbouring countries (82). For example, researchers developed Harmonia^{+} and Pandora^{+} (http://ias.biodiversity.be/harmoniaplus), free semi-quantitative tools for evaluating risk of invasion by species and pathogens/parasites, based on user-supplied qualitative levels of probability and confidence (or uncertainty) (83). The Harmonia^{+} protocol uses weighted means of the risk of introduction, establishment, and spread to calculate an exposure score, and the maximum environmental, plant, animal, human health, or other impacts score to calculate an overall impact score; the product of the exposure and impacts scores then gives a final risk score (83). Table 10 lists examples of semi-quantitative risk assessments from the literature.

Table 10: Examples of semi-quantitative risk assessments

Disease(s)	**Situation**	**Method**	**Year (Ref)**
Bovine tuberculosis	Risk to cattle from wild mammals in South-West England	Stochastic simulation	2007 (85)
Rinderpest	Reintroduction after eradication	Scenario tree/stochastic simulation	2014 (44)
African swine fever	Introduction into Finland	NORA rapid assessment tool	2016 (46)
African swine fever	Risk to Belgium in early 2014	Pandora screening tool	2017 (82)
Transboundary diseases	Risks at human, livestock, wildlife interface for Korea	Bayesian multivariate normal order-statistics model	2017 (86)

African swine fever	Potential introduction routes from wild reservoir to domestic pig industry in Belgium	Regression tree analysis	2021 (87)

As a relevant example, researchers used a semi-quantitative format to evaluate the risk of reintroduction of rinderpest after its eradication, based on scenarios of deliberate or accidental use of virus in laboratories, deliberate or accidental use of vaccines, host exposure to an environmental source of virus, and use of virus for biological warfare (44). The semi-quantitative format was used over a fully quantitative approach due to a lack of detailed data, and the model was informed by expert opinion (44).

6. Conclusion

Once the risk assessment is completed based on a stakeholder-agreed methodology, recommendations can be made on the three priority fences proposed for partial decommissioning due to their negative impacts on the wildlife resource (1). A complete report will be prepared documenting the entire process. It is crucial to document data sources used and assumptions made for full transparency (17). The report will then be made available to support science-based decision-making on veterinary fencing, in ongoing consultation with key stakeholders. Ultimately, in terms of this collaborative endeavor, the decision as to whether to decommission any sections of existing veterinary fences lies with the relevant authorities in the Government of Botswana.

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APPENDIX C: Stakeholder meetings and communications

Table C1. Stakeholder meetings log.

Date	Place	Stakeholder(s)	Summary
26-Sep-22 27-Sep-22	CBT/Fencing workshop; Protea Hotel Katima Mulilo, Namibia	Participants from Namibia DVS, MEFT, NGOs	Delivered presentation on risk assessment methodologies and garnered feedback from workshop participants during breakout session; and informal discussions with participants
3-Oct-22	DVS Office, Gaborone, Botswana	Kobedi Segale (DVS)	Gave brief presentation on risk assessment with follow-up discussion, including risk mitigation measures, suggested contacts in Botswana
3-Oct-22	DVS Office, Gaborone, Botswana	Kefentse Motshegwa, Letlhogile Oarabile, John Kgosiemang, and Kabo Cabusher Thema (DVS), Chandapiwa Marobela-Raborokgwe (BNVL)	Gave brief presentation on risk assessment with follow-up discussion, including potential data sources, suggested contacts in Botswana & identifying core team in Botswana for collaboration on assessment
3-Oct-22	DWNP Office, Gaborone, Botswana	Kabelo Senyatso (DWNP)	Brief update on risk assessment plans and shared methodologies document & identification of DWNP rep to collaborate with on the assessment.
3-Oct-22	Virtual – Zoom call	Comfort Nkgowe (DWNP)	Gave brief presentation on risk assessment with follow-up discussion, including potential data sources, suggested contacts in Botswana and shared methodologies document
4-Oct-22	Virtual – Zoom call	Bernard Mbeha, Yvonne Sereetsi, Odireleng Thololwane, (DVS) and Nlingisisi Babayani (ORI)	Gave brief presentation on risk assessment with follow-up discussion, including potential data sources, risk mitigation measures
4-Oct-22	Virtual – Zoom call	Odireleng Thololwane and Nlingisisi Babayani	Follow-up discussion on logistics of risk assessment
4-Oct-22	Protea Masa Square, Gaborone, Botswana	Letlhogile Modisa (Green Climate Fund)	Discussion on potential data sources
4-Oct-22	Protea Masa Square, Gaborone, Botswana	Mokganedi Mokopasetso (BVI)	Discussion on potential data sources and shared methodologies document
5-Oct-22	Virtual – Zoom call	Obakeng Kemolatlhe (DVS)	Brief update on risk assessment plans and shared methodologies document

Date	Place	Stakeholder(s)	Summary
5-Oct-22	Protea Masa Square, Gaborone, Botswana	Alec Bishi (EU Economic Partnership Agreement Implementation Support Programme in Botswana)	Discussion on risk assessment project and gathered suggested contacts in Namibia
6-Oct-22	DVS Office, Gaborone, Botswana	Chandapiwa Marobela-Raborokgwe	Summary discussion on week's progress and request for letter of support from Director of DVS
19-Oct-22	Okavango Research Institute, Maun, Botswana	Nlingisisi Babayani	Discussion on risk assessment project and data sources, scenario trees, received hard copy data from farmer questionnaires
20-Oct-22	Virtual - Zoom	Odireleng Thololwane	Discussed data sources and plan to visit Maun/Shakawe in November to gather data and visit fences
20-Oct-22	Dusty Donkey Café, Maun, Botswana	Catja Orford (CLAWS Conservancy)	Brief update on risk assessment plans and discussed livestock movement data
21-Oct-22	DVS Office, Francistown, Botswana	Bernard Mbeha and Yvonne Sereetsi	Discussion on risk assessment project and data sources and gaps, scenario trees
14-Nov-22	Department of Agriculture office, Maun, Botswana	Odireleng Thololwane and DVS staff from Maun and Shakawe offices	Overview of risk assessment and discussion on data sources available at Maun and Shakawe DVS offices to review during this trip
15-Nov-22	Wild Entrust, Maun, Botswana	Tico McNutt (Wild Entrust)	Discussion on poaching risk and habits in Ngamiland, movement of predators with and without fencing
16-Nov-22 17-Nov-22	DVS Office, Maun, Botswana	Bruce Mafonko (DVS)	Review of DVS documents at Maun office under supervision of Dr Mafonko, discussion on FMD vaccination campaign strategies and explanation of reporting
22-Nov-22	DVS Office, Shakawe, Botswana	Emmanuel Ramokwena, Serigi Serigi (DVS)	Discussion of veterinary fences, conditions, incursions and policies on the three fences
23-Nov-22	Zambezi Border (east) and Northern Buffalo fences	Emmanuel Ramokwena, Philimon Salepito (DVS)	Drove ~133 km along Zambezi Border fence (Kaputura camp to Xhoroma camp) and ~60 km along Northern Buffalo fence (Xhoroma camp to Selinda gate) to assess fence conditions
24-Nov-22	DVS Office, Shakawe, Botswana	Emmanuel Ramokwena	Review of fence drive the day before and materials on buffalo/cattle incursions, crush coordinates, and vaccination records to be sent

Date	Place	Stakeholder(s)	Summary
13-Feb-23	Virtual - Zoom	Odireleng Tholowane, Yvonne Sereetsi, Nlingisisi Babayani, Mokganedi Mokopasetso, Bernard Mbeha (joined for a few minutes)	Discussed risk pathways, risk mitigation measures, and outstanding data sources
13-Jun-23 14-Jun-23 15-Jun-23	KAZA Animal Health Sub Working Group (AHSWG) meeting, Divundu, Namibia	Albertina Shilongo, Natangwe Amuthenu, Kenneth Shoombe (Namibia DVS), Kefentse Motshegwa, Kobedi Segale, Comfort Nkgowe, Mokganedi Mokopasetso	Delivered presentation on progress thus far and obstacles on acquiring data; dinner meeting with DVS Botswana and Namibia to discuss risk assessment and further data needs
20-Jun-23	Virtual - WhatsApp call	Obakeng Kemolatlhe	Discussed Botswana's prevention measures for CBPP
2-Jul-23	Victoria Falls, Zimbabwe	Jacques van Rooyen (H4H)	Discussed H4H model and relevance as a risk mitigation measure
5-Jul-23	Virtual - Zoom call	Chandapiwa Marobela-Raborokgwe	Discussed risk pathway for CBPP, vaccines, risk mitigation measures, consequences for CBPP outbreak
10-Aug-23	Virtual - WhatsApp call	Comfort Nkgowe	Discussed poaching risks in Ngamiland
30-Aug-23	Virtual - WhatsApp call	Janine Sharpe (MEFT)	Discussed wildlife, cattle, and poaching in Khaudum and Bwabwata National Parks and Nyae Nyae Conservancy
5-Sep-23	Virtual - WhatsApp call	Piet Beytell (MEFT)	Discussed wildlife, cattle, and poaching in Khaudum and Bwabwata National Parks and Nyae Nyae Conservancy
13-Sep-23	Virtual - WhatsApp call	Lise Hanssen (Kwando Carnivore Project)	Discussed wildlife, cattle, and poaching in Zambezi Region and Bwabwata National Park
15-Sep-23	Virtual - WhatsApp call	Theunis Pietersen (MEFT)	Discussed poaching and wildlife movement in Bwabwata and Khaudum National Parks and Nyae Nyae Conservancy
15-Sep-23	Virtual - WhatsApp call	Donovan Jooste (African Parks)	Discussed human settlements and livestock in Angola north of Bwabwata National Park
24-Sep-23 thru 26 Sep-23	Cross-Border Harmonisation on Transboundary Animal Diseases meeting, Katima Mulilo, Namibia	Albertina Shilongo, Kenneth Shoombe, Emmanuel Hikufe, Beatrice Shikongo (Namibia DVS), Kefentse Motshegwa, Odireleng Tholowane	Delivered presentation on KAZA AHSWG and priorities for 2023/2024, including disease risk assessment; discussions with DVS Botswana and Namibia officials

Date	Place	Stakeholder(s)	Summary
14-May-24 thru 16-May-24	KAZA Fencing Disease Risk Assessment Validation meeting, Maun, Botswana	Natangwe Amuthenu, Nlingisisi Babayani, Simeon Elago (Namibia DVS), Bruce Mafonko, Agang Makala (Botswana DVS), Mokganedi Mokopasetso, Comfort Nkgowe, Emmanuel Ramokwena, Kobedi Segale, Janine Sharpe, Kenneth Shoombe, Thompson Shuro (Namibia DVS), Odireleng Thololwane, Jacques van Rooyen	Presented draft disease risk assessment report and recommendations to government and regional stakeholders for validation of findings. Botswana and Namibia government representatives co-developed modified recommendations and identified data gaps to be filled by 31 May 2024 deadline and corrections to be made to report narrative.
24-May-24	Virtual – Zoom call	Jacques van Rooyen	Discussed revisions requested to report, including H4H sustainability and field level documentation, and topics for further discussion at AHSWG meeting.

Table C2. Stakeholder communications log.

Key: E = email, W = WhatsApp message, P = Phone (landline), SO = Steve Osofsky, LR = Laura Rosen, NR = Nidhi Ramsden, SA = Shirley Atkinson

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
9-Aug-22	E	SO	Yvonne Sereetsi, Bernard Mbeha, Obakeng Kemolatlhe, Comfort Nkgowe, Odireleng Thololwane, Nlingisisi Babayani, Mokganedi Mokopasetso	Introductory Zoom call to discuss next steps	Proposed dates from Drs Mokopasetso, Mbeha, Nkgowe, Dr Tholołwane unavailable - no call was scheduled
31-Aug-22	E	LR	Bernard Mbeha	In-person meeting in Kasane on 15 Sep while visiting for KAZA laboratory assessment	Dr Mbeha unavailable, in Francistown for FMD outbreak control until November - no meeting scheduled
6-Sep-22	W	NR	Obakeng Kemolatlhe	Availability for meeting week of 3 Oct	Tentatively confirmation dependent on FMD outbreak situation in the east.
6-Sep22	W	NR	Yvonne Sereetsi	Availability for meeting week of 3 Oct	Confirmed availability

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
6-Sep-22	E	SO	Yvonne Sereetsi, Bernard Mbeha, Obakeng Kemolatlhe, Comfort Nkgowe, Odireleng Tholowane, Nlingisisi Babayani, Mokganedi Mokopasetso	In-person meeting in Gaborone 4-5 Oct, with offer to provide venue and catering plus support for travel	Dr Tholowane unavailable, Dr Nkgowe acknowledged receipt only, Dr Mokopasetso confirmed availability, Dr Mbeha unavailable, Dr Babayani confirmed availability - no meeting scheduled
8-Sep-22	E	LR	Odireleng Tholowane, Nlingisisi Babayani	In-person meetings in Maun between 13-15 September while visiting for KAZA laboratory assessment	**no response**
12-Sep-22	E	SO	Yvonne Sereetsi, Bernard Mbeha, Obakeng Kemolatlhe, Comfort Nkgowe, Odireleng Tholowane, Nlingisisi Babayani, Mokganedi Mokopasetso, Kefentse Motshegwa, Letlhogile Oarabile, Kabelo Senyatso, Kobedi Segale	Resent previous email as requested by Director-level stakeholders, with option for meeting in Francistown to accommodate staff at FMD outbreak	**no response**
12-Sep-22	W	LR	Odireleng Tholowane	in-person meeting in Maun while visiting for laboratory assessment	Dr Tholowane said he would make time despite having another engagement
13-Sep-22	E	LR	Odireleng Tholowane, Nlingisisi Babayani	Follow-up request for in-person meetings in Maun between 13-15 Sep while visiting for KAZA laboratory assessment and shared draft of risk assessment methods document	**no response**
14-Sep-22	W	LR	Odireleng Tholowane	Invitation for dinner meeting	Dr Tholowane unavailable - no meeting while in Maun
16-Sep-22	E	SO	Odireleng Tholowane, Nlingisisi Babayani	Follow-up on interest in meeting in Gaborone or Francistown in Oct	Dr Babayani responded with thoughts on the risk assessment approach

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
29-Sep-22	E	SO	Yvonne Sereetsi, Bernard Mbeha, Obakeng Kemolatlhe, Comfort Nkgowe, Odireleng Thololwane, Nlingisisi Babayani, Mokganedi Mokopasetso, Kefentse Motshegwa, Letlhogile Oarabile, Kabelo Senyatso, Kobedi Segale	Resent previous email as requested by Director-level stakeholders, to note AHEAD being in Gaborone 3-6 Oct and willingness to travel to Palapye/ Francistown if necessary	Dr Nkgowe replied with availability in Palapye, no other responses
3-Oct-22	E	SO	Odireleng Thololwane, Nlingisisi Babayani	Zoom call while in Gaborone	Dr Babayani confirmed availability
3-Oct-22	E	NR	Andrew Madeswi	In-person courtesy call for introductions and update on activities	Mr Madeswi unavailable - no meeting while in Gaborone
3-Oct-22	W	NR	Odireleng Thololwane	Reminder about zoom meeting with full team	Responded the following day to say he was hosting the Deputy Permanent Secretary
3-Oct-22	W	NR	Nlingisisi Babayani	Reminder about zoom meeting with full team	Confirmed availability
4-Oct-22	W	NR	Obakeng Kemolatlhe	Reminder about zoom meeting with full team	In Namibia on work, was unable to join. Had a separate discussion with him on 5 Oct
4-Oct-22	W	NR	Albertina Shilongo	Possibility of physical meeting in Windhoek to meet with epidemiological team in Namibia DVS on disease risk assessment	Busy during proposed timeframe, requested to write directly to Drs Hikufe, Shoombe & Amuthenu to check on their Dec schedule
5-Oct-22	E	SO	Kefentse Motshegwa, Letlhogile Oarabile, Chandapiwa Marobela-Raborokgwe, Kabo Thema, John Kgosiemang	10 minute meeting the following day to debrief on Gaborone visit and signed copy of letter indicating support for DVS staff to participate in disease risk assessment	**no response**
5-Oct-22	E	LR	Obakeng Kemolatlhe	Shared risk assessment draft paper	Dr Kemolatlhe acknowledged receipt and promised to read and revert; no further communication received

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
6-Oct-22	W	NR	Yvonne Sereetsi	Availability on 21 Oct for physical meeting with her & Dr Mbeha in Francistown	Asked to liaise with Dr Mbeha to confirm his availability
6-Oct-22	E	SO	Emmanuel Hikufe, Natangwe Amuthenu, Kennedy Shoombe, Albertina Shilongo	In-person meeting in Windhoek first or second week of Dec for discussion of risk assessment, with offer to support travel, accommodation, and meals	**no response**
6-Oct-22	E	SA	Andrew Madeswi, Mokganedi Mokopasetso, Keneilwe Mathware	Zoom call on 24 or 25 Oct for introductions and update on activities	Ms Mathware confirmed for 25 Oct
7-Oct-22	E	SO	Joseph Mbaiwa, M Murray-Hudson, Nlingisisi Babayani	Inclusion of Dr Babayani as a member of the disease risk assessment working group	**no response**
10-Oct-22 thru 22-Nov-22	W	NR	Albertina Shilongo	Follow up on request made to epidemiologists & request to provide update on the disease risk assessment	Requested an email update
12-Dec-22	W	NR	Kefentse Motshegwa	Review of content for a letter to be drafted by DVS confirming collaboration on the project & identifying core advisory team from Botswana	Due to FMD outbreak, NR was redirected to Dr Oarabile & disease risk assessment collaboration team & inform the Director if there were any challenges.
17-Oct-22 thru 28-Oct-22	W	NR	Letlhogile Oarabile	Review of content for a letter to be drafted by DVS confirming collaboration on the project & identifying core advisory team from Botswana & request to meet to discuss the same	Due to work travels, Dr Oarabile was unable to meet during this period & no response was received on the draft.
17-Oct-22	W	NR	Yvonne Sereetsi	Update of plans for meeting with her & Dr Mbeha on 21 Oct in Francistown	**no response**

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
18-Oct-22	W	NR	Odireleng Tholowane	Follow up on potential for physical meeting in Maun	Had travelled to Gaborone for work. Met virtually on 20 Oct for an update on discussions to date
19-Oct-22	E	SO	Joseph Mbaiwa, M Murray-Hudson, Nlingisisi Babayani	Resent previous email	Acceptance of working with Dr Babayani
19-Oct-22	W	LR	Odireleng Tholowane	Sent notes from discussion with Dr Babayani and requested input on risk pathways, getting data, type of approach, and risk mitigation measures during meeting the following morning	Dr Tholowane mentioned that he had done some work on risk pathways similar to what we shared
27-Oct-22	W	LR	Odireleng Tholowane	Availability weeks of 7 and 14 Nov to collect data in Maun and to travel to Shakawe together	Dr Tholowane said he thought he had class that week; no response when asked what might work with his class schedule
31-Oct-22	E	SA	Andrew Madeswi, Mokganedi Mokopasetso, Keneilwe Mathware	Rescheduling due to cancellation of previous meeting, suggested 7, 10, 14, 15, or 16 Nov	Ms Mathware confirmed for 16 Oct
31-Oct-22	E	SO	Kefentse Motshegwa, Letlhogile Oarabile, Chandapiwa Marobela-Raborokgwe	Letter of support for risk assessment	Dr Motshegwa requested that Dr Rosen communicate directly with Dr Oarabile, and for her to feel free to engage the rest of the DVS team (Drs Sereetsi, Mbeha, Tholowane) for background info and data collection
1-Nov-22	E	LR	Kefentse Motshegwa, Letlhogile Oarabile, Chandapiwa Marobela-Raborokgwe	Letter of support for risk assessment	Dr Oarabile acknowledged receipt and promised to revert early the next week after internal consultations

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
2-Nov-22	W	LR	Odireleng Tholotwane	Availability in coming weeks to collaborate during an in-person meeting in Maun and travel to Shakawe	Dr Tholotwane said he was busy and asked when LR could come. Dates of 7-21 Nov were offered and Dr Tholotwane said he only had class the week of 7 Nov. Proposed 14-23 Nov, including travel to Shakawe, and Dr Tholotwane said that he would be available in that time unless something came up.
8-Nov-22	W	NR	Odireleng Tholotwane	Follow up on LR request to meet during physical data gathering visit to Ngamiland	Was busy with other work but managed to liaise with LR.
9-Nov-22	E	LR	Kefentse Motshegwa, Letlhogile Oarabile, Chandapiwa Marobela-Raborokgwe	Follow up for letter of support for risk assessment	**no response**
14-Nov-22	W	LR	Odireleng Tholotwane	Availability to meet that afternoon in Maun	Dr Tholotwane said 3pm - meeting was held
15-Nov-22	W	LR	Odireleng Tholotwane	Availability to meet that afternoon in Maun	Dr Tholotwane said 2pm with Dr Mafonko at DVS field office - meeting was held
15-Nov-22	W	LR	Nlingisisi Babayani	Availability to meet that week in Maun	Dr Babayani said he was around

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
16-Nov-22	W	LR	Odireleng Thololwane	Clarification on plans for the rest of the week and travel to Shakawe	Dr Thololwane did not respond regarding these clarifications. Later LR asked for the contact in Shakawe, which Dr Thololwane provided, then he asked if there was any possibility for funding for travel from our side as they were dry. LR conferred with Dr Osofsky and Shirley and requested what expenses Dr Thololwane would like covered and for how many days. Dr Thololwane did not respond but asked when LR was planning to tour fences on the Dobe side. Dr Rosen said she was planning to discuss this with Dr Ramokwena and asked Dr Thololwane's availability. He did not respond to that but said he was meeting up with the guys tomorrow and would update her. He also said he was flying to Eretsha the following day (for mobile quarantine launch) and would return to Maun the same day. Dr Rosen then asked when he was available the following week. He did not reply.
17-Nov-22	W	LR	Odireleng Thololwane	Clarification on what travel expenses would need to be covered	**no response**
17-Nov-22	W	LR	Nlingisisi Babayani	Availability to meet that afternoon in Maun	Dr Babayani said he was a bit engaged preparing for travel - no meeting held

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
18-Nov-22	W	LR	Odireleng Thololwane	Availability for a call or meeting that day in Maun	Dr Thololwane said he would let her know when he was done with the minister. No further response received so LR followed up late in the day asking when he could chat and reiterating that she could assist with travel expenses but needed to know more details. Dr Thololwane asked what her itinerary was and mentioned there was dermatophilosis to respond to. LR said there was no itinerary yet but had tentative plans for Tuesday with Dr Ramokwena in Shakawe, and asked for clarification on the dermatophilosis. Dr Thololwane said it was in Shakawe area and for him it was more of a strategic plan than fieldwork. LR said she was available Mon-Wed the following week and again asked for what travel expenses were needed. Dr Thololwane did not respond regarding the travel expenses but asked if she would only be in Shakawe area and when she was planning to go to Dobe area. LR said she would like to go to the [Shakawe] office and see the [Zambezi Border and Northern Buffalo] fences, and get to north of Dobe if possible, and asked what would work for Dr Thololwane. He said he didn't think she could manage all of that in 3 days because of the distances apart, so she asked which areas he thought should be prioritised. He said the office and Caprivi side of the fence, then asked if she was doing questionnaires. She agreed to arrange that with Dr Ramokwena and stated that she did not have a questionnaire and wanted to see the fence conditions and get some photos. Dr Thololwane

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
					said that she had to see the Dobe side as well and asked what methodology she was following. She said that this was just to get a sense of the fences and surrounding areas and to get photos for the report, and asked what his itinerary was for the following week. Dr Thololwane then said he just realized he was not available until Thursday after LR was gone. She said that was unfortunate and asked if someone from Shakawe would be available to go out [to the fences], and he said there should be.
18-Nov-22	E	LR	Bruce Mafonko	FMD vaccination returns from 2013-2019	Dr Mafonko said he would try his best to assist - no further response received
21-Nov-22	W	LR	Jacques van Rooyen	Request to meet in Shakawe to discuss H4H	Communicated for several days to try to meet in Shakawe but schedules did not align
22-Nov-22	E	LR	Kefentse Motshegwa, Letlhogile Oarabile, Chandapiwa Marobela-Raborokgwe	Follow up for letter of support for risk assessment	**no response**
22-Nov-22	W	LR	Thati - BAITS coordinator	Zone 2a, 2b, 2f crush and kraal coordinates from BAITS	Thati said she would attend to the request tomorrow - no further response received
25-Nov-22	E	NR	Albertina Shilongo	Provided updates & follow up requested on risk assessment	**no response**
25-Nov-22 thru 30-Nov-22	W	NR	Albertina Shilongo	Follow up on email sent	**no response**
01-Dec-22 thru 13-Dec-22	W	NR	Letlhogile Oarabile	Request to meet to discuss draft content for DVS letter of collaboration	Dr Oarabile & NR met on 13 Dec - email was resent on 13 Dec with the draft letter for review & input
5-Dec-22	E	LR	Emmanuel Ramokwena	Request for vaccination returns and buffalo/cattle incursion reports	**no response**

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
6-Dec-22	W	LR	Thati - BAITS coordinator	Follow-up on request for crush and kraal coordinates	**no response**
8-Dec-22	E	LR	Chandapiwa Marobela-Raborokgwe	Feedback on draft risk pathway for CBPP	Dr Marobela-Raborokgwe said she was out of office and would respond in the next week or so. No further response until 11 Jan, when she indicated it was fine and that we should consider the prevention measures in Botswana. LR asked for further information and was referred to Dr Kemolatlhe.
13-Dec-22	E	NR	Letlhogile Oarabile	Letter of support for risk assessment after in-person meeting held that morning	Dr Oarabile requested clarification of why LR was conducting the assessment, who the reporting line for the study included, and who was funding the study and what the linkage was with DVS or Botswana government
16-Dec-22	E	NR	Kefentse Motshegwa, Letlhogile Oarabile, Kabo Thema, Nyambe Nyambe	Nidhi responded to Dr Oarabile's questions and offered to facilitate a Zoom call with the KAZA Secretariat Executive Director if further clarifications were required	**no response**
19-Dec-22	E	LR	Emmanuel Ramokwena	Follow up on request for vaccination returns and incursion reports	Dr Ramokwena shared vaccination returns and incursion reports
19-Dec-22 thru 21-Dec-22	W	NR	Letlhogile Oarabile	Follow up on whether responses to clarifications requested related to the DVS letter of collaboration were received & noted	Dr Oarabile requested that the letter be resent so it could be finalised & committed to having it ready for to be sent to collaboration team in their respective districts by 22 Dec
21-Dec-22	E	NR	Letlhogile Oarabile, Kefentse Motshegwa, Kabo Thema	Resent previous email with request to confirm receipt	Dr Oarabile sent NR WhatsApp message on 22 Dec to inform that the letter was awaiting Director's signature

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
9-Jan-23	W	NR	Letlhogile Oarabile	Follow up on DVS letter of collaboration	Dr Oarabile informed he was on end of contract leave & directed NR to Director Motshegwa
09-Jan-23 Thru 18-Jan-23	W	NR	Kefentse Motshegwa	Follow up on DVS letter of collaboration as field staff expressed their discomfort of participating in & facilitating data gathering without a formal letter from DVS HQ	Dr Motshegwa redirected NR to Dr Mbeha who took over Dr Oarabile's duties.
20-Jan-23 thru 3-Feb-23	W	NR	Bernard Mbeha	Follow up on DVS letter of collaboration	Further clarifications requested about role of KAZA & who the letter should be directed to. It was confirmed that the letter was for internal use within DVS so that staff are given the authority to meet with LR & share data given that this is a collaborative exercise.
25-Jan-23	E	LR	Jacques van Rooyen	Request for data on animal health and H4H	**no response**
1-Feb-23	E	LR	Bernard Mbeha, Yvonne Sereetsi, Odireleng Thololwane, Kefentse Motshegwa, Chandapiwa Marobela-Raborokgwe	Availability for zoom meeting on 13, 14, or 15 Feb to catch up on risk assessment	Dr Marobela-Raborokgwe said she was on end of contract and wouldn't be able to attend. Drs Mbeha, Thololwane responded with availability.
2-Feb-23	E	NR	Albertina Shilongo, Colgar Sikopo	Shared copy of letter sent to Executive Director requesting a virtual meeting with epidemiologists	Dr Shilongo confirmed receipt. No further response.
06-Feb-23 07-Feb-23	W	NR	Yvonne Sereetsi	Availability for zoom meeting the following week	Asked to liaise with Dr Mbeha to confirm his availability. Based on his response, Dr Sereetsi confirmed her availability too.
6-Feb-23 thru 9-Feb-23	W	NR	Odireleng Thololwane	Availability for zoom meeting the following week	Delayed response due to travel - indicated availability on 13 Feb

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
7-Feb-23	W	NR	Bernard Mbeha	Follow up on DVS letter of collaboration and possible date for touchbase on risk assessment with other team members & LR	Letter was confirmed to have been prepared
9-Feb-23	W	NR	Bernard Mbeha	Possibility of changing Zoom call date from 14 to 13 Feb & attendance by technical resource experts	Agreed as long as no last minute urgent work assignments & also include Dr Mokopasetso & Dr Babayani on the group call
9-Feb-23	W	NR	Yvonne Sereetsi	Possibility of changing Zoom call date from 14 to 13 Feb & attendance by technical resource experts	Confirmed availability
9-Feb-23	W	NR	Nlingisisi Babayani	Possibility of changing Zoom call date from 14 to 13 Feb & attendance by technical resource experts	Confirmed availability
9-Feb-23	W	NR	Mokganedi Mokopasetso	Possibility of changing Zoom call date from 14 to 13 Feb & attendance by technical resource experts	Confirmed availability
9-Feb-23	E	LR	Nlingisisi Babayani, Mokganedi Mokopasetso	Attendance at catch up Zoom call	Dr Babayani confirmed receipt and Dr Mokopasetso said he would try to make time to attend
13-Feb-23	W	NR	Bernard Mbeha	Reminder about meeting	Indicated would not be able to join as planned due to other work
13-Feb-23	W	NR	Yvonne Sereetsi	Reminder about meeting	Confirmed availability
13-Feb-23	W	NR	Mokganedi Mokopasetso	Reminder about meeting	Confirmed attendance
20-Feb-23	W	NR	Bernard Mbeha, Yvonne Sereetsi, Odireleng Thololwane, Mokganedi Mokopasetso, Nlingisisi Babayani	NR created WhatsApp group for risk assessment and reminded group of email sent with slides from meeting	Dr Mbeha acknowledged receipt of slides

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
20-Feb-23 thru 13-Mar-23	W	NR	Bernard Mbeha	Attempts to find time to have a meeting to provide a more detailed debrief of the team discussion on 13 Feb which he was unable to attend	Several attempts made but kept rescheduling due to other work commitments. In the end, it did not take place.
22-Feb-23	W	LR	Nlingisisi Babayani	Availability for brief WhatsApp call the following day or Friday	Dr Babayani replied the following week stating that DVS and BVI were still seized with the ongoing EU inspections and to hope for an effective response soon
23-Feb-23	E	LR	Emmanuel Ramokwena	Questions on buffalo/cattle incursions and repatriation	**no response**
24-Feb-23	E	LR	Emmanuel Ramokwena	Follow up on previous email	Dr Ramokwena responded with answers to questions
28-Feb-23	W	LR	Bernard Mbeha, Yvonne Sereetsi, Odireleng Tholwane, Mokganedi Mokopasetso, Nlingisisi Babayani	Data on department policies on destruction/compensation and crush geolocations as discussed on call	Dr Tholwane said they would make arrangements for the data. No further response. Dr Babayani suggested more in person meetings were needed. Dr Rosen replied indicating that budget was available for these and while they were always preferred, not possible now given the upcoming EU audit and her maternity leave. Suggestion of in person meeting in Maun in Jun was offered. Dr Babayani said that was encouraging and that DVS needed to lead the request for data; no response to suggestion for meeting. No other responses from group about meeting or other thoughts.
8-Mar-23	E	LR	Comfort Nkgowe	Request for data on wildlife movement and poaching records	Dr Nkgowe said he would check with anti-poaching team and research officers and revert. No further response received.
20-Mar-23	E	LR	Comfort Nkgowe	Follow up on previous email	**no response**

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
21-Mar-23	E	LR	Jacques van Rooyen	Request for data on animal health and H4H	Dr van Rooyen suggested a quick call the following week. LR proposed times. No further response received.
5-May-23	W	NR	Albertina Shilongo	Offered several windows to meet virtually with Namibia DVS epidemiologists	Unavailable due to attendance of WOAH General Session but asked to contact Dr Hikufe
9-May-23	E	NR	Emmanuel Hikufe, Natangwe Amuthenu, Kennedy Shoombe, Albertina Shilongo	Availability for Zoom meeting the week of 15 or 22 May	**no response**
10-May-23	E	NR	Emmanuel Hikufe, Natangwe Amuthenu, Kennedy Shoombe, Albertina Shilongo	Follow up on availability for Zoom meeting the week of 15 or 22 May	**no response**
17-May-23	E	LR	Comfort Nkgowe	Follow up on previous email	**no response**
18-May-23	E	LR	Russell Taylor	Data on buffalo or cattle distribution from KAZA Elephant Survey	**no response**
24-May-23	E	LR	Obakeng Kemolatlhe, Bernard Mbeha	Information on CBPP control measures in place	Dr Mbeha replied, both he and Dr Kemolatlhe in France this week but said Dr Kemolatlhe would assist and to let him know if there were challenges
24-May-23	E	LR	Chandapiwa Marobela-Raborokgwe	Availability for Zoom call to discuss CBPP risk pathway	
31-May-23	E	LR	Kabelo Senyatso, Comfort Nkgowe	Follow up request for data on buffalo density near fences, poaching records, and any FMD surveillance data	Dr Nkgowe referred to DVS on surveillance data - no further response received
1-Jun-23	E	LR	Emmanuel Hikufe, Natangwe Amuthenu, Kennedy Shoombe, Albertina Shilongo	Follow up to note that we would all be attending the KAZA AHSWG meeting in Divundu and hopefully have an opportunity to discuss the risk assessment	**no response**

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
5-Jun-23	E	LR	Obakeng Kemolatlhe, Bernard Mbeha	Follow up on CBPP request	Dr Kemolatlhe asked to discuss the following day; LR at AHSWG meeting and unavailable. Agreed plan to discuss the following week.
11-Jun-23 thru 17-Jun-23	W	NR	Odireleng Thololwane	Touchbase meeting in Maun on disease risk	Initially wasn't available but changes in schedule meant was available to meet with AHEAD team on 19 Jun in Maun
11-Jun-23 thru 17-Jun-23	W	NR	Nlingisisi Babayani	Touchbase meeting in Maun on disease risk	Initially wasn't available but changes in schedule meant was available to meet with AHEAD team on 19 Jun in Maun
14-Jun-23	E	LR	Albertina Shilongo, Kefentse Motshegwa, Bernard Mbeha, Kobedi Segale, Mokganedi Mokopasetso, Natangwe Amuthenu, Emmanuel Hikufe, Kennedy Shoombe	Following discussions at AHSWG meeting, request for livestock census data, geographic coordinates, incursion reports, department policies, outbreak and strain characterisation data, serosurveillance data, vaccination records, post-vaccination seromonitoring data and EU audits from Botswana and Namibia DVS	Dr Motshegwa directed Dr Segale to coordinate, Dr Mokopasetso to provide virus characterisation data, and provided EU audit codes. Dr Thema provided DVS data on 6 Jul. Dr Mokopasetso provided data on 7 Jul. Dr Shilongo stated they would revert as soon as possible.
14-Jun-23	E	LR	Anna Songhurst	Wildlife and cattle movement data, spatial data on boreholes	**no response**
18-Jun-023	W	LR	Comfort Nkgowe	Shapefiles for wildlife management areas	Dr Nkgowe provided shapefiles the following week.
19-Jun-23	E	SO	Kabelo Senyatso, Comfort Nkgowe	Request to meet with AHEAD between 22-26 Jun	Dr Senyatso responded with his availability; meeting was tentatively scheduled but subsequently cancelled

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
20-Jun-23	E	LR	Odireleng Tholowane, Kobedi Segale, Kabo Cabusher, Kefentse Motshegwa	Follow-up on cattle incursion reports, vaccination data, serosurveillance data	Dr Tholowane asked for clarification on incursion reports, which LR provided. Dr Tholowane provided serosurveillance data and crush-level vaccination returns for 2023, as well as coordinates for serosurveillance crushes and shapefiles for Ngamiland. LR also asked about whether Seshokora crush had been vaccinated this year and Dr Tholowane confirmed it had not.
20-Jun-23	E	LR	Ben Heermans	Information on poaching in Ngamiland	Dr Heermans provided some information on meat harvesting from poached animals
23-Jun-23	W	LR	Jacques van Rooyen	Request to discuss H4H	Scheduled meeting during Dr van Rooyen's visit to Victoria Falls the following week
25-Jun-23	E	SO	Kabelo Senyatso, Comfort Nkgowe, Nyambe Nyambe	Follow up on request for data and request to meet with AHEAD on 26 Jun	**no response**
29-Jun-23	E	LR	Albertina Shilongo, Natangwe Amuthenu, Emmanuel Hikufe, Kennedy Shoombe	Follow up on request for data	**no response**
10-Jul-23	E	SO	Kabelo Senyatso, Comfort Nkgowe, Nyambe Nyambe	Follow up on request for data	**no response**
11-Jul-23	W	LR	Albertina Shilongo	Follow up on request for data	Dr Shilongo requested Dr Amuthenu to provide information and thought it had already been provided
11-Jul-23	E	LR	Natangwe Amuthenu, Albertina Shilongo	Follow up on request for data	**no response**
17-Jul-23	E	SO	Nyambe Nyambe	Availability of KAZA Elephant Survey data (specifically livestock portion)	Dr Nyambe stated the report was still under external review
18-Jul-23	W	LR	Albertina Shilongo	Follow up on request for data	Dr Shilongo requested LR email Dr Hikufe to provide information as Dr Amuthenu out of office

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
18-Jul-23	E	LR	Emmanuel Hikufe, Natangwe Amuthenu, Kennedy Shoombe, Albertina Shilongo	Follow up on request for data per direction from Dr Shilongo	**no response**
24-Jul-23	E	NR	Joseph Kapapero	Request for Dr Kapapero to follow up on data request	Dr Kapapero acknowledged receipt and promised to follow up - no further response received
27-Jul-23	W	LR	Lise Hanssen	Discussion of wildlife and cattle in Zambezi Region	Unable to coordinate meeting
2-Aug-23	W	LR	Lise Hanssen	Follow up on request for discussion	**no response**
7-Aug-23	W	LR	Comfort Nkgowe	Call to discuss poaching within Ngamiland	Call held on 10 Aug
8-Aug-23	E	LR	Emmanuel Hikufe, Natangwe Amuthenu, Kennedy Shoombe, Albertina Shilongo	Follow up on request for data per direction from Dr Shilongo after Dr Nyambe spoke with her	Dr Siteketa responded with FMD and CBPP contingency plans, animal health legislation, and responses from DVS. LR requested further information on crushes, cattle incursions, FMD serosurveillance, vaccination records, and post-vaccination seromonitoring. Dr Hikufe requested clarification on area of interest and LR provided a map.
15-Aug-23	W	LR	Jacques van Rooyen	Follow up on request for H4H model information	Dr van Rooyen responded by email with H4H materials
28-Aug-23	E	LR	Emmanuel Hikufe, Tuovi Siteketa, SAT Elago, Natangwe Amuthenu	Follow up on request for data	**no response**
30-Aug-23	E	LR	Anna Songhurst	Follow up on request for data	Data sharing agreement signed and data provided on 5 Oct
30-Aug-23	E	LR	Arthur Albertson	Cattlepost data	Cattlepost data received
30-Aug-23	E	LR	Robin Naidoo	Spatial data for KAZA region on rivers, roads, settlements and fences in Namibia	Dr Naidoo provided spatial files requested

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
31-Aug-23	W	LR	Piet Beytell	Discussion on wildlife and cattle in Nyae Nyae and Khaudum	Call held on 5 Sep
31-Aug-23	W	LR	Ortwin Aschenborn	Discussion on wildlife and cattle in Bwabwata and Zambezi Region	Unable to coordinate meeting
4-Sep-23	W	LR	Russell Taylor	Availability of livestock and buffalo data from KAZA Elephant Survey	Dr Taylor shared volumes 1 and 2 of survey
4-Sep-23	W	LR	Lise Hanssen	Follow up on request for discussion	Call held on 13 Sep
12-Sep-23	W	LR	Theunis Pietersen	Discussion of poaching risk in Namibia	Call held on 15 Sep
13-Sep-23	W	LR	Donovan Jooste	Discussion of livestock risk from Angola	Call held on 15 Sep
13-Sep-23	P	LR	Emmanuel Hikufe	Tried office phone to discuss outstanding data and other queries	**no answer**
13-Sep-23	P	LR	Natangwe Amuthenu	Tried office phone to discuss outstanding data and other queries	**no answer**
26-Sep-23	E	SO	Albertina Shilongo, Kefentse Motshegwa, Nyambe Nyambe	Availability to meet week of 6 Nov in Johannesburg to discuss risk assessment findings at a validation meeting	Dr Motshegwa confirmed on 4 Oct that date was acceptable & requested formal invitation be sent to his Permanent Secretary; Dr Shilongo confirmed on 6 Oct that date was acceptable & requested formal invitation be sent to her Executive Director. Such letters / formal invitations were provided.
22-Oct-23	E	KAZA Sec	Albertina Shilongo, Kefentse Motshegwa; other validation meeting participants	Inform of validation meeting postponement	The timeframe to finalise meeting logistics was inadequate given that attendance of Partner State representatives had not been formally confirmed. Both DVS Directors confirmed that invitations need to be routed through the

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
					ministries of environment to the ministries of agriculture from the KAZA Secretariat.
22-Nov-23	E	LR	Kobedi Segale	Dr Segale wrote to confirm that all required information had been provided. The 2023 buffalo and cattle incursion reports were still outstanding.	Dr Thololwane provided 2023 buffalo and cattle incursion reports for zone 2 via WhatsApp
06-Feb-24 thru 21-Mar-24	Various	NR	Albertina Shilongo, Kefentse Motshegwa, Kenneth Shoombe, Nyambe Nyambe	Availability to meet week of 13 May to discuss risk assessment findings at re-scheduled validation meeting	Dr Shilongo and Dr Shoombe confirmed during virtual zoom call on 11 Mar that date was acceptable & requested formal invitation be sent; Dr Motshegwa re-confirmed during in-person meeting with NR on 21 Mar that date was acceptable & requested meeting be held in Botswana due to travel constraints. Namibia indicated travel to Botswana was a viable option. Formal invitations were provided by KAZA Secretariat.
22-Apr-24	E	LR	Kefentse Motshegwa, Kobedi Segale, Bernard Mbeha, Odireleng Thololwane, Chandapiwa Marobela-Raborokgwe, Comfort Nkgowe, Janine Sharpe, Joseph Kapapero, Natangwe Amuthenu, Emmanuel Hikufe, Kenneth Shoombe, Albertina Shilongo, Nyambe Nyambe, Nlingisisi Babayani, Mokganedi Mokopasetso, Mary-Lou Penrith, Jacques van Rooyen, Michael Molaodi, Jose Kaumba	Shared draft disease risk assessment report for discussion during validation meeting.	Several recipients acknowledged receipt and Drs Nyambe and Penrith sent regrets as they would be unavailable for the meeting.
16-May-24	E	SA, LR	Natangwe Amuthenu, Nlingisisi Babayani, Simeon Elago, Bruce Mafonko, Agang Makala, Mokganedi Mokopasetso, Comfort Nkgowe,	Phase 1 KAZA fencing report, PowerPoint presentation on risk assessment from the validation meeting, and	Several recipients acknowledged receipt. Dr van Rooyen provided some clarification on language used to describe H4H, and the report was updated accordingly.

Date	Medium	Sender	Recipient(s)	What Was Requested	Response/Outcome
			Emmanuel Ramokwena, Kobedi Segale, Janine Sharpe, Kenneth Shoombe, Thompson Shuro, Odireleng Tholowane, Jacques van Rooyen	PowerPoint presentation on new recommendations shared with meeting attendees	
17-May-24	W	LR	Thompson Shuro	Clarification of whether a CBPP outbreak occurred at Masivi, lat -18.61 long 19.68, in 2018	Dr Shuro was not aware of this outbreak and other officials also did not recall it; the point has been removed from maps in the report.
03-Jun-24	E	LR	Natangwe Amuthenu, Nlingisisi Babayani, Simeon Elago, Bruce Mafonko, Agang Makala, Mokganedi Mokopasetso, Comfort Nkgowe, Emmanuel Ramokwena, Kobedi Segale, Janine Sharpe, Kenneth Shoombe, Thompson Shuro, Odireleng Tholowane, Jacques van Rooyen	Final reminder about missing data	Dr Elago provided incursion data and CBPP contingency plan from Namibia. Dr Tholowane provided data from Botswana.

APPENDIX D: Herding 4 Health model outline and case study

An overview of the Herding 4 Health model, with emphasis on the KAZA TFCA

Herding 4 Hope (Pty) Ltd, June 2024

What was the need for the development of a model?

The principal motivation for the development of the Herding 4 Health (H4H) model was the considerable body of evidence highlighting the issue of uncontrolled livestock movement within communal farming systems, in particular those at the wildlife-livestock interface, and the low presence of what is generally accepted best farming practice. In numerous communal pastoral systems throughout the region, livestock are generally kraaled at night at homesteads. However, the consistency of this practice fluctuates according to the season and the specific landscape. It is not uncommon for livestock to be left unattended, even during nighttime hours. By day, very few farmers across landscapes still herd livestock permanently and even where there are paid herders, they often serve more as gate keepers at kraals than herders during the day. Most full-time herding that still occurs has been reduced to seasonal herding (mostly during the cropping season to protect crops from livestock) and has become what can be referred to as 'drop and fetch' herding. Vast numbers of livestock roam unattended, driving land degradation piospheres wider and wider around villages and reducing animal productivity as livestock must travel further and further for food and water. In certain landscapes, the failure of livestock to return to the kraal constitutes the primary cause of cattle losses, surpassing those attributed to other factors such as disease, predation, and stock theft (Heermans, 2022)[2]. Extensive research and numerous community consultations conducted over several years across multiple countries in the region have consistently highlighted unattended livestock as a central issue in most of the livestock-related risks and challenges confronting farmers in the area. Livestock, particularly cattle and goats/sheep, not being kraaled and herded properly leads to uncontrolled, nonstrategic animal movement that causes or increases:

Directly:

- Rangeland degradation
- Predation
- Disease transmission and spread
- Poor herd health
- Poor animal production
- Stock theft
- Road accidents
- Tourism and other land use conflict

Indirectly:

- Animal trade barriers
- Negative climate impact
- Lower investment confidence
- Lower developmental success
- Reluctance to trade

What is Herding 4 Health?

Herding 4 Health is first and foremost a framework or model designed by combining science, farming best practice, and traditional knowledge to address the complex suite of challenges faced by pastoral communities at the wildlife-livestock interface in a simple, systematic and practical way. Some organisations also call their programmes that drive the implementation of the H4H model where they

[2] Heermans, 2022. PhD Thesis, Faculty of Veterinary Science, University of Pretoria

work, *Herding 4 Health* (Peace Parks Foundation and Conservation International). The original H4H model was developed by Dr Jacques van Rooyen (Van Rooyen, 2016)[3] as a One Health solution to the multiple challenges faced by communal livestock farmers at the wildlife-livestock interface in southern Africa. Under his guidance the model has undergone continuous development into a versatile process for implementation by pastoral communities and/or entities involved in pastoral farming systems, particularly at the wildlife-livestock interface. He has also helped to establish the Herding 4 Health programme (2018) of the Peace Parks Foundation and Conservation International and recently (2022) co-founded Herding 4 Hope (H4Hope) as an independent organisation dedicated to the further development of the H4H model and to support the implementation of the model by any community or organisation in any relevant landscape. The H4H model can be defined as:

A One Health model to empower communities & stakeholders to develop a farming system able to address the suite of challenges faced at the wildlife-livestock / community-conservation interface in a practical, traditionally acceptable way offering livelihood impact, sustainability, and biodiversity outcomes in the face of climate change, wildlife-livestock conflict, skills & job shortages, poverty, and transboundary animal diseases.

The H4H model promotes and facilitates skilled herding within pastoral communities as a key strategy to address unattended, nonstrategic animal movement, including lack of kraaling and associated consequences. Improved herding and kraaling practices can be achieved through training and collective action among pastoralists who utilise shared natural resources. The H4H model empowers communities by equipping local herders with the necessary skills and processes to implement strategic herding and kraaling that enables compliance with good livestock and land management practices that are also wildlife-friendly, climate-smart, and sustainable. Compliance records kept by skilled herders and the governance structures developed to enable collective action by farmers in a landscape can assist in overcoming trade barriers and promoting investment needed to ensure communities are more resilient and livelihood strategies become more sustainable. In other words, risks are systematically overcome by enabling best practices and a farming system that make communities gradually more investment friendly as opposed to being mainly reliant on donor and government support that is not likely to result in sustainable long-term prosperity.

The H4H model builds on **four pillars** or cornerstones, with four key actions by farmers with support from landscape stakeholders to achieve four critical returns or outcomes that are essential for generational prosperity and landscape resilience (Figure D1). Healthy **rangelands**, **animals** (livestock & wildlife), prosperous **livelihoods** and solid **governance** of natural resources by land users are the pillars on which H4H is built. Processes in all four of these pillars at community level form part of the model. Improvement in all four pillars revolves around actions farmers take, ideally collectively, in the form of the **4-H action cycle** that help pull communities out of a poverty trap towards hope and a better future: **H**ope, **H**erd, **H**eal, and **H**arvest. Communities with the hope and belief that they themselves, their livestock, and their land and all its animals and resources can prosper if they are willing and able to manage their livestock well will move out of conviction and not incentive alone. Empowered through skilled herders within communities, livestock are herded and kraaled strategically to heal the land, the herds, livestock-wildlife conflict, and relationships towards greater unity amongst stakeholders. Farmers

[3] Van Rooyen, J. 2016. PhD Thesis, Faculty of Veterinary Science, University of Pretoria. https://repository.up.ac.za/handle/2263/60128

working collectively in unity enable improved compliance with best farming practices, and the healthy and productive herds on restored rangelands coexisting with wildlife offer a harvest in the form of diversified livelihood opportunities, enterprise, and investment opportunities that further sustain best practice and instil more hope for more action. Such a positive impact in rangelands, animals, livelihoods, and community governance is a gradual, diligent systematic process that ultimately results in **inspiration, social, ecological and financial returns** over generations.

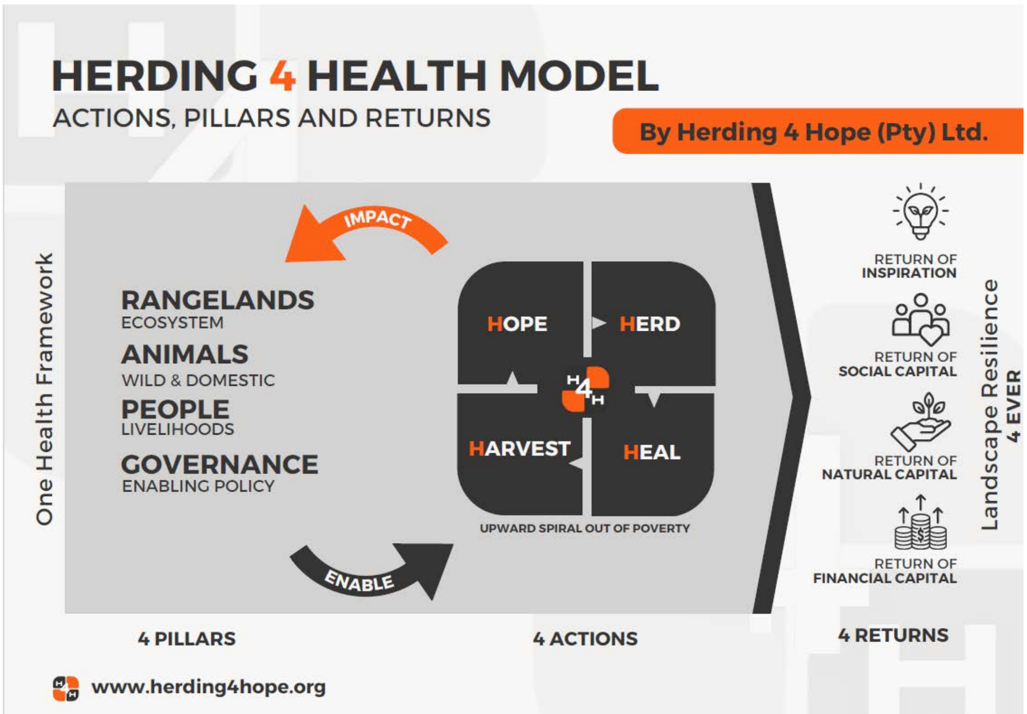

Figure D1. Schematic overview of the H4H model as implemented by Herding 4 Hope (Pty.) Ltd.

How does H4H work?

The H4H model is introduced to interested communities and landscape stakeholders as *a way of farming* that empowers farmers with the necessary skills and innovations so that together with traditional knowledge a suitable and sustainable farming system can be co-developed by all concerned. Such a farming system must be landscape specific and appropriate. Herders are recruited from within communities by farmers themselves and are equipped to become change agents through which pastoral communities are empowered to overcome farming challenges and unlock opportunities. Various training curricula are offered at various levels, but the eight core competencies required by herders and implementers, are as follows:

- Strategic planned grazing & kraaling
- Animal production & husbandry
- Primary animal health care
- Wildlife contact management (predators / disease carrying wildlife)
- Record keeping, animal identification & traceability
- Community liaison / mobilisation
- Tracking and wildlife protection
- Low-stress animal handling

These core competencies and 24/7 control of livestock movements in a village help minimise all the major risks typically faced by farmers at the wildlife-livestock interface, such as predation, land degradation, disease, stock theft, lost animals and road accidents. It also helps to build up compliance records and a farming system needed to unlock opportunities such as improved trade, water provision and governance, new enterprises (e.g. medicine and farming supplies) and livelihood diversification (e.g. climate and biodiversity-based credits). The H4H model is integrated with indigenous knowledge and traditional farming practices. All relevant landscape partners and land users, especially government departments, are part of the implementation design and strategy.

Following an engagement process by willing communities, a pilot implementation strategy is co-developed for the landscape or site by farmers, H4H specialists, government and non-government stakeholders. Grazing Area Committees (GACs) are formed by farmers per relevant farmer unit and take responsibility for herder recruitment, deployment and supervision. GACs provide basic governance and collective decision-making support to all farmers for improved herd and natural resource management. Various kraals in a grazing area can be clustered together to form combined herds and kraals managed by skilled herders if such a practice is of strategic advantage and only if agreed to by farmers. Mobile predator-proof kraal technology is at the farmers' disposal, where budgets allow, to support strategic herding and kraaling and especially grazing and water access further afield from villages where necessary. Livestock are herded permanently throughout the year and an adaptive grazing plan is overseen by the GAC and executed by the skilled herders and all their support herders/farmers (volunteer support). Grazing plans and herding practice consider seasonal changes in water and grazing, and important risks and threats such as wildlife movement patterns, disease risk, predators, stock theft, bush fire, flooding, and tourism or hunting conflicts. Grazing plans can be modified with herding and especially mobile kraaling techniques and technology to restore degraded rangeland, regenerate soils and fertilize crop fields. Grazing plans are dynamic and developed and adapted in a participatory way as far as possible with all relevant landscape stakeholders, such as tourism operators, hunting operators, veterinary services, wildlife management, and traditional leadership.

Skilled herders assess and record animal health twice a day (morning and evening) and monitor animal health throughout the day as animals are herded. Animals are counted every day and productivity records are kept. All animals in H4Hope-supported sites are individually tagged with a visual ID and the legislated traceability ID where relevant. Herd level and individual animal records on health (vaccinations, treatments), production performance (calving, breeding, condition, weights, etc.) and trade are kept through a state-of-the-art yet user friendly and robust animal recording system that works through a mobile app (off-line enabled) and a dynamic user interface. Lead herders are trained to use the system. Reports on individual animals and herds can be drawn and shared at any time for purposes of trade, disease control compliance or management decisions.

Herders follow a grazing plan and herd animals in ways that optimize rangeland utilization without compromising animal performance and health as far as possible. During herding, herders actively avoid contact or even proximity with any animal posing a disease risk, especially buffalo and even stray cattle. Wildlife-friendly livestock management techniques are enabled through the skilled herders and a combination of reinforced static or mobile predator proof kraals. Disease outbreaks and associated treatments are immediately reported due to continuous surveillance by herders. Any outbreak or treatment response by veterinary services is supported by the H4H implementation team, including the GAC and farmers to improve the coordination, communication and effectiveness of the control measures. Herder-teams and GACs work as closely as possible with local veterinary and livestock production extension staff for improved extension impact, and where possible H4H implementation and government extension efforts are integrated to save costs and be more efficient. Herders record and report wildlife-related threats to wildlife officials, especially signs of poaching or the presence of damage-causing animals. Compliance records are kept and associated producer agreements are used to overcome trade barriers and this has successfully unlocked new markets through, for example, commodity-based trade in various sites. Compliance records and producer agreements further enable collective bargaining power for reduced transactional costs by individual farmers, which is a major trade barrier for many small-scale farmers. Skilled herders and GACs play a vital role in accessing and enabling the use of trade technology such as mobile quarantine facilities in support of compliance with trade standards.

Skilled herders enable farmers to demonstrate H4H compliance, a record farmers have that proves they are actively participating in and compliant with H4H protocol (Figure D2). H4H compliance means there is evidence that an animal is being herded and kraaled strategically every day in a wildlife-friendly manner by herders with decent working conditions and support, is treated humanely and with the necessary animal welfare considerations, is following a grazing plan that is regenerative, and has all the necessary animal identification, traceability, treatment and performance records. H4H compliance is aligned with best practices promoted by the FAO and WOAH.

Figure D2. Schematic of the basic H4H compliance requirements for which evidence must be provided ideally at individual owner and animal level.

In the first 3-5 years an implementation partner should ideally be present in a landscape to facilitate the necessary technical and operational support to GACs until H4H has established critical participation mass (70-80% of the farmers), governance, skills and implementation rhythm. During this time skilled herders can be hosted by an NGO or community-based trust (H4H implementation partner) on behalf of the farmers until they have the necessary structures and administration in place to host employment themselves. Typically, farmers start to form cooperatives, or syndicates or trusts if they so wish, which can support H4H compliance efforts in the long term. However, skilled herders *always* work for farmers, and not an NGO (Implementation partner), even if the latter is hosting the herders in the foundational phases of the initiative. Additional support in the form of H4H extension officers (team leaders) and an implementation manager during the first five years of an initiative is generally also required and is typically hosted by the implementing partner. This capacity is often required in early stages in new landscapes to support farmers in the foundational years to get established in best practice and the necessary systems and skills to support continuous compliance.

At around five years, in the case of H4Hope-supported sites, a long-term sustainability strategy with all the relevant landscape stakeholders is developed. The sustainability strategy guides landscape-specific collaborations and partnerships required to securing investment for enterprises and any other mechanism for long-term support of H4H compliance. Such sustainability mechanisms and pathways are diverse and landscape-specific and require a deep understanding of the local rangeland system, farming system, community governance, government, landscape stakeholders such as the tourism industry and agri-businesses, and all associated risks. Insight into all these and the long-term opportunities that exist through stakeholder partnerships developed in support of the H4H effort is collected through the first five years of piloting, which then supports sustained efforts as landscape-level scaling starts to happen organically.

How is H4H compliance sustained in, for example, the KAZA TFCA?

Small-scale farmers in southern Africa face what can arguably be deemed as some of the most difficult livestock farming environments in the world. Due to the prominence of predation, erratic environmental conditions, disease, generally poor infrastructure and basic services, transboundary disease threats and associated disease control-based trade barriers, and limited access to financial capital systems, these systems are considered high-risk and not deemed investible except for by governments and donors. Still, livestock are present and represent a livelihood strategy and likely untapped opportunity for most. H4H is relevant to farmers that recognise that the full potential of their livestock assets is not yet achieved largely due to the environment they find themselves in. However, they also recognise that heir herding and kraaling practices have deteriorated significantly and that they and their herders lack the skills to overcome the full suite of pressing challenges they face. Trade barriers have increased, driving up the cost of trade and market compliance, and farming input costs have increased significantly, leaving such farmers, especially small-herd farmers, to settle for a low-input, low-output farming system – survival farming. Facing this daunting reality leads to heightened individualism, where farmers try to survive as best they can with the little they have. Government support may be present to varying degrees, but is insufficient to effect systems transformation by itself.

Given the reality of farming in these conditions, Herding 4 Hope defines sustainability in the context of H4H implementation not as the point at which it can be self-sustained by a farmer, but rather, the point at which the level of support needed to sustain H4H compliance in any farming community can be secured through the strategic collaboration of all relevant stakeholders in the landscape, which includes the farmers themselves. At the wildlife-livestock interface in landscapes such as the KAZA TFCA, H4H compliance is a livelihood strategy for the majority of the people in a community, and livestock is the largest land user besides perhaps protected areas. Livestock is as abundant as wildlife[4]. It is therefore a landscape concern – not a private farmer concern only as might be the case in a commercial farming setting where livestock farming is a commercial enterprise on a commercial property that can justify the individuals' investment in the land use and associated farming operation. At the wildlife-livestock interface in communal farming system, such as in the KAZA TFCA, it is in all stakeholders in a landscape's interest for farmers to be able to maintain H4H compliance because it directly relates to reduced human-wildlife conflict and reduced disease transmission, land regeneration, and land use conflict mitigation that can help achieve landscape-level objectives for all concerned, including those objectives KAZA member states committed themselves to. These include improved wildlife-livestock coexistence in a way that reduce resource competition, disease transmission and lethal predator control so that wildlife can disperse better and maintain healthy populations through what had become rangelands where only livestock occurred. This in turn protects the interests of existing tourism and conservation efforts on the one side, and on the other side extends the reach of tourism and hunting opportunities into rangelands previously occupied by livestock only. It allows for more effective livelihood diversification that can help communities overcome poverty traps whilst making government support efforts in the form of poverty alleviation, skills development, rural development, animal disease control, wildlife protection, damage causing animal control, and provision of agricultural extension services more effective and sustainable. More importantly, these efforts can be co-financed by landscape stakeholders supporting H4H implementation.

Wildlife presence in high numbers comes at a considerable cost to the farmers willing to on the one side embrace their presence but on the other side need to make a living beyond just that which can be gained from wildlife-based opportunities. The collective costs of having to deal with high annual mortalities and loss combined with extensive distances from any support services or facilities, limited basic services such as roads, electricity and water, low literacy and formal skills, limited agricultural and veterinary extension support, to name some, is too much to bear by livestock farmers alone. Hence, sustained support for H4H compliance in the foreseeable future will have to be a collective effort by all concerned, and if done strategically, should be affordable, efficient and sustainable with the reward being the multiple benefits gained from the combined effort.

In landscapes such as the KAZA TFCA, long-term support for H4H compliance is achieved through multiple sustainability pathways identified and positioned during the first five years of H4H implementation in a landscape. To transform the system is a process and requires external investment for the first 3-5 years especially. These initial input costs are typically borne primarily by donor organisations because farmers themselves and other landscape stakeholders first need to start reaping the value of H4H implementation before they typically start investing more themselves at more sustainable levels. There is therefore a bridging period structured in the form of a pilot process over the first 3-5 years. The process starts with farmers, as a collective, in unity, recognising the need for change and requesting support in achieving it. The H4H model is only intended to be implemented where the community and its leaders, including local government and other relevant stakeholders, such as tourism operators and protected area managers, have supported the strategy. Some degree of farmer hesitance

[4] Bussière, E. M. S., & Potgieter, D. 2023. KAZA Elephant Survey 2022. *Volume I: Results*. https://www.kavangozambezi.org/download/81/kaza-elephant-survey-report-english/1891/1-kaza-elephant-survey_volume-i.pdf.

is expected in the beginning of implementation; therefore, a pilot is the first step through which the community of farmers and all relevant stakeholders learn, test the model and work out how best it should be implemented in their context. After about three years of piloting, demonstration of consistent H4H compliance as supported by a well-established GAC should be achieved with sufficient levels of participation at community level. The level of compliance and participation should then test and unlock prospective sustainability mechanisms, or pathways through which resources (time for effort, equipment, expertise and finance) can flow to sustain minimum H4H compliance (Figure D3). These are then used to build a sustainability plan for the long term (20 years and beyond) between years 3–5. Once sustained H4H compliance is seen as being in the interest of the landscape at large, a sustainability plan of shared and blended financial support amongst relevant landscape stakeholders can be developed, including new enterprise, investment and entrepreneurial opportunities emanating from H4H compliance. Examples include new red meat trade opportunities, such as commodity-based trade, newly built slaughter facilities or better access to existing facilities.

No H4H implementation site has yet run out of the necessary support to sustain compliance, given the multiple benefits unlocked through H4H implementation and compliance. Importantly, as farmers and especially GACs build their strength and governance, they start managing their own finances even from year 2–3 and GACs may become like a local cooperative with their own bank accounts if needed by year three. These are then further supported and ideally a landscape level fund or entity is created in a well-managed and audited way whilst maintaining basic support effort for H4H compliance. As farmers become compliant and the skills are established through the investment in the initial 3-5 years, the level of support to maintain compliance reduces significantly which further aids long-term sustainability. Only a few skilled herders and a few extension support personnel might be required at a landscape level to continue the support of decision making, coordination of stakeholders and technical support in the long term. Financial modelling has shown these could be supported in the long term through opportunity unlocked through H4H compliance, such as increased contributions by tourism operators, government support and investments from carbon and or biodiversity credit schemes, for example. Such efforts help lessen the need for government investment in animal health and disease control which again could unlock government support for compliance. Consequently, government vet services, for example, collaborate closely with H4H teams for added value and cost savings.

A H4H basic implementation graphic is provided in Figure D4. Also see below a case study from CLAWS (Communities Living Amongst Wildlife Sustainably) Conservancy.

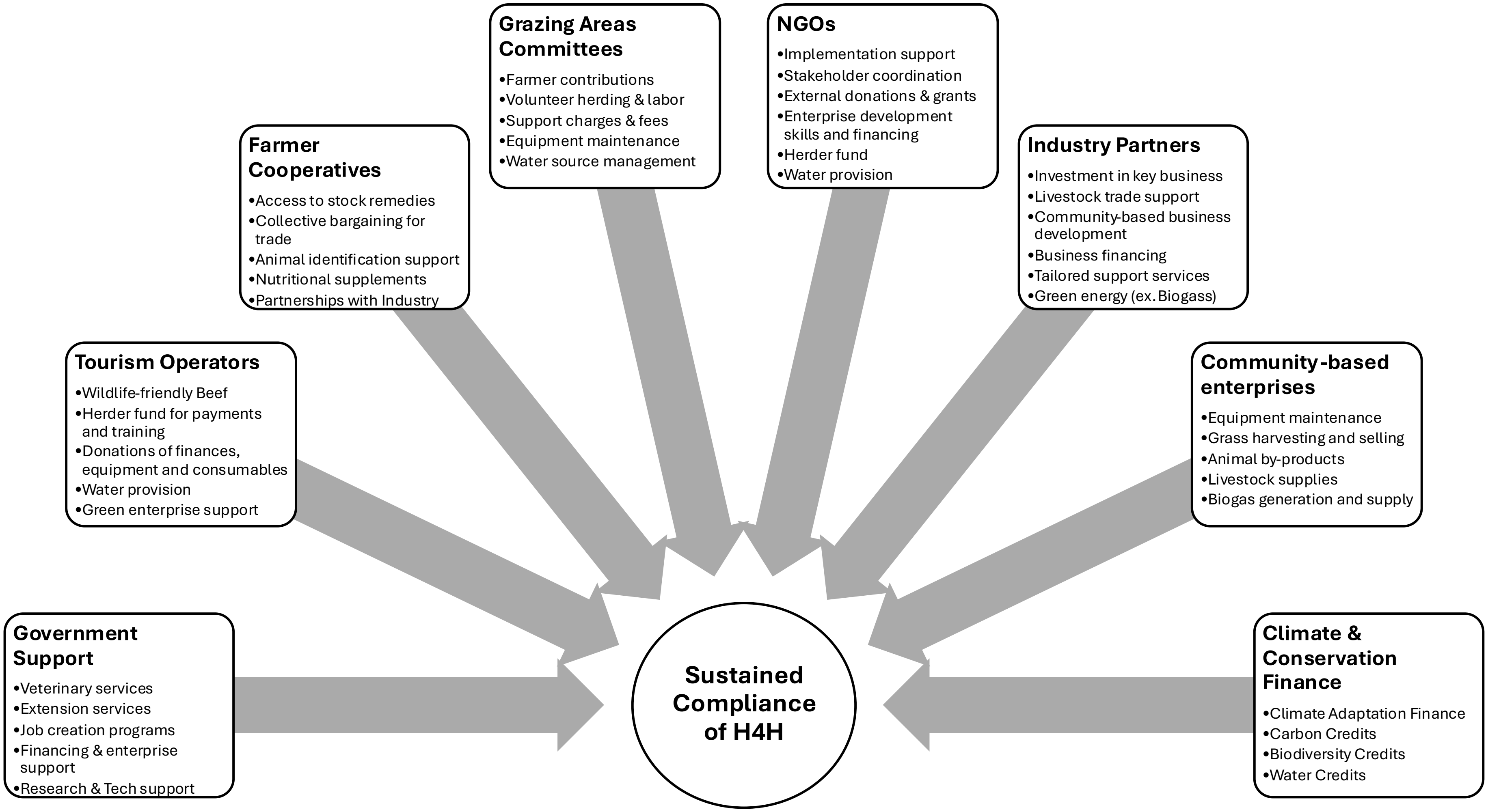

Figure D3. Diagram indicating the suite of sustainability mechanisms potentially available through all existing and new landscape stakeholders to sustain H4H compliance in a typical KAZA landscape.

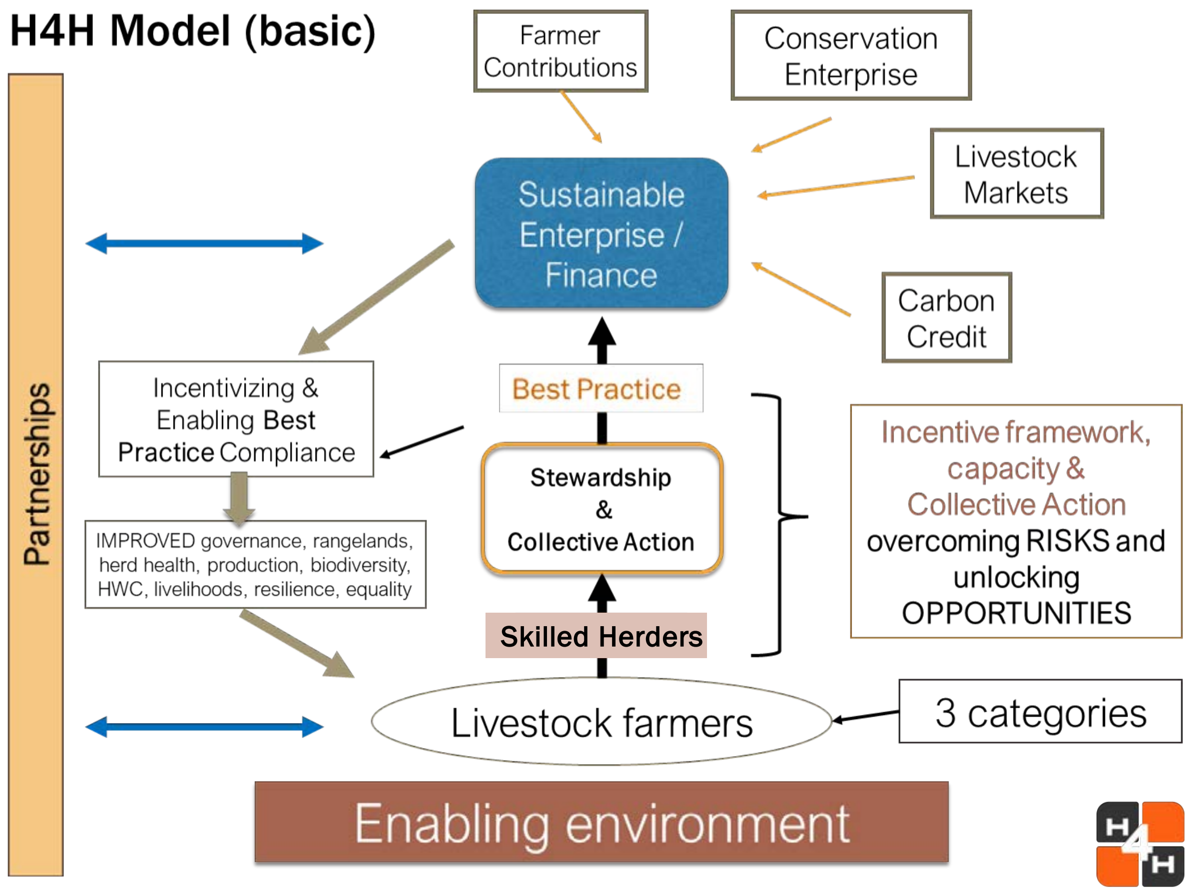

Figure D4. The basic H4H implementation process and cycle.

H4H case study - CLAWS herding programme, eastern panhandle, Botswana

CLAWS has been researching lion dispersal and survival rates in the eastern panhandle since 2014. Given the very high levels of lethal conflict between livestock, their owners and free ranging lions in the area, CLAWS started lion alert systems through geofencing technology. More work was needed, given the high level of livestock unattendance in the area and between 2017-2019, CLAWS began engaging the communities of Beetsha, Eretsha and Gunotsoga on interventions to help mitigate livestock depredation and lethal retaliation. At that stage pastoralists in Eretsha, with an estimated herd size of ~1,500 cattle, were losing 32% of their livestock a year through mainly predation (24%), disease (24%), strayed animals (22%), drought (8%) and stock theft and other unknown reasons (22%). Farmers were highly isolated from trade and given the high-risk environment and limited trade opportunity only 2% off-take was reported at the time, mainly to local butcheries. The average price received at the time was USD200 (BWP2,300) per head. CLAWS quickly realised that herding would have to be at the centre of their approach given the broader environmental and farming systems issues that needed attention as well. They initially focused more on herding and mobile kraaling with herders employed and trained primarily in rangeland management. At the time, there was not much expertise in such a herding initiative and so many of the activities occurred in a research period of trial and error. CLAWS soon learned that a broader skill set was needed as animal health issues were not effectively dealt with and farmers became sceptical of the initiative, especially when a drought between 2018-2020 was followed by a year of exceptionally high rainfall (2021). This brought many challenges with its related disease burden. Despite having had a livestock committee, the initiative was not set up to be fully community-led, but rather community-informed and involved, which brought about tension between the initiative and some farmers when implementation challenges started emerging. For example, the entire herd was kraaled together in one mobile but very cumbersome kraal, which hampered mobility. Herding and kraaling such a big herd in the context of Eretsha's environment is not efficient and creates risks in itself. Fifty percent (over 750 animals) of the community participated in the initiative when it started but after the drought and subsequent exceptionally high rainy season, participation dropped to only 5 farmers with 150 animals late 2021.

The herding programme then prioritised private herd health support (Dr Erik Verreynne) and expanded their herder skills sets and management system with funding support to start implementing the H4H model. Herders now received training in primary animal health care and record keeping, and improved mobile kraals could be sourced. Through H4H technical support, DVS support and donors such as the EU and AFD, market improvement pilots were conducted and Eretsha became one of the first sites in Botswana to successfully pilot a mobile quarantine system to comply with commodity-based trade standards. Due to major reduction in predation and associated retaliation killings of lions, neighbouring tourism operators started getting involved to support the herding programme with funding and market opportunities. The overall performance of the herding programme started turning and by 2023 animal losses by participating farmers decreased by 21% to 11%. Predation first dropped by 32% but then stopped altogether since 2019. Few animals strayed anymore because of the adoption of improved herding and kraaling techniques, a huge feat in an area with the highest level of livestock unattendance in southern Africa. Disease-related deaths reduced significantly compared to non-participating communities. A major dermatophilosis outbreak in the area since 2022 following the drought and very high rainfall year in 2021 have decimated herds in general for at least two years. Data showed that in comparison, cattle participating in H4H had a mortality rate of 4% compared to 10% in free-roaming animals. In 2023 the herding initiative started separating infected animals from healthy animals during night kraaling to reduce reinfection risk and to boost treatment and recovery rates. This has paid off and following government treatment support and the successful treatment of a lumpy skin disease co-infection through a vaccination campaign by CLAWS and H4Hope early in 2024, recovery rates are still improving.

To ensure the H4H model implemented by CLAWS is sound and based on the principle of being community-led and driven, CLAWS partnered with H4Hope in 2023 to support H4H model implementation, mentorship and expansion in the area. In April 2023, the Eretsha herd was back to over 550 again. Neighbouring communities have self-started and invited CLAWS in partnership with H4Hope to support them with H4H implementation. Gunotsoga already mobilized 200 animals and herders, and Beetsha is initiating in June 2024 with farmers showing interest for over 700 head of cattle to start. To support the expansion and impact, CLAWS is expanding its team and will have a full-time H4H implementation manager on site from the first of June.

Key features and achievements of the Initiative to date:

CLAWS Staff complement, including its lion guardian programme:

- 34 staff members, mainly from local communities
- Hosting 18 skilled herders (14 male, 4 female-also called ecorangers) on behalf of GACs, who have received the following training over the years:
    - Most have attended at least two, weeklong Basic Ecoranger Courses offered through the Southern African Wildlife College, a H4H model training partner
    - CLAWS has hosted two Primary Animal Health Care Training (Afrivet, an H4H model training partner) sessions for herders, and DVS vet technicians and state vets participated
    - Two of our lead herders have attended a one month Ecoranger Leadership Course at the Southern African Wildlife College
    - Our boma coordinator and a lead herder attended a year-long course through the Herding Academy in South Africa
- CLAWS employed an H4H implementation manager, Mr Jack Ramsden, to lead H4H implementation support to communities in the eastern panhandle. Jack is a Motswana from Maun, he studied animal production and worked for DVS as an extension officer. He started on 1 June 2024. He will oversee the herding team consisting of the rangeland researcher (Me Warona Emmanual) and boma coordinator (Me Binang Montshoi) who provide dedicated support to the GACs and their 18 skilled herders still hosted by CLAWS.
- CLAWS has an office base in Seronga, a research field station in Gunotsoga and an office building at the Kgotla in Eretsha.

Implementation extent:

- <u>Eretsha</u>: has about 1026 inhabitants and approximately 1200-1500 head of cattle.
    - Currently there are two active mobile predator-proof bomas, with an additional sick bay for treatment of the dermatophilosis cases

    - Total of 400 cattle
    - Participating farmers: 54
    - +/- 1/3 of community herd with interest to increase participation as additional bomas are sourced. An additional boma has been ordered and will boost numbers and ensures that collective herding when practiced is done through smaller herds in-line with the environmental context.
- Gunotsoga: neighbours Eretsha and they initiated H4H by themselves after being inspired by the success of the Eretsha effort, especially in mitigating predation and unlocking market opportunities. They formed their own GAC and recruited their own volunteer herders and started herding until CLAWS was able to help source a boma and funding for training.
    - They started with 150 cattle in 2023
    - Currently they have 1 predator-proof mobile boma
    - The herd has grown to almost 200 cattle with 24 farmers, and with interest growing in the community since CLAWS in partnership with H4Hope initiated community mobilisation on invitation.
    - With 24 farmers participating
- Beetsha: Beetsha invited CLAWS to support them with H4H implementation and in June 2024 CLAWS in partnership with H4Hope will initiate an H4H situational analysis with Beetsha farmers, the outcome of which will be an implementation strategy to guide implementation.
- Beetsha leadership confirmed interest already from owners with at least 1,000 cattle

Implementation impact:

- Predation:
    - Since 2019 no livestock have been lost to lion predation. This was the initial motivation behind the start of the programme. The herding programme has succeeded in this regard
- Animal health:
    - Animal health support is provided through:
        - State vet official in the area
        - Herd veterinarian, Dr Erik Verreynne,
        - H4Hope Veterinary Advisory Group, headed by Professor Jan Myburgh, Faculty of Veterinary Science, University of Pretoria, including more than six experienced veterinary clinicians and experts in fields such as pathology and epidemiology. Much of the support is pro-bono or provided at a much-reduced cost.
        - CLAWS is coordinating integration of herd health support into the herding programme
    - All cattle in H4H have full vaccination records for both government-controlled diseases (FMD) and additional important diseases such as anthrax, black-quarter, botulism and lumpy skin disease.
    - Cattle are now on a strategic parasite control programme, with strategic dipping and liver fluke treatments.

    - Reporting of any signs of disease is rapid, and follow-up responses are improving as the system and stakeholder communication improves. Recently during a liver fluke treatment drive herders noticed suspect lesions on an animal's tongue. They took pictures and reported it to the H4H vet support team who immediately requested the local state vet officials to be notified. The entire herd was inspected the following day by local vet services and 3x animals with old lesions were identified but found to be not linked to FMD.
    - During an early morning health inspection herders identified heavy breathing in an animal and it was reported with supporting photo and video material. The vet advisory team was concerned about lung sickness and with local state vet support a treatment plan was put forward following the state vet visits the following day.
    - Signs of disease are seen immediately by full-time herders and appropriate action can be taken, either by isolating an animal, treatment, or reporting to authorities or vet support teams. Skilled herders in consultation with owners lead these steps.
    - Herders actively avoid contact between livestock and buffalo or any stray cattle during herding and kraaling.
- Animal identification and traceability
    - An animal must be BAITS (Botswana Animal Identification and Traceability System) compliant to move for trade in Botswana. BAITS uptake is still a challenge in Eretsha and through the herding programme, BAITS compliance is assisted by availing computers, trained personnel, and transport if necessary, or even just coordination with government officials.
    - In partnership with H4Hope, CLAWS is implementing a state-of-the-art animal identification and record keeping system compatible with H4H implementation and compliance monitoring in remote areas. The system will have full health, treatment, production and trade records for each individual animal and its associated herd to support improved H4H compliance, herd health and production performance monitoring, and reporting to government, farmers and buyers.
- Trade:
    - Commodity-based trade:
        - A commodity-based trade pilot including the piloting of a mobile quarantine system in Eretsha during 2022/23 was a huge success. Three batches were successfully quarantined:
        - Dec 2022 - 25 cattle / 6 farmers / 4.38 tons / P118,061
        - March 2023 - 25 cattle / 13 farmers / 4.68 tons / P126,579.75
        - Aug 2023 - 40 cattle / 18 farmers / 7.36 tons / P199,690
        - Farmers received 25% more for their cattle through mobile quarantining at site than selling cattle locally.
        - The process was subsidised but showed a positive operational cost:benefit compared to quarantining at a government facility, especially if either transport or labour is partially or fully subsidised.
    - Wildlife friendly beef:
        - Wilderness is piloting 4 cattle a month for staff rations. They will pay 10% premium on the going red zone price per/kg.

        - Slaughter slab under investigation - the land has been identified by the Eretsha VDC. It has been fenced off with electric fencing, and the property contains a container as an office. The infrastructure was paid for by CIRAD. Next step is a full feasibility and business case for the most suitable option/facility.
        - Other tourism operators have also come forward showing interest in wildlife friendly beef through H4H implementation.
- <u>Herd productivity</u>
    - Genetic improvement*:*
        - Bull quality is very low in the area and with support gained through the commodity-based trade pilot, Botswana Government decided to support the initiative.
        - Breeding bulls were donated by the government to support herd productivity. The president donated four bulls to the programme for the Eretsha community: 2 Brahman, 1 Tswana and 1 Simmental. (This animal died within 4 weeks of arrival at the boma. It may not have been suitable for the environment.)
        - With the improved record keeping from June 2024, further improvements in herd composition and herd productivity at individual animal level could be facilitated by improved decision making by farmers. Unproductive animals can be identified and replaced with productive animals and bull selection training will be provided.
    - Nutrition:
        - CLAWS aims to reduce the need for nutritional supplementation by utilising the full spectrum of the heterogeneous rangeland system as optimally as possible. A grazing plan and smart herding can help to balance the nutritional requirements of livestock as much as possible in a natural rangeland.
        - Some minerals are known to be deficient in the CLAWS environment and support in the provision of the following are provided as needed and as budgets are available:
            - Salt blocks/loose rock salt
            - P6 blocks
            - Energy blocks for upcoming drought
            - Production lick
            - Herders and farmers will soon start making their own basic licks
            - Grass harvested – grass harvested by ladies from the village is bought and stored for supplementary feed during the drought and mixed with nutrients, such as molasses.
            - Ladies will also harvest and sell grass seed to aid rangeland restoration through mobile kraal rotations.
    - Rangeland management*:*
        - Planned grazing support is provided by:

            - H4Hope Rangeland Advisory Group, which includes experienced rangeland scientists and practitioners from across the region, including Prof Richard Fynn, Okavango Research Institute.
            - CLAWS recently appointed a rangeland research assistant to monitor rangeland health and to provide support to GACs on planned grazing.
        - The GAC, together with H4H implementation support, identifies grazing areas monthly with weekly grazing blocks identified and monitored. Grass growth has improved in kraaled areas where kraal impact has been applied correctly.
        - A challenge has been to get the balance right between effective kraaling and herding to avoid predation, and sufficient grazing time and intake. In some instances, free ranging animals' body condition was better than that of the herded animals and H4Hope is now supporting the implementation teams and farmers with the necessary tactics and skills to adapt herding practices better in response to rangeland condition and rangeland heterogeneity. Especially in drought periods, night kraaling can limit biomass intake and lead to nutritional stress and associated immune suppression. This can be seen as a trade-off with predation mitigation strategies. Getting the balance right takes extra insight and tactics during drought conditions. Impact further improves as farmers participation increases over the first three years.

Sustainability mechanisms:

- <u>Blended financing</u> for initial H4H effort to support various elements, from human-wildlife conflict mitigation, livelihood development, disease control and herd health, trade access, and climate change adaptation/rangeland restoration, consisted of:
    - Restricted public funding through international donor mechanisms: 4x sources
        - German (KFW, GIZ) and French-linked agencies (AFD) (through Conservation International and CIRAD) and European Union
    - Flexible finance through local tourism operators investing in the H4H effort: 4x sources
        - Wilderness, Great Plains, Natural Selection and Helicopter Horizons
    - Unrestricted philanthropic-based donations: 2x sources
    - Private investment to unlock additional enterprise and carbon-related opportunities: multiple interested entities
- <u>Continuous financing:</u>
    - Tourism support:
        - Helicopter Horizons brings tourist to see the herding programme. Each tourist donates into a herder fund which is used for training ecorangers further.
        - Wilderness is piloting wildlife friendly beef through the herding programme. For the pilot, Wilderness is willing to pay a premium of up to 10% on beef from cattle in the programme. This process aims to motivate farmers to

participate in the programme. It will now be piloting a way to test supply consistency of wildlife friendly beef on a monthly basis to one lodge before expanding to others. Much room for expansion is possible.
    - Other tourism operations have shown interest in participating by buying wildlife friendly beef as well.
    - Natural Selections donated the boma, tents and uniforms for the Gunotsoga herding programme, and will continue to be a support partner.
    - A local lodge committed to financing H4H situational analyses in Gudigwa community to support the future of H4H in that village which is nearest to it.
  - Farmer support:
    - Mechanisms are being developed for farmer contributions into the programme and will be facilitated through the GACs as part of their empowerment process. Farmers are already starting to contribute their time on livestock handling days and will work out mechanisms for financial support as in other H4H sites.
  - Enterprise development in support of H4H implementation:
    - Various credit schemes are being investigated (carbon, biodiversity) for long-term financial support.
    - Agribusiness development is being investigated in the form of slaughter facilities and local cooperative/livestock hub for livestock supplies in support of H4H implementation.

Landscape expansion:

- The following communities have recently reached out to CLAWS for support with H4H implementation, and will now be visited to be introduced to the concept and associated process:
  - *Seronga*
  - *Xaro*
  - *Gudigwa*

APPENDIX E: Risk of SAT-type FMDV from cattle in Namibia to cattle in Botswana along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1**	low	moderate
	P2A	low	moderate
	P3A	very low	moderate
	P4	high	low
	P5	low	moderate
Exposure	**P6**	high	low
Consequence		moderate	low

Risk Calculation

				Assessed Risk
low				
moderate	low			
	very low	very low		
		high	very low	
			low	**very low**
				high
				moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1**	low	moderate
	P2A	low	moderate
	P3A	very low	moderate
	P4	high	low
	P5	low	moderate
Exposure	**P6**	high	low
Consequence		moderate	low

Risk Calculation

				Assessed Risk
low				
low	low			
	very low	very low		
		high	very low	
			low	**very low**
				high
				moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1**	very low	moderate
	P2A	very low	moderate
	P3A	negligible	low
	P4	low	moderate
	P5	very low	moderate
Exposure	**P6**	moderate	moderate
Consequence		moderate	low

Risk Calculation

				Assessed Risk
very low				
very low	very low			
	negligible	negligible		
		low	negligible	
			very low	**negligible**
				moderate
				moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	moderate	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation			
Entry	P1	low	moderate	low					Entry x Exposure = Probability of Occurrence			
	P2B	very low	moderate	very low	very low			very low	very low	low		very low
Exposure	P3B	low	moderate	low					Consequence			moderate
	P4	high	low	high	low			low	Risk Estimate Calculation			low
Consequence		moderate	low					moderate	Highest level of Uncertainty			moderate

Fence Removal - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation			
Entry	P1	low	moderate	low					Entry x Exposure = Probability of Occurrence			
	P2B	very low	moderate	very low	very low			very low	very low	low		very low
Exposure	P3B	low	moderate	low					Consequence			moderate
	P4	high	low	high	low			low	Risk Estimate Calculation			moderate
Consequence		moderate	low	moderate				moderate	Highest level of Uncertainty			moderate

Fence Removal w/Risk Mitigation - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation			
Entry	P1	very low	moderate	very low					Entry x Exposure = Probability of Occurrence			
	P2B	negligible	low	negligible	negligible			negligible	negligible	very low		negligible
Exposure	P3B	very low	moderate	very low					Consequence			moderate
	P4	low	moderate	low	very low			very low	Risk Estimate Calculation			low
Consequence		moderate	low	moderate				moderate	Highest level of Uncertainty			moderate

APPENDIX F: Risk of SAT-type FMDV from buffalo in Namibia to cattle in Botswana along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	low	moderate	low	low			
	P3A	low	moderate		low	low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	low	moderate	low	low			
	P3A	low	moderate		low	low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	moderate	very low	very low			
	P3A	low	moderate		low	very low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	high	low	high	low			**low**	low	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	high	low	high	low			**low**	low	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	high	low	high	low			**low**	low	very low	**very low**
Exposure	**P3B**	very low	moderate	very low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

APPENDIX G: Risk of SAT-type FMDV from poaching to cattle in Botswana along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1A**	low	moderate
	P2A	moderate	moderate
	P3	very low	low
	P4	moderate	moderate
Exposure	**P5**	negligible	moderate
Consequence		moderate	low

Risk Calculation			Assessed Risk
low			
moderate	low		
	very low	very low	
		moderate	**very low**
			negligible
			moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1A**	low	high
	P2A	moderate	moderate
	P3	very low	low
	P4	moderate	moderate
Exposure	**P5**	negligible	moderate
Consequence		moderate	low

Risk Calculation			Assessed Risk
moderate			
moderate	moderate		
	very low	very low	
		moderate	**very low**
			negligible
			moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**high**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1A**	low	moderate
	P2A	moderate	moderate
	P3	very low	low
	P4	moderate	moderate
Exposure	**P5**	negligible	moderate
Consequence		moderate	low

Risk Calculation			Assessed Risk
moderate			
moderate	moderate		
	very low	very low	
		moderate	**very low**
			negligible
			moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1B**	high	low	high			**high**
Exposure	**P2B**	moderate	moderate	moderate			
	P3	very low	low	very low	very low		
	P4	moderate	moderate		moderate	very low	
	P5	negligible	moderate			negligible	**negligible**
Consequence		moderate	low				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
high	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1B**	high	low	high			**high**
Exposure	**P2B**	moderate	moderate	moderate			
	P3	very low	low	very low	very low		
	P4	moderate	moderate		moderate	very low	
	P5	negligible	moderate			negligible	**negligible**
Consequence		moderate	low				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
high	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1B**	high	low	high			**high**
Exposure	**P2B**	moderate	moderate	moderate			
	P3	very low	low	very low	very low		
	P4	moderate	moderate		moderate	very low	
	P5	negligible	moderate			negligible	**negligible**
Consequence		moderate	low				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
high	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

APPENDIX H: Risk of FMDV serotype O from cattle in Namibia to cattle in Botswana along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1**	low	moderate
	P2A	low	moderate
	P3A	very low	moderate
	P4	high	low
	P5	low	moderate
Exposure	**P6**	high	low
Consequence		high	

Risk Calculation				**Assessed Risk**
low				
low	low			
	very low	very low		
		high	very low	
			low	**very low**
				high
				high

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1**	low	moderate
	P2A	low	moderate
	P3A	very low	moderate
	P4	high	low
	P5	low	moderate
Exposure	**P6**	high	low
Consequence		high	

Risk Calculation				**Assessed Risk**
low				
low	low			
	very low	very low		
		high	very low	
			low	**very low**
				high
				high

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1**	very low	moderate
	P2A	very low	moderate
	P3A	negligible	low
	P4	low	moderate
	P5	very low	moderate
Exposure	**P6**	moderate	moderate
Consequence		high	

Risk Calculation				**Assessed Risk**
very low				
very low	very low			
	negligible	negligible		
		low	negligible	
			very low	**negligible**
				moderate
				high

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	moderate	**negligible**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**high**
	P4	high	low	high	low			**low**	**Risk Estimate Calculation**		**moderate**
Consequence		high						**high**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

								Assessed Risk	Risk Estimation		
Entry	**P1**	low	low	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**high**
	P4	high	low	high	very low			**low**	**Risk Estimate Calculation**		**moderate**
Consequence		high						**high**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

								Assessed Risk	Risk Estimation		
Entry	**P1**	low	low	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	negligible	moderate	negligible	negligible			**negligible**	negligible	very low	**negligible**
Exposure	**P3B**	very low	moderate	very low					**Consequence**		**high**
	P4	low	moderate	low	very low			**very low**	**Risk Estimate Calculation**		**moderate**
Consequence		high						**high**	**Highest level of Uncertainty**		**moderate**

APPENDIX I: Risk of SAT-type FMDV from cattle in Botswana to cattle in Namibia along Zambezi Border fence

<u>Status Quo - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	moderate	moderate	moderate				
	P2A	very low	moderate	very low	very low			
	P3A	low	moderate		low	very low		
	P4	moderate	moderate			moderate	very low	
	P5	very low	moderate				high	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

<u>Fence Removal - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	moderate	moderate	moderate				
	P2A	very low	moderate	very low	very low			
	P3A	low	moderate		low	very low		
	P4	moderate	moderate			moderate	very low	
	P5	very low	moderate				very low	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

<u>Fence Removal w/Risk Mitigation - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	negligible	low	negligible	negligible			
	P3A	very low	moderate		very low	negligible		
	P4	low	moderate			low	negligible	
	P5	very low	moderate				high	**negligible**
Exposure	**P6**	negligible	low					**negligible**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation			
Entry	**P1**	moderate	moderate	moderate					**Entry x Exposure = Probability of Occurrence**			
	P2B	low	moderate	low	low			**low**	low	very low		**very low**
Exposure	**P3B**	very low	moderate	very low					**Consequence**			**moderate**
	P4	moderate	moderate	moderate	low			**very low**	**Risk Estimate Calculation**			**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**			**moderate**

Fence Removal - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation			
Entry	**P1**	moderate	moderate	moderate					**Entry x Exposure = Probability of Occurrence**			
	P2B	low	moderate	low	low			**low**	low	very low		**very low**
Exposure	**P3B**	very low	moderate	very low					**Consequence**			**moderate**
	P4	moderate	moderate	moderate	very low			**very low**	**Risk Estimate Calculation**			**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**			**moderate**

Fence Removal w/Risk Mitigation - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation			
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**			
	P2B	very low	moderate	very low	very low			**very low**	very low	negligible		**negligible**
Exposure	**P3B**	negligible	low	negligible					**Consequence**			**moderate**
	P4	low	moderate	low	very low			**negligible**	**Risk Estimate Calculation**			**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**			**moderate**

APPENDIX J: Risk of SAT-type FMDV from buffalo in Botswana to cattle in Namibia along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	moderate	very low	very low			
	P3A	low	moderate		low	very low		
	P4	very low	low			very low	very low	
	P5	very low	moderate				very low	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		moderate						**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	moderate	very low	very low			
	P3A	low	moderate		low	very low		
	P4	very low	low			very low	very low	
	P5	very low	moderate				very low	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		moderate						**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	negligible	low	negligible	negligible			
	P3A	very low	low		very low	negligible		
	P4	negligible	low			negligible	negligible	
	P5	very low	moderate				very low	**very low**
Exposure	**P6**	negligible	low					**negligible**
Consequence		moderate						**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	high	low	high	high			**high**	high	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	low	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate						**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

								Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	high	low	high	high			**high**	high	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	low	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate						**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

								Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	high	low	high	high			**high**	high	negligible	**negligible**
Exposure	**P3B**	negligible	low	negligible					**Consequence**		**moderate**
	P4	negligible	low	negligible	negligible			**negligible**	**Risk Estimate Calculation**		**low**
Consequence		moderate						**moderate**	**Highest level of Uncertainty**		**moderate**

APPENDIX K: Risk of SAT-type FMDV from poaching to cattle in Namibia along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1A**	low	moderate
	P2A	moderate	moderate
	P3	very low	low
	P4	moderate	moderate
Exposure	**P5**	negligible	moderate
Consequence		moderate	low

Risk Calculation			Assessed Risk
low			
moderate	low		
	very low	very low	
		moderate	**very low**
			negligible
			moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1A**	low	high
	P2A	moderate	moderate
	P3	very low	low
	P4	moderate	moderate
Exposure	**P5**	negligible	moderate
Consequence		moderate	low

Risk Calculation			Assessed Risk
low			
moderate	low		
	very low	very low	
		moderate	**very low**
			negligible
			moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**high**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty
Entry	**P1A**	low	moderate
	P2A	low	moderate
	P3	very low	low
	P4	moderate	moderate
Exposure	**P5**	negligible	moderate
Consequence		moderate	low

Risk Calculation			Assessed Risk
low			
low	low		
	very low	very low	
		moderate	**very low**
			negligible
			moderate

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	high	low	high			**high**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	low	moderate	low				high	negligible	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	high	low	high			**high**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	low	moderate	low				high	negligible	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	high	low	high			**high**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	low	moderate	low				high	negligible	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

APPENDIX L: Risk of SAT-type FMDV from buffalo to cattle in Botswana along Northern Buffalo fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	low	moderate	low	low			
	P3A	moderate	moderate		moderate	low		
	P4	very low	moderate			very low	very low	
	P5	high	low				high	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	moderate	moderate	moderate	low			
	P3A	moderate	moderate		moderate	low		
	P4	very low	moderate			very low	very low	
	P5	high	low				high	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	moderate	very low	very low			
	P3A	very low	moderate		very low	very low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	P1	low	moderate	low					Entry x Exposure = Probability of Occurrence		
	P2B	moderate	low	moderate	low			low	low	very low	very low
Exposure	P3B	low	moderate	low					Consequence		moderate
	P4	very low	moderate	very low	very low			very low	Risk Estimate Calculation		low
Consequence		moderate	low					moderate	Highest level of Uncertainty		moderate

Fence Removal - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	P1	low	moderate	low					Entry x Exposure = Probability of Occurrence		
	P2B	high	low	high	low			low	low	very low	very low
Exposure	P3B	moderate	moderate	moderate					Consequence		moderate
	P4	very low	moderate	very low	very low			very low	Risk Estimate Calculation		low
Consequence		moderate	low					moderate	Highest level of Uncertainty		moderate

Fence Removal w/Risk Mitigation - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	P1	low	moderate	low					Entry x Exposure = Probability of Occurrence		
	P2B	high	low	high	low			low	low	very low	very low
Exposure	P3B	very low	moderate	very low					Consequence		moderate
	P4	very low	moderate	very low	very low			very low	Risk Estimate Calculation		low
Consequence		moderate	low					moderate	Highest level of Uncertainty		moderate

APPENDIX M: Risk of SAT-type FMDV from poaching to cattle in Botswana along Northern Buffalo fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1A**	moderate	moderate	moderate				**Entry x Exposure = Probability of Occurrence**		
	P2A	moderate	low	moderate	moderate			very low	negligible	**negligible**
	P3	very low	low		very low	very low		**Consequence**		**moderate**
	P4	moderate	moderate			moderate	**very low**	**Risk Estimate Calculation**		**low**
Exposure	**P5**	negligible	moderate				**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1A**	moderate	high	moderate				**Entry x Exposure = Probability of Occurrence**		
	P2A	moderate	high	moderate	moderate			very low	negligible	**negligible**
	P3	very low	low		very low	very low		**Consequence**		**moderate**
	P4	moderate	moderate			moderate	**very low**	**Risk Estimate Calculation**		**low**
Exposure	**P5**	negligible	moderate				**negligible**	**Highest level of Uncertainty**		**high**
Consequence		moderate	low				**moderate**			

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1A**	moderate	moderate	moderate				**Entry x Exposure = Probability of Occurrence**		
	P2A	moderate	high	moderate	moderate			very low	negligible	**negligible**
	P3	very low	low		very low	very low		**Consequence**		**moderate**
	P4	moderate	moderate			moderate	**very low**	**Risk Estimate Calculation**		**low**
Exposure	**P5**	negligible	moderate				**negligible**	**Highest level of Uncertainty**		**high**
Consequence		moderate	low				**moderate**			

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	moderate	low	moderate			**moderate**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	moderate	moderate	moderate				moderate	very low	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	high	low	high			**high**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	moderate	high	moderate				high	very low	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**high**
Consequence		moderate	low				**moderate**			

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	high	low	high			**high**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	moderate	high	moderate				high	very low	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**high**
Consequence		moderate	low				**moderate**			

APPENDIX N: Risk of SAT-type FMDV from cattle in Namibia to cattle in Botswana along Western Border fence

<u>Status Quo - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	low	moderate	low	very low			
	P3A	low	moderate		low	very low		
	P4	high	low			high	very low	
	P5	moderate	moderate				moderate	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

<u>Fence Removal - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	low	high	low	very low			
	P3A	low	moderate		low	very low		
	P4	high	low			high	very low	
	P5	moderate	moderate				moderate	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**high**

<u>Fence Removal w/Risk Mitigation - Pathway</u> A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	very low	moderate	very low	very low			
	P3A	low	moderate		low	very low		
	P4	moderate	moderate			moderate	very low	
	P5	very low	moderate				very low	**very low**
Exposure	**P6**	moderate	low					**moderate**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	low	moderate	low	very low			**very low**	very low	moderate	**very low**
Exposure	**P3B**	moderate	moderate	moderate					**Consequence**		**moderate**
	P4	high	low	high	moderate			**moderate**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	moderate	**very low**
Exposure	**P3B**	moderate	moderate	moderate					**Consequence**		**moderate**
	P4	high	low	high	moderate			**moderate**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	very low	**very low**
Exposure	**P3B**	very low	moderate	very low					**Consequence**		**moderate**
	P4	moderate	moderate	moderate	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

APPENDIX O: Risk of SAT-type FMDV from buffalo in Namibia to cattle in Botswana along Western Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	negligible	low	negligible				
	P2A	low	moderate	low	negligible			
	P3A	very low	low		very low	negligible		
	P4	very low	moderate			very low	negligible	
	P5	moderate	moderate				moderate	**negligible**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	high	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	negligible	low	negligible				
	P2A	low	high	very low	negligible			
	P3A	very low	low		very low	negligible		
	P4	very low	moderate			very low	negligible	
	P5	moderate	moderate				moderate	**negligible**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	high	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**high**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	negligible	low	negligible				
	P2A	very low	moderate	very low	negligible			
	P3A	very low	low		very low	negligible		
	P4	very low	moderate			very low	negligible	
	P5	very low	moderate				very low	**negligible**
Exposure	**P6**	low	moderate					**low**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	low	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	negligible	low	negligible					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	low	very low	negligible			**negligible**	negligible	very low	**negligible**
Exposure	**P3B**	very low	moderate	low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	negligible	low	negligible					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	high	negligible			**negligible**	negligible	very low	**negligible**
Exposure	**P3B**	very low	moderate	very low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

				Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	negligible	low	negligible					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	high	negligible			**negligible**	negligible	very low	**negligible**
Exposure	**P3B**	very low	moderate	very low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

APPENDIX P: Risk of SAT-type FMDV from poaching in Namibia to cattle in Botswana along Western Border fence

<u>Status Quo - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1A**	moderate	low	moderate			
	P2A	very low	low	very low	very low		
	P3	negligible	low		negligible	negligible	
	P4	moderate	moderate			moderate	**negligible**
Exposure	**P5**	negligible	moderate				**negligible**
Consequence		moderate	low				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

<u>Fence Removal - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1A**	moderate	high	moderate			
	P2A	very low	low	very low	very low		
	P3	negligible	low		negligible	negligible	
	P4	moderate	moderate			moderate	**negligible**
Exposure	**P5**	negligible	moderate				**negligible**
Consequence		moderate	low				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**high**

<u>Fence Removal w/Risk Mitigation - Pathway A</u>

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1A**	moderate	high	moderate			
	P2A	very low	low	very low	very low		
	P3	negligible	low		negligible	negligible	
	P4	moderate	moderate			moderate	**negligible**
Exposure	**P5**	negligible	moderate				**negligible**
Consequence		moderate	low				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**high**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	very low	low	very low			**very low**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	low	moderate	low				very low	negligible	**negligible**
	P3	negligible	low	negligible	negligible			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	negligible		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			very low	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	very low	moderate	very low			**very low**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	low	moderate	low				very low	negligible	**negligible**
	P3	negligible	low	negligible	negligible			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	negligible		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			very low	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	very low	moderate	very low			**very low**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	low	moderate	low				very low	negligible	**negligible**
	P3	negligible	low	negligible	negligible			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	negligible		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			very low	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	low				**moderate**			

APPENDIX Q: Risk of FMDV serotype O from cattle in Namibia to cattle in Botswana along Western Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	low	moderate	low	very low			
	P3A	low	moderate		low	very low		
	P4	high	low			high	very low	
	P5	moderate	moderate				moderate	**very low**
Exposure	**P6**	high	low					**high**
Consequence		high	moderate					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	low	high	low	very low			
	P3A	low	moderate		low	very low		
	P4	high	low			high	very low	
	P5	moderate	moderate				moderate	**very low**
Exposure	**P6**	high	low					**high**
Consequence		high	moderate					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**high**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	very low	moderate	very low	very low			
	P3A	very low	moderate		very low	very low		
	P4	moderate	moderate			moderate	very low	
	P5	very low	moderate				very low	**very low**
Exposure	**P6**	moderate	moderate					**moderate**
Consequence		high	moderate					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	**Risk**	**Uncertainty**	**Risk Calculation**				**Assessed Risk**	**Risk Estimation**		
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	moderate	**very low**
Exposure	**P3B**	moderate	moderate	moderate					**Consequence**		**high**
	P4	high	low	high	moderate			**moderate**	**Risk Estimate Calculation**		**moderate**
Consequence		high	moderate					**high**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

								Assessed Risk	**Risk Estimation**		
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	moderate	**very low**
Exposure	**P3B**	moderate	moderate	moderate					**Consequence**		**high**
	P4	high	low	high	moderate			**moderate**	**Risk Estimate Calculation**		**moderate**
Consequence		high	moderate					**high**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

								Assessed Risk	**Risk Estimation**		
Entry	**P1**	very low	moderate	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	very low	**very low**
Exposure	**P3B**	very low	moderate	very low					**Consequence**		**high**
	P4	moderate	moderate	moderate	very low			**very low**	**Risk Estimate Calculation**		**moderate**
Consequence		high	moderate					**high**	**Highest level of Uncertainty**		**moderate**

APPENDIX R: Risk of SAT-type FMDV from cattle in Botswana to cattle in Namibia along Western Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	low	very low				
	P2A	very low	moderate	very low	very low			
	P3A	moderate	moderate		moderate	very low		
	P4	high	low			high	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	low	very low				
	P2A	very low	moderate	very low	very low			
	P3A	moderate	moderate		moderate	very low		
	P4	high	low			high	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	low	very low				
	P2A	very low	moderate	very low	very low			
	P3A	very low	moderate		very low	very low		
	P4	high	low			high	very low	
	P5	low	moderate				very low	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	very low	low	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	low	moderate	low	very low			**very low**	very low	low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	high	low	high	low			**low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

								Assessed Risk	Risk Estimation		
Entry	**P1**	very low	low	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	low	high	low	very low			**very low**	very low	low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	high	low	high	low			**low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**high**

Fence Removal w/Risk Mitigation - Pathway B

								Assessed Risk	Risk Estimation		
Entry	**P1**	very low	low	very low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	high	low	high	low			**low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**moderate**

APPENDIX S: Risk of SAT-type FMDV from buffalo in Botswana to cattle in Namibia along Western Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	low	very low	very low			
	P3A	very low	moderate		very low	very low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**moderate**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	moderate	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	moderate	very low	very low			
	P3A	very low	moderate		very low	very low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**high**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	low	moderate	low				
	P2A	very low	moderate	very low	very low			
	P3A	very low	moderate		very low	very low		
	P4	very low	moderate			very low	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	low					**low**
Consequence		moderate	low					**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	low					**Entry x Exposure = Probability of Occurrence**		
	P2B	very low	moderate	very low	very low			**very low**	very low	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low					**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	high					**Entry x Exposure = Probability of Occurrence**		
	P2B	low	moderate	low	low			**low**	low	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk	Risk Estimation		
Entry	**P1**	low	moderate	high					**Entry x Exposure = Probability of Occurrence**		
	P2B	low	moderate	low	low			**low**	low	very low	**very low**
Exposure	**P3B**	low	moderate	low					**Consequence**		**moderate**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**low**
Consequence		moderate	low	moderate				**moderate**	**Highest level of Uncertainty**		**moderate**

APPENDIX T: Risk of SAT-type FMDV from poaching in Botswana to cattle in Namibia along Western Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1A**	very low	moderate	very low			
	P2A	very low	moderate	very low	very low		
	P3	very low	low		very low	very low	
	P4	moderate	moderate			moderate	**very low**
Exposure	**P5**	negligible	moderate				**negligible**
Consequence		moderate	moderate				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1A**	very low	moderate	very low			
	P2A	very low	moderate	very low	very low		
	P3	very low	low		very low	very low	
	P4	moderate	moderate			moderate	**very low**
Exposure	**P5**	negligible	moderate				**negligible**
Consequence		moderate	moderate				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk
Entry	**P1A**	very low	moderate	very low			
	P2A	very low	moderate	very low	very low		
	P3	very low	low		very low	very low	
	P4	moderate	moderate			moderate	**very low**
Exposure	**P5**	negligible	moderate				**negligible**
Consequence		moderate	moderate				**moderate**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**negligible**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	very low	moderate	very low				**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	very low	low	very low	very low			very low	negligible	**negligible**
	P3	very low	low		very low	very low		**Consequence**		**moderate**
	P4	moderate	moderate			moderate	**very low**	**Risk Estimate Calculation**		**low**
	P5	negligible	moderate				**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	moderate				**moderate**			

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	low	moderate	low			**low**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	very low	low	very low				low	negligible	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	moderate				**moderate**			

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation			Assessed Risk	Risk Estimation		
Entry	**P1B**	low	moderate	low			**low**	**Entry x Exposure = Probability of Occurrence**		
Exposure	**P2B**	very low	low	very low				low	negligible	**negligible**
	P3	very low	low	very low	very low			**Consequence**		**moderate**
	P4	moderate	moderate		moderate	very low		**Risk Estimate Calculation**		**low**
	P5	negligible	moderate			negligible	**negligible**	**Highest level of Uncertainty**		**moderate**
Consequence		moderate	moderate				**moderate**			

APPENDIX U: Risk of MmmSC from cattle in Namibia to cattle in Botswana along Zambezi Border fence

Status Quo - Pathway A

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2A	low	moderate	low	very low			**very low**
Exposure	**P3A**	very low	moderate	very low				
	P4	high	moderate	high	very low			**very low**
Consequence		high	low					**low**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	very low	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway A

				Risk Calculation				
Entry	**P1**	very low	moderate	very low				
	P2A	low	moderate	low	very low			**very low**
Exposure	**P3A**	very low	moderate	very low				
	P4	high	moderate	high	very low			**very low**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	very low	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway A

				Risk Calculation				
Entry	**P1**	very low	moderate	very low				
	P2A	very low	moderate	very low	very low			**very low**
Exposure	**P3A**	negligible	low	negligible				
	P4	very low	moderate	high	negligible			**negligible**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	negligible	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	moderate	very low				
	P2B	very low	moderate	very low	very low			
	P3B	low	moderate		low	very low		
	P4	high	moderate			high	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	moderate					**high**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	low	very low				
	P2B	very low	moderate	very low	very low			
	P3B	low	moderate		low	very low		
	P4	high	moderate			high	very low	
	P5	low	moderate				low	**very low**
Exposure	**P6**	high	moderate	high				**high**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	**P1**	very low	low	very low				
	P2B	negligible	low	negligible	negligible			
	P3B	very low	moderate		very low	negligible		
	P4	very low	moderate			high	negligible	
	P5	very low	moderate				moderate	**negligible**
Exposure	**P6**	high	moderate	high				**high**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
negligible	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

APPENDIX V: Risk of MmmSC from cattle in Namibia to cattle in Botswana along Western Border fence

Status Quo - Pathway A

	Probability	**Risk**	**Uncertainty**	**Risk Calculation**				**Assessed Risk**	**Risk Estimation**		
Entry	**P1**	low	low	low					**Entry x Exposure = Probability of Occurrence**		
	P2A	low	moderate	low	low			**low**	low	low	**low**
Exposure	**P3A**	low	moderate	low					**Consequence**		**high**
	P4	high	moderate	high	low			**low**	**Risk Estimate Calculation**		**moderate**
Consequence		high	low					**high**	**Highest level of Uncertainty**		**moderate**

Fence Removal - Pathway A

				Risk Calculation					**Risk Estimation**		
Entry	**P1**	low	low	low					**Entry x Exposure = Probability of Occurrence**		
	P2A	low	high	low	low			**low**	low	low	**very low**
Exposure	**P3A**	low	moderate	low					**Consequence**		**high**
	P4	high	moderate	high	low			**low**	**Risk Estimate Calculation**		**moderate**
Consequence		high	low					**high**	**Highest level of Uncertainty**		**high**

Fence Removal w/Risk Mitigation - Pathway A

				Risk Calculation					**Risk Estimation**		
Entry	**P1**	very low	low	very low					**Entry x Exposure = Probability of Occurrence**		
	P2A	very low	moderate	very low	very low			**very low**	very low	very low	**very low**
Exposure	**P3A**	low	moderate	low					**Consequence**		**high**
	P4	very low	moderate	very low	very low			**very low**	**Risk Estimate Calculation**		**moderate**
Consequence		high	low					**high**	**Highest level of Uncertainty**		**moderate**

Status Quo - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	P1	low	low	low				
	P2B	very low	moderate	very low	very low			
	P3B	moderate	moderate		moderate	very low		
	P4	high	moderate			high	very low	
	P5	moderate	moderate				moderate	**very low**
Exposure	P6	high	moderate					**high**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	P1	low	low	low				
	P2B	very low	moderate	very low	very low			
	P3B	moderate	moderate		moderate	very low		
	P4	high	moderate			high	very low	
	P5	moderate	moderate				moderate	**very low**
Exposure	P6	high	moderate	high				**high**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

Fence Removal w/Risk Mitigation - Pathway B

	Probability	Risk	Uncertainty	Risk Calculation				Assessed Risk
Entry	P1	very low	low	very low				
	P2B	very low	moderate	very low	very low			
	P3B	very low	moderate		very low	very low		
	P4	very low	moderate			very low	very low	
	P5	very low	moderate				very low	**very low**
Exposure	P6	high	moderate	high				**high**
Consequence		high	low					**high**

Risk Estimation		
Entry x Exposure = Probability of Occurrence		
very low	high	**very low**
Consequence		**high**
Risk Estimate Calculation		**moderate**
Highest level of Uncertainty		**moderate**

APPENDIX W: Risk of PPRV from small stock in Namibia to small stock in Botswana along Zambezi Border fence

Status Quo

Entry x Exposure = Probability of Occurrence		
very low	very low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**low**

Fence Removal

Entry x Exposure = Probability of Occurrence		
very low	very low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/risk mitigation

Entry x Exposure = Probability of Occurrence		
very low	very low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

APPENDIX X: Risk of PPRV from small stock in Namibia to small stock in Botswana along Western Border fence

Status Quo

Entry x Exposure = Probability of Occurrence		
very low	low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal

Entry x Exposure = Probability of Occurrence		
very low	low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

Fence Removal w/risk mitigation

Entry x Exposure = Probability of Occurrence		
very low	low	**very low**
Consequence		**moderate**
Risk Estimate Calculation		**low**
Highest level of Uncertainty		**moderate**

APPENDIX Y: Validation meeting comments and responses

Table Y1. Comments generated during group discussions during the validation meeting in Maun, Botswana (14—16 May 2024), with responses and any action taken as a result.

Comment	Response	Action Taken
The term “decommission” carries a legal definition about permanent removal, but there may be a desire to have the legal right to re-erect a fence or to leave some fence infrastructure in order to reconstruct certain sections in the event of an emergency.	Meeting attendees agreed to replace decommission with remove.	Replaced “decommission” with “remove” throughout the report.
The risk of movement of animal products should have been considered.	This was not considered as a priority during the co-development of the risk pathways with DVS and is not that relevant to the presence or absence of the fence. The poaching pathways presented in the report do cover the risk of some animal product movement.	None required for this report.
Multiple transmission routes, such as aerosol transmission, should have been considered.	Multiple transmission routes are considered in the report and those excluded from the analysis are covered in the assumptions section along with the justification and supporting references.	None required for this report.
The role of FMD serotype O in buffalo should be considered, as there are papers from Uganda and West Africa showing evidence of serotype O in buffalo.	The report notes that serotype O virus has not been isolated in buffalo under natural conditions and there is no evidence of maintenance of serotype O in buffalo. A study from Uganda found some serological evidence (but not viral isolation) of serotype O in buffalo (Ayebazibwe et al. 2010). Another study presented serological evidence of serotype O in West African buffalo (*Syncerus caffer brachyceros*) rather than Cape buffalo which occur in southern Africa (Di Nardo et al. 2015). A study of cattle and buffalo in Kenya found serotypes O, A, SAT-1, and SAT-2 in cattle, with no serological evidence or viral isolation of serotypes O and A from buffalo (Wekesa et al. 2015). A more recent study specifically noted that the low seroprevalence of serotypes O and A observed in buffalo likely represented occasional	Additional citations added to report.

Comment	Response	Action Taken
	cattle-to-buffalo spillover or serological cross-reactivity and suggested that buffalo are not epidemiologically important for these serotypes (Casey-Bryars et al. 2018).	
With regards to FMD serotype O – DVS fence patrol is taking place (1 x month), which helps with detection of illegal movement of cattle/theft. If fence section removed, patrols should be part of risk mitigation (w/ support from others, e.g. DWNP, Botswana Defence Force, NAMBOT etc). There are increased fence patrols along the border with Khaudum National Park due to presence of high value species.	Noted for implementation of risk mitigation.	Added increasing security patrols to the risk mitigation strategies section of the report.
Seasonal migration of farmers occurs in the eastern panhandle.	Grazing management plans under H4H in Eretsha are using areas to the north of the village in NG11. Also, some cattle farmers use areas away from the delta in the wet season to graze their cattle under H4H.	Seasonal movement of farmers to be considered in H4H implementation in the eastern panhandle.
The distribution of cattle in Angolan villages above Omega settlement is of interest.	No specific data are available from Angola at this time, but some livestock distribution data are available from the KAZA Elephant Survey.	Survey data on livestock presence in Angola and Zambia from the KAZA Elephant Survey were incorporated into report.
Maps should include distances between points of interest.	All maps include a scale bar. The report recommendations and narrative contain further information about relevant distances to and along fence lines.	To avoid visual clutter, no distances between points are printed directly onto maps, but these may be calculated from the scale bar.
Illegal movement of cattle from Seshokora to Zambia has been recorded.	The report mentions that 11 cattle were found in Zambia in 2022 and believed to have been stolen from Seshokora. Botswana DVS noted that after this, the cattle had been removed from Seshokora to decrease the risk of further theft, although the farmer may choose to return at any time.	None required for this report.
Botswana DVS should evaluate risk of FMD serotype O in Chobe area.	During discussion of the FMD serotype O pathway at the Zambezi Border fence, it was noted that there is likely a higher risk of FMD serotype O to Chobe District than to Ngamiland. This is a valid observation and may warrant further	None required for this report.

Comment	Response	Action Taken
	consideration, perhaps of risk-based surveillance or targeted vaccination against serotype O in Chobe District.	
There should be a single measure of risk summing all diseases at each fence line.	Neither the WOAH import risk analysis handbook nor other published references describe a best practice to sum risk estimates across hazards. Numerous examples from the literature assess risk for multiple hazards without summing overall risk estimates into a single estimate (Pharo et al. 1998; Australian Quarantine and Inspection Service 1999; Thomson and Venter 2012; Sargeant 2015; Gale et al. 2016; Nelson et al. 2022). Meeting participants also noted that decision makers are less interested in a measure of aggregate risk across all diseases and more interested in the highest risk of any single disease.	None required for this report.
The data provided for the report did not fully capture the degree of cattle movement that is occurring between Botswana and Namibia along the Western Border fence, and some cattle were observed in Khaudum National Park from the air.	Botswana and Namibia DVS agreed to share incursion reports to more fully illustrate the reality of cattle movement at this fence line.	Added this caveat to the special considerations section from the meeting outcomes in the report. Namibia DVS provided 4 reports of incursions of Namibian cattle into Botswana; 2 of these were already accounted for in Botswana DVS data and one sentence was added to the report. The other 2 incursions occurred in 2024, after data was originally provided, and involved cattle originating from the CBPP free zone. These were not added to the report as the free zone is well south of the area of the Western Border fence under consideration, and these cattle pose negligible risk of CBPP or FMD to Botswana given area of origin.
H4H takes time to set up and for benefits to be achieved.	The report notes that H4H requires a bottom-up holistic approach. Further consultations will be necessary to gauge the geographic extent of H4H implementation necessary to be considered adequate risk mitigation for proceeding with fence removal.	H4Hope to begin work on implementation scoping and costing for prospective donors. Botswana DVS has agreed for data to be shared with H4Hope on cattle in the eastern panhandle, and preliminary data was provided by KAZA epidemiologist.
Need support for KAZA-approach to disease control, i.e. what	There is ongoing work with harmonisation among the KAZA	None required for this report.

Comment	Response	Action Taken
happens in Angola is important to managing risk for Namibia and Botswana. Need further border harmonisation, commitments at country level to implement their control programmes and a business case to motivate for countries to provide budgets so DVS's can undertake mandates. The SADC Livestock Technical Committee may be beneficial to involve.	Partner States and the within the KAZA Animal Health Sub Working Group (AHSWG) to make progress on harmonised disease control.	
There is a need to incorporate water sources into report, as it can help inform decisions on likely wildlife movement if fence section removed. CBT steps can assist in risk mitigation, as can processes outlined in the 2014 BOCODOL Resolutions.	Botswana DVS agreed to send borehole data by 31 May 2024. CBT is included in the risk mitigation strategy as are some of the BOCODOL resolutions (such as vaccination and encouraging farmer participation).	Some borehole data from 2018 were received and added below.
Enablers to success of this initiative – communities need to be kept front and centre; existing enablers include H4H, CBT, wildlife economies. Direct benefits to communities at the household level are paramount.	Community involvement on fence decision-making is critical and as such the next phase is dedicated to community engagement. Developing pathways for household-level benefits should be a part of Phase 3.	None required for this report.
Priority H4H sites – this report can help identify new sites for H4H across landscape as they form a very important role in disease risk mitigation.	Noted. Recommendations would be shared with KAZA structures to guide H4H site identification.	With permission from Botswana DVS, internal data have been shared with Herding4Hope to guide implementation planning.
Understanding of current wildlife movement as well as potential movement if fences are removed is important, as is what is happening across borders, e.g. in Angola (specifically Luengue-Luiana National Park) would be important in final decision making.	There is some information on wildlife movement available in the Phase 1 report, which has now been made available to the participants. Engaging with ecologists to understand potential wildlife movements and developing a better understanding of the situation in Angola/Zambia will also be a part of Phase 3. The KAZA AHSWG will be working with, for example, the Elephant Working Group in this regard.	None required for this report.
Conversion of livestock boreholes into wildlife boreholes is currently being undertaken in NG13 (ORI has GBP 600,000).	Based on discussions from this meeting and potential conflicts between proposed fence removal and borehole installation, further collaborative consideration of this issue is warranted.	No modifications to report, but WWF, AHEAD, ORI and other regional stakeholders to have a virtual meeting after KAZA Heads of State Summit and KAZA AHSWG meeting.

Comment	Response	Action Taken
There is currently a policy disconnect and alignment of efforts/policies/decisions is needed. Specifically, removing fences is at odds with the DVS vision of Ngamiland becoming a green zone (FMD free w/ vaccination).	Botswana DVS advised that the vision will change as H4H & CBT grow and the need for a green zone in Ngamiland will be reduced.	None required for this report.
Explore innovations in tech and AI on fencing & gates for elephants.	Current alternative fencing modalities would restrict the movement of other species. KAZA Wildlife Dispersal Areas require corridors that function for multiple species, not just elephants. Options such as virtual fencing by collaring/ tagging cattle could be considered but have considerable logistical and financial challenges to implement at a broad scale.	None required for this report; further consideration may be warranted in Phase 3.

Table Y2. Data gaps identified during the validation meeting, with designated sources for providing the relevant data.

Fence(s)	Type of Data Missing	Designated Data Provider	Were the data provided?
Western Border	• Common/migratory elephant routes • Number of breakages and GPS points • Human-wildlife conflict hotspots • Number and dates of cattle incursions in Khaudum NP • Security threats to Bwabwata and Khaudum national parks	Groups to be consulted (Namibia): • Animal Health Committee • Elephant Committee • Namibia National Farmers Union (NNFU) • Namibia Agricultural Union (NAU) • MAWLR (Land Department) • Traditional Authorities • Conservancy scientists • Anti-Poaching Units (APU) in respective parks • MEFT Khaudum staff	Some data on elephant routes and breakages are available in the Phase 1 report and other published data. Security data not obtained as it was agreed that these data are important to consider with relevant stakeholders and experts for Phase 3 but are not strictly necessary for evaluating disease risk.
Zambezi Border & Northern Buffalo	• Cattle census in KAZA • Disease surveillance/control activities • Disease status (historical and current)	Angola and Zambia competent authorities via KAZA Secretariat	In the interest of time, livestock data from the KAZA Elephant Survey have been incorporated into the report. Information from Angola and Zambia shared in previous AHSWG meetings on disease control and from WAHIS regarding disease status are also incorporated.

Fence(s)	Type of Data Missing	Designated Data Provider	Were the data provided?
Zambezi Border & Northern Buffalo	• Poaching activities • Migratory routes • Park status and APU in place	Angola and Zambia competent authorities via KAZA Secretariat	After group discussion, it was agreed that these data were not necessary to complete the disease risk assessment but might be valuable in Phase 3.
Zambezi Border & Western Border	• When did cattle enter/cross Namibia in last 3 years. Entry/Exit site, number of cattle, disease status known • Buffalo occurrence in Ngamiland	Botswana Competent Authority & Namibia Competent Authority	Botswana and Namibia DVS provided data on cattle incursions which was incorporated into the report. Data on buffalo occurrence from the KAZA Elephant Survey was also incorporated.
All	Undeveloped and developed boreholes where there is no current livestock activity	Botswana DVS (via water authority)	Botswana DVS provided a map of boreholes (see below).
All	Future land use plans	Botswana DVS (via land board authority)	No data were provided by the deadline.
Zambezi Border & Western Border	Cross-border illegal movement of livestock	Botswana DVS & Namibia DVS	Botswana DVS provided data on cattle theft (see below). No data were received from Namibia DVS.
All	Contribution of fences to the reduction of wildlife	AHEAD/KAZA	The Phase 1 report provides information on impairment of wildlife movement around the fences of interest. The detrimental effects of fences on wildlife are also explored in published literature (*sensu* Williamson and Williamson 1984; Taylor and Martin 1987; Mbaiwa and Mbaiwa 2006; Ferguson and Hanks 2010; Bartlam-Brooks et al. 2011; Gadd 2012; Smith et al. 2020; Hering et al. 2022; Naidoo et al. 2022).
Northern Buffalo	• Sustainability of H4H programme • Detailed functionality at field level	H4Hope	H4Hope provided a summary document which was added to the report appendices.
All	Accurate livestock census for crushes/kraals along the border fences (and geodata for crushes/ kraals from Namibia)	Botswana DVS & Namibia DVS	Botswana DVS provided data for select crushes (see below). No data were received from Namibia DVS.
Western Border	For Namibian cattle that have crossed into Botswana, the CBPP status of the zone from which they originated	Namibia DVS	DVS Namibia provided these data for 4 incursions which were incorporated into the report.
All	Extent of gaps/breakages in kilometres per fence	Botswana DVS & Namibia DVS	Information on fence damage is available in the Phase 1 report. Attendees agreed that it was not

Fence(s)	Type of Data Missing	Designated Data Provider	Were the data provided?
			feasible to incorporate updated data into the current report but it would be beneficial to include data capture in future NAMBOT patrols.

Table Y3. Deficiencies in the technical analysis identified during the validation meeting.

Report Section	Deficiency	Corrective Action	Comments
All fence sections	The SAT-type FMD assessments did not consider SAT serotype strains that are not adequately covered by the existing vaccine strains.	A similar risk pathway as for FMD serotype O should be developed.	The group agreed that the magnitude of consequences for SAT-type outbreaks is moderate, but in cases where the outbreak strain is not covered by the vaccine, the consequences should be high, as for type O. Rather than developing new pathways, the SAT-type FMD assessments now include a clarification that consequences are high and overall risk estimate is moderate for cases where the strain is not covered by the vaccine.
All fence sections	Although the transmission of FMDV from buffalo to cattle is not well understood, the probability of transmission is considered relatively higher than the probability of occurrence of FMD due to poaching. This is on the basis that a viraemic animal has to be killed and the virus must survive for it to be transmitted to cattle.	Buffalo/cattle transmission should be reviewed higher, while poaching/cattle transmission should retain its estimated probability.	In further group discussions, it was agreed that buffalo/cattle transmission should remain very low rather than increasing to low, while poaching/cattle transmission could be lowered to negligible. Specifically, the risk of effective contact between a poacher and cattle was lowered to negligible in the risk pathways, leading to a negligible probability of occurrence.
Western Border	Namibia DVS called into question one of the outbreaks, occurring in commercial farms west of Khaudum National Park, on the CBPP outbreak map. No outbreak is believed to have occurred here.	The coordinates (Masivi, lat -18.61 long 19.68) were confirmed in the WAHIS database and the details shared with the state veterinarian for Kavango East District. He has no record of this outbreak nor did other DVS officials he consulted recall any CBPP outbreak at this location.	It is unclear why this location is recorded in WAHIS but it has been removed from the maps in the report.

Data Provided by Botswana DVS

Table Y4. Statistics of cross border illegal movement of livestock (past 3 yr).

Country of origin	Country of incursion	Number of cattle	Month of incursion	Comments
Botswana	Zambia	10	Apr 2022	All cattle were sold to the local abattoir by the suspect thieves
Botswana	Zambia	11	Jun 2022	All cattle were destroyed in Zambia 5 days after incursion.
Botswana	Zambia	18	Nov 2022	All cattle were recovered and sold to the local abattoir
Botswana	Zambia	22	Aug 2023	Cattle were recovered and sold to the local abattoir.
Botswana	Zambia	8	May 2024	All cattle were slaughtered in Zambia
Botswana	Angola	2	Jun 2024	Cattle are under custody of the Angola police, pending investigations.

Table Y5. Accurate livestock census for crush/kraals along the border fences.

Fence	Crush	Census
Northern Buffalo	Seshokora	There are currently no cattle at the crush
Zambezi Border	Tovera 4	120
	Tovera 2	85
	Tovera settlement	420
	Kaputura	144
	Mohembo East	966
	Mohembo west	500
	Shaikarawe	30
	Xamokucha	
	Rikonga 1	422
	Pelotshweu	186
	Ipopeng	235
Western Border	Maronga	200
	Jerusalema	186
	Dobe	53
	Magopa 1	687
	Magopa 2	250
	Xhanxao	53

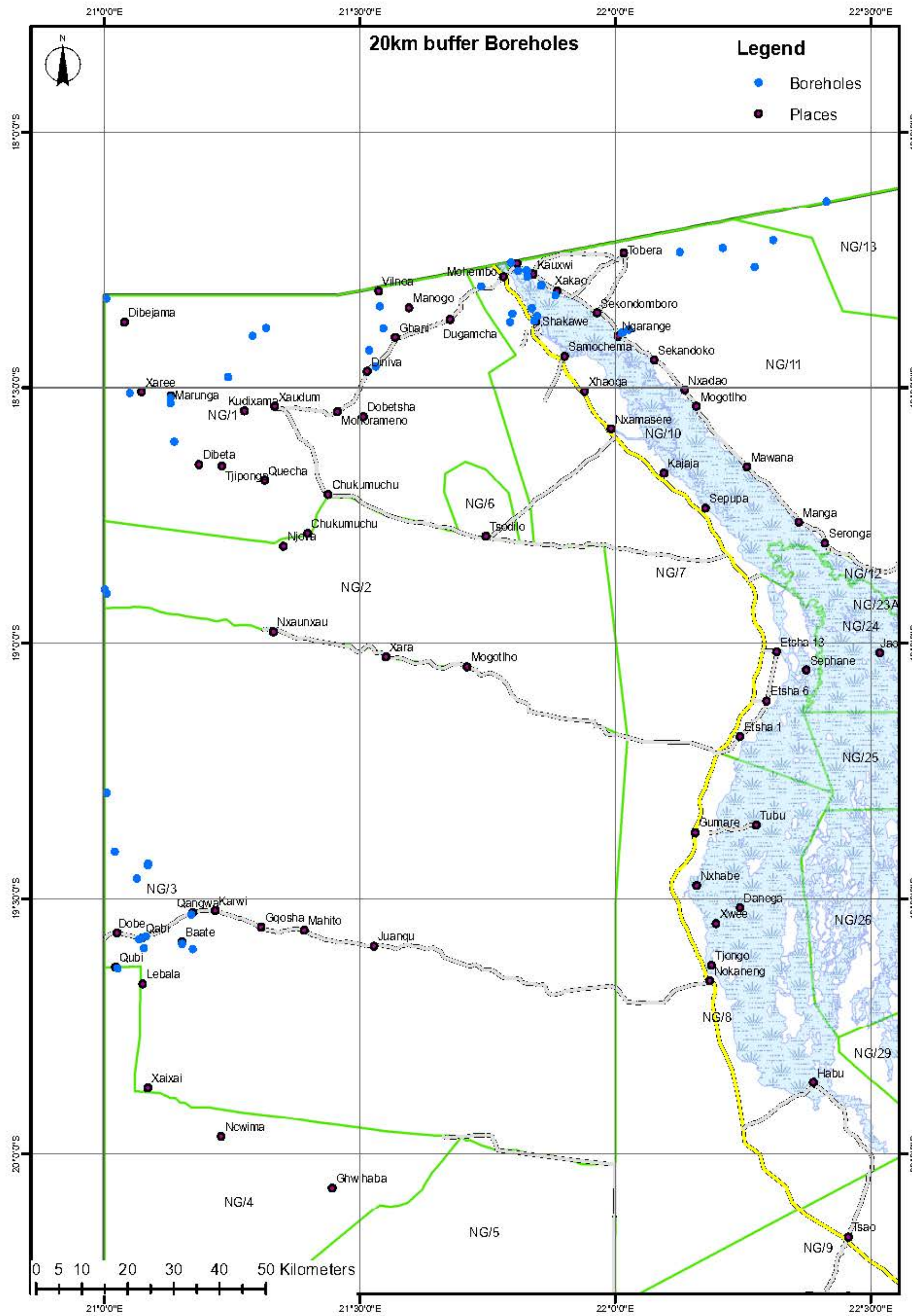

Figure Y1. Map for existing boreholes in Botswana located within a 20km distance from the border fences of interest. The data provided is from 2018; current data is available at Water Affairs.

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