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Paper Biosecurity and Smallholder Vulnerability to Contagious Livestock Diseases in Indonesia

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ABSTRACT

Contagious livestock diseases reveal a persistent weakness in smallholder biosecurity. Formal guidance may define reporting, movement control, vaccination, and farm-level prevention, yet those measures often lose force once they reach household farms with limited space, uneven veterinary access, and strong dependence on livestock as economic assets. Drawing on secondary data from livestock statistics, disease reports, policy documents, and scientific literature published between 2019 and 2026, this study examines why formal biosecurity has not been sufficient to protect smallholder livestock systems from foot-and-mouth disease and lumpy skin disease in Indonesia. The analysis combines policy document review, descriptive epidemiological reading, and gap analysis. The findings indicate that biosecurity is administratively present but operationally thin. Formal documents allocate responsibility to farmers and veterinary authorities with reasonable clarity, while the practical conditions needed for early reporting, isolation, vaccination continuity, and movement control remain uneven. Foot-and-mouth disease exposes the fragility of rapid reporting and animal movement control under high transmission pressure, whereas lumpy skin disease highlights the need for sustained field response and cattle-value protection after public urgency declines. The article develops the concept of paper biosecurity to describe this mismatch and proposes minimum viable biosecurity as a more feasible direction for smallholder settings. Biosecurity policy becomes stronger when technical standards are translated into affordable routines, trusted reporting channels, and locally supported veterinary action.

INTRODUCTION

Livestock disease control becomes most fragile where national biosecurity guidance meets the material limits of smallholder farming. Foot-and-mouth disease and lumpy skin disease give that problem an empirical weight rather than a purely theoretical one. Indonesia had been free from FMD for more than three decades before the 2022 outbreak expanded across many provinces, infecting more than 600,000 animals and killing more than 11,000, while LSD affected cattle and buffalo during the same recovery period (Chen et al., 2022). Such figures matter because they connect disease control with household livestock systems that carry much of the burden of cattle and small ruminant production (Susila et al., 2023). A recommendation to separate sick animals may be scientifically sound, yet its practical meaning changes in a shed built for ordinary husbandry rather than emergency containment.

Smallholder farms do not resemble the controlled farm model often implied in biosecurity protocols. Livestock are kept close to household routines, and their movement is shaped by market timing, urgent cash needs, and trust-based transactions that rarely leave a detailed record. A farmer may delay selling an animal during an outbreak only if the household can absorb the cost of waiting. Veterinary advice enters that calculation, but it does not erase it. Disease risk is then produced through an everyday economy in which animals remain productive assets before they become epidemiological units. Farm-level prevention has to make sense inside this economy, otherwise formal guidance becomes a technically correct instruction with weak traction in daily decision-making (Hayden et al., 2021).

Research on livestock biosecurity has given substantial attention to knowledge, attitudes, and practices among farmers. That line of work remains useful because reporting, vaccination acceptance, and hygiene routines are shaped by perception and trust. A narrower reading of compliance, however, can turn smallholders into the main explanation for failure while leaving the design of prevention largely untouched. The more difficult question concerns the fit between technical standards and the farm conditions assumed by those standards. Many recommendations presuppose space for isolation, predictable access to veterinary services, and the financial ability to bear short-term losses after reporting. Smallholder production begins from a less secure base, and disease control has to pass through that base before it becomes routine (Chowdhury et al., 2023).

Paper biosecurity names the condition in which prevention is administratively present but operationally thin. Regulations, manuals, and campaign messages may create a visible architecture of preparedness, yet exposure is reduced only when those instruments reach the points where farmers decide, animals move, and services arrive. The concept is not meant to dismiss formal policy. Formal guidance is necessary in outbreak control. The problem lies in the missing translation between veterinary knowledge and feasible farm practice. A rule that asks farmers to report early will remain weak if reporting brings uncertainty about market access, delayed assistance, or social stigma around an infected herd. The administrative form of biosecurity can be strong while its practical base remains underbuilt (Mehmedi et al., 2025).

Indonesia is a useful case because livestock policy must work through a dispersed household production system while still protecting national supply, animal health, and trade confidence. BPS data describe livestock populations, production, consumption, and market indicators, whereas disease reports trace affected areas and vaccination responses (BPS-Statistics Indonesia, 2026) . Taken separately, these data give only a partial picture. Their analytical value increases when linked to the organisation of local livestock economies, especially the distance between veterinary services and farm households, the role of market intermediaries, and the pressure created by animals as liquid household assets. Disease vulnerability cannot be inferred from herd numbers alone. The same population figure may carry different levels of risk depending on service reach and reporting incentives (Worsley-Tonks et al., 2022).

Foot-and-mouth disease and lumpy skin disease are used as tracer diseases because they expose the chain that connects farm-level prevention with veterinary governance. Their relevance lies in the way they test whether biosecurity can move from instruction to workable practice. The central question is why formal biosecurity has not been enough to protect smallholder livestock systems from contagious animal diseases. The answer advanced here rests on three connected ideas. Paper biosecurity describes the administrative presence of prevention without sufficient operational depth. Design gap explains the poor fit between technical standards and smallholder conditions. Minimum viable biosecurity points toward low-cost, risk-based routines that farmers can maintain with local veterinary support before outbreaks widen (Bianchini et al., 2023).

RESEARCH METHODS

The research uses a secondary data design that combines policy analysis with retrospective veterinary epidemiology. Such a design is appropriate because the problem under examination is not limited to the biological characteristics of FMD and LSD. The main concern lies in the distance between formal biosecurity standards and the capacity of smallholder farms to carry those standards into routine husbandry. Primary fieldwork would certainly enrich that question, but enough publicly available material exists to examine how disease risk, policy design, and farm-level feasibility are connected. The analytical unit is not the individual farmer. Greater attention is given to the interface between smallholder livestock systems, animal movement, veterinary service reach, and the formal instruments used to organise disease prevention (Paul et al., 2021).

Data were drawn from four main bodies of material. National livestock statistics supplied information on population, production, consumption, trade, and price patterns. Official disease reports and institutional updates provided information on FMD and LSD occurrence, vaccination response, affected regions, and outbreak control measures. Policy documents were used to identify how biosecurity is framed in formal governance, especially in relation to reporting, movement control, vaccination, farm hygiene, and veterinary intervention. Scientific literature published between 2019 and 2026 supplied the conceptual base for smallholder vulnerability, biosecurity adoption, veterinary governance, and transboundary animal disease control. Sources were selected for their relevance to livestock systems where disease prevention depends heavily on household farms rather than large commercial units (Dhaka et al., 2023).

Document selection followed a relevance-based approach. Materials were retained when they addressed at least one of three analytical concerns. The first concern was disease pressure, especially evidence related to FMD and LSD in Indonesia or comparable smallholder livestock settings. The second was biosecurity design, including protocols, official guidance, and institutional arrangements for disease prevention. The third was operational feasibility at farm level, such as access to services, reporting behaviour, animal movement, and the economic constraints shaping farmer response. Documents that only described general livestock development without a clear connection to animal health risk were not treated as core material. This screening helped prevent the analysis from becoming a broad review of the livestock sector.

The analysis proceeded through a layered reading rather than a purely chronological account of outbreak events. Policy documents were examined through thematic content analysis to identify how responsibilities are assigned across farmers, veterinary officers, markets, and local authorities. Disease reports were read descriptively to trace how FMD and LSD placed pressure on surveillance, vaccination, and farm-level response. Scientific literature was used to test whether the assumptions embedded in formal biosecurity fit the conditions commonly associated with smallholder systems. The purpose was not to calculate causal effects, since the available public data do not support that claim with sufficient precision. A stronger contribution can be made by explaining how several types of secondary evidence point toward the same design problem.

Gap analysis provided the main interpretive strategy (Kadir, 2026). Formal biosecurity expectations were compared with the practical conditions required for those expectations to become routine. For example, an official instruction to isolate sick animals was not assessed only as a technical recommendation. The analysis asked what kind of housing, labour, service access, and economic protection would be needed before isolation could become a realistic practice among smallholders. The same logic was applied to early reporting and movement control. Rather than treating non-compliance as an end point, the analysis examined whether the expected behaviour was supported by the institutional and material conditions surrounding the farm.

RESULTS AND DISCUSSION

Results

1. Formal Biosecurity and the Architecture of Responsibility

Across the reviewed policy materials, biosecurity is mainly organised through an allocation of responsibility that begins at the farm and then extends toward veterinary officers, district services, and national agencies. Indonesian FMD control guidance, official vaccination updates, FAO reports on the post-2022 outbreak response, and WOAH technical materials place early detection, reporting, vaccination, and movement control at the centre of disease prevention. The coding process produced a consistent pattern. Formal documents describe what should happen during disease control with reasonable clarity, yet they give less detail on the farm-level conditions that make those expectations workable for smallholders. Biosecurity appears as a chain of assigned duties, while the practical support required to carry those duties remains less visible in the same textual space (Agustiar et al., 2026).

Table 1. Thematic Structure of Formal Biosecurity Responsibilities

Dominant theme in reviewed materials	Policy logic	Main actor receiving responsibility	Operational assumption requiring scrutiny
Early disease reporting	Suspected cases must enter the surveillance system quickly	Farmers and local veterinary officers	Farmers can report without fearing economic loss
Vaccination response	Herd immunity depends on field delivery and farmer cooperation	Veterinary services and livestock owners	Services can reach dispersed farms in time
Movement control	Exposure is reduced by limiting animal circulation	Government authorities, traders, farmers	Animal movement can be controlled without severe household cost
Farm-level prevention	Disease risk can be reduced through routine husbandry measures	Farmers	Smallholders have enough space, labour, supplies, and advice

The strongest textual emphasis falls on early action. Disease reporting is framed as the entry point of surveillance, vaccination as the main protective response, and movement control as the means of reducing wider spread. Such emphasis is epidemiologically reasonable, especially for FMD, where delayed detection can quickly expand exposure across animals and territories. The difficulty lies in how time is imagined in formal guidance. Policy documents treat early response as a procedural target, while smallholder farmers experience time through sale decisions, household cash flow, animal condition, and the availability of officers. A suspected case does not enter the surveillance system through technical awareness alone. Reporting begins only when the farmer believes that the consequences can be managed (Win et al., 2021).

Responsibility becomes more complex as national guidance moves toward household farms. Official documents can assign roles across government levels, veterinary services, and livestock owners with institutional clarity. At farm level, however, the same allocation becomes heavier because the farmer is asked to act before receiving full certainty about diagnosis, assistance, and economic consequence. Early reporting, temporary restriction, and cooperation with vaccination all require trust in the response system. Without that trust, formal instructions may still circulate through extension messages and emergency campaigns, but their effect depends on whether farmers expect support or loss after they comply. Biosecurity is then shaped by the credibility of governance, not only by the content of guidance (Buckel et al., 2024).

The analysis also found that biosecurity duties are expressed more concretely than the resources needed to perform them. Formal materials state the need for clean housing, restricted contact, prompt reporting, and coordinated vaccination, while the conditions behind those actions receive less developed attention. A smallholder who keeps cattle in a household shed cannot isolate an animal in the same way as a commercial farm with separate facilities. A rule on movement control can also carry different consequences for farmers who treat livestock as liquid household assets. The formal text may use a single language of responsibility, but the cost of fulfilling that responsibility is distributed unevenly across production systems (Kadir, 2024, 2025).

Movement control illustrates the tension most clearly. Official disease-control logic treats animal circulation as a risk pathway that must be slowed once outbreak signs appear. Smallholder livestock economies, however, rely on movement as part of normal economic life. Animals are purchased, sold, transported, and exchanged through relationships that cannot be suspended without cost. A restriction that appears necessary from the viewpoint of outbreak containment may become risky for a farmer who depends on sale timing or who fears a decline in animal value after disease suspicion spreads. Policy materials recognise movement as epidemiological risk, yet they are less explicit about how farmers should absorb the economic burden produced by limiting that movement.

The coding results point to an imbalance between administrative clarity and operational specification. Formal biosecurity gives disease control a recognisable structure, and such structure is necessary during outbreaks involving many institutions. Yet preparedness cannot be inferred from the presence of roles, protocols, and campaign messages alone. The more difficult question is whether the prescribed actions are supported by local veterinary reach, reliable communication, feasible farm routines, and reporting arrangements that do not transfer disproportionate risk to farmers. This pattern provides the empirical basis for the later argument on paper biosecurity. The documents do not lack prevention language; rather, prevention becomes thinner as it approaches the smallholder conditions where disease control must first work.

2. Disease Pressure and the Limits of Administrative Preparedness

The reviewed disease materials allow FMD and LSD to be read as two different stress tests for smallholder biosecurity. FMD pressures the system through speed, broad host range, and animal movement. LSD places pressure on cattle and buffalo systems through field detection, vaccination continuity, and the economic weakening of affected animals. The Indonesian evidence gives both diseases more than illustrative value. FAO reported that Indonesia had been free from FMD for more than three decades before the 2022 outbreak, which infected more than 600,000 animals, killed more than 11,000, and forced the slaughter of a further 15,000. During the same wider response period, LSD infected more than 22,000 animals across 13 provinces.

Table 2. Disease Pressure Dimensions of FMD and LSD in Smallholder Biosecurity

Disease pressure dimension	FMD	LSD	Relevance to smallholder biosecurity
Main pressure	Rapid spread across susceptible livestock	Cattle and buffalo losses with field-level persistence	Different diseases test different parts of preparedness
Reported Indonesian burden	More than 600,000 infected animals, over 11,000 deaths, and 15,000 forced slaughtered animals	More than 22,000 infections across 13 provinces	Disease response must reach dispersed livestock households
Biosecurity stress point	Early reporting, surveillance, movement control, and rapid response	Early detection, sustained vaccination, and farmer attention	Formal control measures depend on local operational reach
Smallholder implication	Movement restriction can collide with household liquidity	Reduced animal value can accumulate before wider alarm appears	Cooperation depends on trust, support, and feasible reporting

FMD creates a severe test because its control depends on speed at several points at once. WOAH classifies FMD as a highly contagious disease with major economic consequences, affecting cattle, swine, sheep, goats, and other cloven-hoofed animals. Prevention relies on early warning, surveillance, farm biosecurity, and control of animal movement. These features make FMD especially difficult for smallholder systems where livestock are connected through routine exchange and local markets. The disease does not wait until formal reporting lines become fully activated. By the time a suspicious case is recognised, the animal may already have been in contact with traders, neighbouring herds, or transport arrangements that are ordinary in non-outbreak periods (Salman et al., 2025).

LSD exposes a slower but no less important weakness. WOAH links successful LSD control to biosecurity, early detection, movement control, and rapid vaccination with quality vaccines. The disease is not zoonotic, yet households that depend on cattle can face losses from reduced milk production, weight loss, and hide scarring. This profile matters because LSD may not generate the same immediate policy shock as FMD, while still reducing the economic value of animals that function as productive assets and household savings. Field response must therefore remain consistent after public attention declines. A disease that erodes value gradually can weaken farmer cooperation if reporting is associated with restriction but not followed by visible support (Susanti et al., 2023).

Administrative preparedness is visible in official disease updates, vaccination programs, movement-control language, and the existence of technical guidance. Such preparedness is necessary, but the disease evidence suggests that administrative presence is not the same as operational readiness. Operational preparedness begins where reports are made early, officers arrive in time, vaccines reach dispersed farms, and farmers see reporting as a route to assistance rather than loss. This distinction matters because disease control is ultimately judged at the level where exposure occurs. A response system can look coherent through documents and aggregate numbers, while still struggling at the first contact between a farmer, a sick animal, and the local veterinary service (Syihabuddin et al., 2025).

BPS livestock statistics help locate why this problem cannot be treated as a narrow veterinary matter. The national livestock data cover population, production, consumption, trade, prices, and supporting indicators, which means that animal health risk is tied to food supply and rural household economies. Yet those figures do not automatically explain vulnerability. A province with a large cattle population may face stronger exposure, but population size becomes epidemiologically meaningful only when read together with animal movement, service reach, market routines, and reporting incentives. Descriptive epidemiology therefore has to move beyond counting infected animals. The more relevant question is how disease pressure interacts with the production system that receives the control measures.

FMD and LSD show that the main weakness lies between recognised disease risk and practical reach. Both diseases are known to formal animal health systems, and both can be addressed through established veterinary measures. The available evidence does not suggest a knowledge vacuum. Rather, it points to a delivery problem in which control measures must pass through the uneven terrain of smallholder livestock production. Disease pressure makes the operational gap more visible. Once that gap is placed at the centre of analysis, attention shifts from the existence of biosecurity measures to the farm-level conditions required for those measures to survive beyond emergency announcements.

2. The Operational Gap in Smallholder Biosecurity

The gap analysis indicates that weak biosecurity in smallholder systems cannot be reduced to the absence of formal measures. Reviewed materials from WOAH, FAO, Indonesian outbreak guidance, and livestock-sector statistics already recognise the main pillars of disease control, especially early reporting, movement control, vaccination, farm hygiene, and field veterinary response. The problem appears in the operational premises attached to those measures. Formal standards assume that smallholder farms can convert guidance into action once disease risk is announced. Smallholder production is built on a different footing. Livestock are held as productive assets, household savings, and marketable animals whose value can decline once disease suspicion becomes known. This condition changes the practical meaning of compliance before farmer behaviour is even assessed.

Table 3. Operational Gap Between Formal Biosecurity Expectations and Smallholder Conditions

Formal expectation	Source of expectation	Operational premise	Smallholder constraint	Disease-control implication
Early reporting	FAO outbreak response materials and national disease-control guidance	Farmers can report suspected disease without bearing disproportionate loss	Reporting may affect sale value, movement access, and neighbourhood confidence	Delayed suspicion weakens FMD surveillance and reduces the chance of early LSD detection
Isolation of sick animals	WOAH biosecurity guidance and	Farms have space and labour to separate animals quickly	Household sheds are not usually arranged around	Suspected FMD or LSD cases may remain close

	disease-control protocols		containment capacity	to susceptible animals
Movement control	WOAH FMD guidance and national control measures	Animal circulation can be slowed through administrative restriction	Livestock movement is linked to liquidity, market timing, and trader relations	FMD containment becomes difficult when ordinary exchange continues under economic pressure
Vaccination cooperation	FAO and national vaccination response materials	Veterinary services can reach dispersed farms and maintain farmer trust	Field delivery depends on service reach, communication, and repeated local contact	LSD and FMD protection weakens when coverage is uneven or follow-up declines

Farm-level hygiene is one of the clearest points where formal expectation meets uneven feasibility. WOAH biosecurity guidance treats hygiene and contact reduction as necessary elements of farm prevention, and national disease-control materials adopt similar assumptions. The operational premise is that farmers can turn the shed into a manageable prevention space. Smallholder conditions complicate that premise because animal housing is usually arranged around available land, daily labour, and the practical need to keep livestock close to the household. Hygiene routines may still be possible, but their consistency depends on supplies, water access, and advice that translates broad instructions into manageable practice. For FMD, weak hygiene can leave indirect transmission routes open; for LSD, poor field routines can reduce the effect of detection and vaccination once local cases appear.

Isolation presents a more visible design problem. Disease-control protocols treat separation as a reasonable response once suspected infection appears. The biological logic is strong, especially for FMD because exposure can expand quickly in susceptible animals. Yet isolation assumes that farmers possess a second space or can create one without disturbing the entire husbandry arrangement. Many smallholders do not work with that level of spatial flexibility. A suspected animal may remain within the same shed environment because separation requires materials, labour, or a temporary enclosure that the household cannot assemble fast enough. The gap is not between knowledge and ignorance. The gap lies between a technically valid measure and the physical conditions that allow the measure to become immediate practice (Guntoro et al., 2022).

Early reporting carries the strongest governance burden. Surveillance systems depend on farmers acting before disease status is confirmed, which means reporting has to be safe enough to happen under uncertainty. FAO materials on FMD response emphasise the importance of collective action and field control, but smallholder cooperation depends on what reporting produces at farm level. A farmer who reports suspected FMD may face movement limits before receiving economic reassurance. A farmer who reports LSD may fear a decline in cattle value even where the disease does not provoke the same public alarm as FMD. Reporting becomes rational only when the system offers timely assistance, credible follow-up, and protection against avoidable loss (Seifu et al., 2023).

Movement control connects the gap analysis directly to the political economy of livestock keeping. WOAH treats animal movement as a critical pathway in FMD transmission, and national control measures typically rely on restricting circulation once outbreak risk is identified. Smallholder livestock economies do not treat movement as a marginal activity. Sale timing, trader access, transport decisions, and local market relations shape how animals retain value for the household. A movement restriction can be epidemiologically necessary and economically destabilising at the same time. Without a support mechanism that reduces the cost of delayed sale or interrupted exchange, compliance is left to compete with household liquidity. FMD makes this tension sharper because fast containment depends on slowing movement before the farmer has clear certainty about the full consequence of doing so.

Vaccination appears less conflictual than reporting or movement control, but the gap is still evident. FAO and national response materials place vaccination at the centre of outbreak control, while WOAH guidance for LSD stresses the importance of rapid vaccination using quality-assured vaccines. The operational premise is not only vaccine availability. Coverage depends on whether veterinary services can reach scattered households, whether farmers receive clear information, and whether trust survives after earlier encounters with disease-control authorities. A campaign may raise administrative coverage, but smallholder protection depends on field continuity. LSD is especially useful for reading this problem because its control requires sustained attention even when public urgency declines.

The comparison between formal expectations and smallholder conditions produces a consistent finding. Biosecurity duties are assigned earlier than the operational conditions required for those duties are secured. Formal measures remain scientifically sound, and disease-control agencies need them to coordinate action across regions. The weakness lies in how much practical burden is shifted toward farmers without equivalent assurance over cost, service reach, and reporting consequences. PMK and LSD make the gap visible from different directions. PMK exposes the fragility of early reporting and movement control under rapid spread. LSD exposes the need for sustained field response and cattle-value protection after the initial alarm weakens. These findings prepare the conceptual move toward paper biosecurity as a condition where prevention exists administratively while its working base remains thin at the farm level.

Discussion

1. Paper Biosecurity as a Failure of Technical Translation

The preceding findings suggest that the principal weakness of smallholder biosecurity does not originate from the absence of veterinary knowledge or the lack of formal disease-control policy. Formal guidance already defines reporting pathways, movement restrictions, vaccination strategies, and farm-level preventive measures with considerable clarity. A different problem emerges once those standards move from administrative documents into everyday livestock production. The transition from written instruction to workable practice is neither automatic nor neutral because technical recommendations are filtered through the physical, economic, and institutional conditions surrounding smallholder farms. Biosecurity therefore becomes uneven long before farmers decide whether to comply with a particular recommendation.

Paper biosecurity captures this condition more accurately than conventional compliance narratives. The concept refers to a form of preparedness that is institutionally visible but operationally incomplete. Regulations may assign responsibilities precisely, surveillance systems may define reporting procedures, and vaccination campaigns may establish ambitious coverage targets. Practical implementation still depends on whether farmers possess the capacity to transform those expectations into routine husbandry decisions. The gap identified in the previous analysis therefore represents a problem of translation rather than one of scientific validity. Veterinary standards remain technically sound, yet their implementation model often assumes resources, infrastructure, and service access that are distributed unevenly across smallholder production systems.

Such an interpretation also broadens the way biosecurity adoption is usually discussed in the literature. Knowledge, attitudes, and practices remain important because disease prevention ultimately depends on human decisions. Behavioural explanations alone, however, cannot explain why technically appropriate measures repeatedly lose effectiveness under similar structural conditions. Farm-level compliance becomes inseparable from institutional credibility, veterinary reach, and the economic consequences attached to disease reporting. The evidence therefore shifts analytical attention from individual willingness toward the design of implementation itself, where administrative expectations and operational feasibility frequently diverge.

2. From Design Gap to Minimum Viable Biosecurity

Recognition of the design gap does not imply that formal biosecurity standards should be relaxed. Disease control still requires surveillance, movement regulation, vaccination, and rapid reporting. A more productive direction lies in redesigning implementation so that preventive measures correspond to the capacities available within smallholder systems. Minimum viable biosecurity offers such a perspective by asking which preventive actions can realistically be sustained under ordinary farming conditions before emergency interventions become necessary. The emphasis moves from ideal compliance toward durable compliance.

Minimum viable biosecurity should therefore be understood as a process of prioritisation rather than simplification. Preventive measures deserve priority when they interrupt the most influential transmission pathways while remaining economically and operationally feasible for livestock households. Reporting systems become more effective when they are accompanied by timely veterinary support. Vaccination achieves greater value when continuity is maintained beyond emergency campaigns. Movement control becomes more credible when farmers are not required to absorb the full economic burden created by temporary restrictions. Such adjustments do not reduce veterinary standards. They strengthen the likelihood that those standards will survive routine practice instead of remaining confined to administrative guidance.

This interpretation also carries wider implications for livestock governance. Smallholder farms should not be treated as scaled-down versions of commercial production because the institutional environment surrounding them differs substantially. Disease preparedness depends as much on relationships between farmers and veterinary services as on technical protocols themselves. Biosecurity becomes more resilient once implementation is designed around existing production realities rather than around ideal farm models. The progression from paper biosecurity toward minimum viable biosecurity therefore represents a shift in implementation logic rather than a revision of veterinary science, providing a more practical foundation for disease prevention across dispersed smallholder livestock systems.

CONCLUSION

Smallholder vulnerability to contagious livestock diseases cannot be explained by the absence of biosecurity policy alone. The analysis shows that formal guidance on reporting, movement control, vaccination, and farm-level prevention already exists, yet its effect weakens when these measures reach household farms with limited space, uneven veterinary access, and strong dependence on livestock as economic assets. FMD and LSD reveal this weakness from different directions. FMD exposes the fragility of rapid reporting and movement control under conditions of fast transmission, while LSD draws attention to the need for sustained field response, vaccination continuity, and protection of cattle value after public urgency declines. The central problem is not a lack of veterinary knowledge, but the thin operational base through which that knowledge is expected to become routine practice.

Paper biosecurity provides a useful way to name this condition. Biosecurity may be administratively present while remaining shallow at the point where farmers, animals, markets, and veterinary services interact. A stronger approach requires moving from checklist compliance toward minimum viable biosecurity, where prevention measures are technically meaningful, affordable, and supported by local veterinary systems. The argument developed here is limited by its reliance on secondary data, since farm-level behaviour and service delays could not be measured directly. Future research should test this framework through household surveys, livestock market tracing, and veterinary service mapping across high-risk districts. Such work would clarify how reporting incentives, animal movement, and field response can be redesigned before outbreak control becomes the only remaining option.

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