LEGS

Livestock Emergency Guidelines and Standards

Livestock Emergency Preparedness and Response for Areas at High Risk of Volcanic Eruptions

A Technical Brief for the Livestock Emergency Guidlines and Standards (LEGS)

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Executive Summary

The Livestock Emergency Guidelines and Standards (LEGS) are a set of international standards and guidelines for the assessment, design, implementation, and evaluation of livestock interventions to assist people affected by humanitarian crises. The aim of LEGS is to improve the quality and livelihoods impact of livestock-related projects in humanitarian situations. In this technical brief, LEGS is partnering with the Food and Agriculture Organization of the United Nations (FAO) Regional Office for Asia and the Pacific to support livestock-owning communities at risk of volcanic eruptions to be better prepared in mitigating and responding to the effects of eruptions on animals through the application of the LEGS Guidelines and Standards.

The Pacific Ring of Fire, a 40,000km belt of volcanoes stretching around East Asia and Western America, constitutes the world's most dangerous tectonic interface. Volcanic eruptions cause devasting economic losses for smallholder farmers who depend on their livestock as a source of animal protein (milk, meat, and eggs), draught power, and transport, and as a store of capital and convertible income.

The LEGS approach and LEGS' considerable experience of disasters such as drought, floods, and cyclones/hurricanes/tornadoes can be adapted and applied to volcano-related emergencies. LEGS uses an evidence-based approach and includes eight core standards and six technical interventions: destocking, veterinary support, feed supplies, provision of water, livestock shelter and settlement, and provision of livestock.

This technical brief documents the impact of both mild and violent volcanic eruptions on livestock, and livestock keepers and their livelihoods. It demonstrates how the LEGS tools, such as the Participatory Response Identification Matrix (PRIM), can be used to develop a response plan that leads to the identification of the most appropriate livestock interventions to support livestock keepers affected by volcanic eruptions. The brief provides standards, key actions, and guidance based on good practice for each of the interventions. It also provides relevant information for preparedness efforts in these unique contexts.

The brief aims to promote a participatory approach to response planning, with strong representation from affected communities and stakeholders. It also emphasizes the importance of a coordinated response between affected communities living by volcanoes and civil defence, agriculture officials, decision makers, and funding agencies in charge of emergency assistance before, during, and after volcano eruptions where livestock is an important component of human livelihoods.

By adapting the LEGS methodology and tools to manage these unique and dramatic contexts, key livestock-related assets may be protected, and rebuilding of these assets once the eruption recedes may be secured in the recovery phase.

Cover Page: Mayon Volcano, the Philippines. Photo credit: Rubina Cresencio

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Acronyms

DRR	Disaster Risk Reduction
FAO	Food and Agriculture Organization of the United Nations
LEGS	Livestock Emergency Guidelines and Standards
PRIM	Participatory Response Identification Matrix
WSPA/WAP	World Society for the Protection of Animals, now World Animal Protection

1. Introduction to volcano contexts and the application of LEGS to volcanic disasters

The Livestock Emergency Guidelines and Standards (LEGS) are a set of international standards and guidelines for the assessment, design, implementation, and evaluation of livestock interventions to assist people affected by humanitarian crises. LEGS aims to improve the quality and livelihood impact of livestock-related projects in humanitarian situations. LEGS is widely used by many organizations and has gained popularity in the humanitarian sector that involves livestock. In this brief, LEGS is partnering with the Food and Agriculture Organization of the United Nations (FAO) Regional Office for Asia and the Pacific to develop standards and guidelines to enable countries at risk of volcanic eruptions to be better prepared in mitigating and responding to the effects of eruptions on livelihoods dependent on livestock.

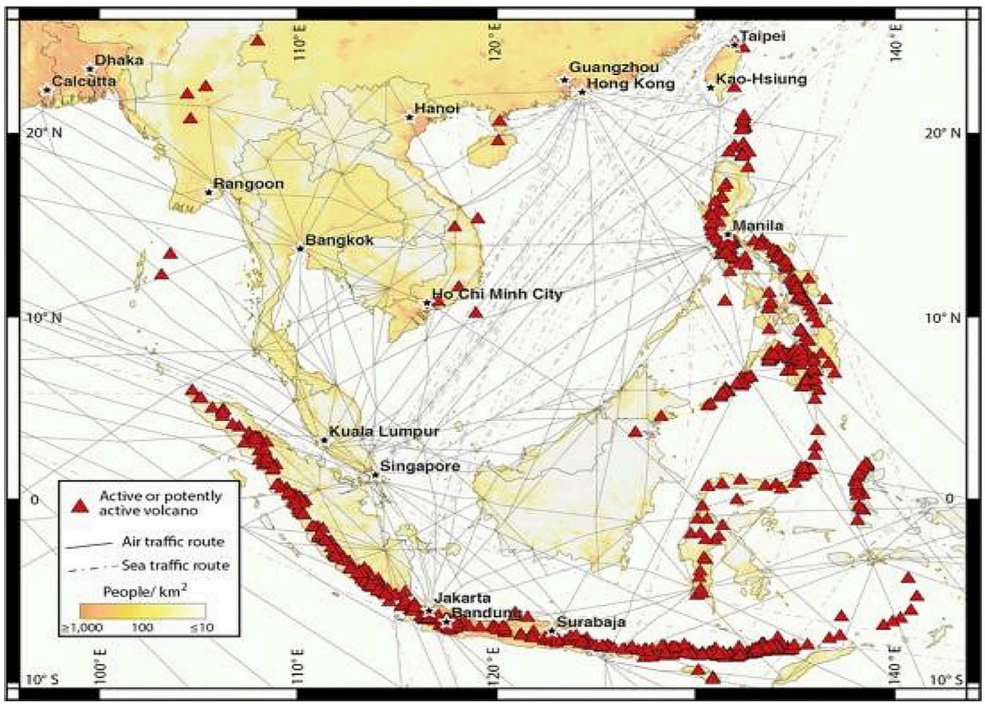
Volcanoes are significant ruptures of the Earth's crust that spew lava, pyroclastic flows,[1] *lahars* (volcanic mudflows), ash, and gases down the volcano slope at different ratios and speeds. Volcanologists have in recent times worked on identifying precursors and placing sensors able to forecast volcanic activity as early warning systems to protect nearby communities that live with the risk of eruption and thus minimize the impact on lives and livelihoods.

The South-East Asia region is highly prone to volcanic activity due to its proximity to the Indo-Australian, Eurasian, and Philippine Sea plates that produce a dense arc of volcanoes (see Figure 1). Currently, there are around 750 potentially active volcanoes in the region, 22 of them in the Philippines and about 76 of them in Indonesia (Whelley *et al.*, 2015).

Eruptions disrupt travel and trade, and result in damage and economic losses. According to FAO's 2006–2016 report on the impact of disasters in the agricultural sector and on food security, volcanoes accounted for 30% of losses resulting from various hazards, with a higher percentage of damage on the Asian continent (Conforti *et al.*, 2018).

Economic losses in the livestock sector are devastating for smallholder farmers who depend on their livestock as a source of animal proteins (milk, meat, and eggs) and as a store of capital and convertible income. Volcano activity has a devastating effect on livestock, leading to farmers losing their livelihood sources owing to drastic and overwhelming production losses and costs incurred in keeping livestock healthy and the subsequent husbandry challenges during volcanic events.

Figure 1: Map showing active and potentially active volcanoes of South-East Asia b (CIESIN, 2014).



1 A pyroclastic flow is a fast-moving volcanic lava flow and contains a mixture of hot rocks, gas, and ash thrown out of the volcanic vent, with temperatures typically between 800°C–1000°C.

2. The LEGS approach and volcano-related emergencies

The LEGS approach and the LEGS project's considerable experience with disasters such as drought, floods, and cyclones/hurricanes/tornadoes can be adapted and applied to volcano-related emergencies. LEGS uses an evidence-based approach and is based on eight core standards and six technical interventions: destocking, veterinary support, feed supplies, provision of water, provision of shelter and settlement, and provision of livestock. This approach and the associated tools aim to improve the quality of humanitarian interventions involving livestock-based livelihoods. The LEGS approach for dealing with emergencies affecting livestock owned or used by smallholder farmers can be applied to the handling of volcanic eruptions, as set out in this technical brief.

2.1 LEGS livelihoods-based objectives

LEGS applies three livelihoods objectives to ensure a livelihood focus in the LEGS approach to designing an emergency response. Table 1 below shows the LEGS objectives and examples of their application in different volcanic eruption scenarios.

Table 1: LEGS livelihood objectives and examples of application

Livelihood objective	Application in volcano context
1. To provide immediate benefits to crisis-affected communities, using existing livestock resources	This objective aims to provide immediate assistance to crisis-affected communities by using the already available livestock resources. In the LEGS approach, this objective is commonly achieved through destocking. In the volcano eruption context, smallholder farmers are encouraged to sell their livestock (beef cattle, pigs, small ruminants, poultry, carabaos,[2] equines) before the body condition score of livestock deteriorates or market prices collapse. Destocking is a way of avoiding catastrophic losses and a way for the money to be used in meeting basic household needs such as food and transport. The money is also available as a source of income. This objective may be adopted in a preparedness plan in which farmers sell their livestock if an eruption is likely to occur. The money can then be used to restock during the recovery phase.
2. To protect key livestock-related assets of crisis-affected communities	This objective aims at protecting already existing livestock resources (asset protection) through the provision of water, feed, veterinary care, and shelter. Livestock keepers may not be able to immediately benefit in full from their livestock during the emergency phase, but they might be able to do so once normality returns and production resumes thereafter. This objective may be applied during mild eruptions or in a situation where evacuation may be achieved successfully.
3. To rebuild key livestock assets among crisis-affected communities	This objective relates to a situation where substantial livestock losses occurred (objective 2 was not achieved). Traditionally, during the recovery phase, livestock keepers are provided with livestock (restocking) and/or are supported with water, feed, veterinary care, and shelter. However, this objective may be achieved through alternative methods such as cash transfers, as discussed in Chapter 9 of the LEGS Handbook. In a situation where recovery cannot be achieved, such as in the case of a prolonged intense eruption, livelihood diversification may be achieved with the adoption of the above alternative methods.

2 A carabao is swamp-type water buffalo native to the Philippines.

The above objectives are, in turn, influenced by a rights-based approach (rights to food and living standards), as affected people have rights that protect their lives and livelihoods (which in this case are livestock related) that may often be ignored or under-represented during rushed emergency response efforts.

The LEGS objective of protecting the livelihoods of affected populations is applicable in this context by using two broad LEGS strategies: (i) help in the identification of the most appropriate livestock interventions; and (ii) provision of standards, indicators, and guidance notes in every context, based on best practices. These strategies not only address the emergency event but also the recovery stage and eventual reconstruction process, which fits volcano contexts that tend to feature long eruption periods (LEGS, 2014).

2.2 LEGS Core Standards

LEGS Core Standards in Chapter 2 of the LEGS Handbook may be utilized as the screening tool for the work and role of stakeholders to ensure fair, relevant, and harmonized outputs. See below for details.

1. Participation – The participatory approach is paramount for the ownership and the accountability of each plan and process by livestock owners, their families, their communities, and the sector. The community, for example, needs to plan and agree to evacuate their livestock *before* an eventual human evacuation, or the animals may need to be moved using different routes, when possible, to avoid jeopardizing the safety of the people in need who are to be evacuated using the same roads. The community also needs to agree on the point of no return for the difficult decision of when destocking is to take place. These are but a few examples of the decisions that need to be taken together.

In the case of volcano hazards, personalized, community-owned approaches enriched by indigenous knowledge are necessary to prepare for a handful of possible scenarios, ranging from learning how to live with discrete *lahars*, acid rain, and ash falls to large-scale animal evacuation. As opposed to methods such as 'direct observation and village walks', staying in the community for several days can help responders gain valuable insights about the history and the sometimes intangible yet important dynamics between livestock owners and the rest of the value chain elements and the village (Kirsopp-Reed, 1994).

Capacity building at the community level is, on one hand, the best investment to build skills for first responders. On the other hand, it faces various challenges, such as financial constraints, local interest, government support, and of course volcanic activity levels. To add to these challenges, the need for new skills training in many communities around the world is challenged nowadays by the COVID-19 pandemic, which has made remote communication tools and online training approaches such as online simulations a necessity and a priority. However, online options may not always be possible, given available resources and local constraints such as good communication systems in the various regions.

The aim of capacity building is the facilitation of sustainable development by ensuring that response plans are in place and communities living near volcanoes have the skills to protect their livestock, including working animals, to assure the sustainability and the prosperity of their livestock-related livelihoods.

2. Preparedness – To respond rapidly and appropriately, response actors should have in place the people, tools, infrastructure, systems, and necessary information about previous eruptions in the area and to what extent livestock may be a source of income for farmers and livestock keepers.

Well-prepared responders should have maps with evacuation points and paths identified for large animals in the case of foot evacuation or for trucks in the case of mechanized evacuation. This preparation also implies knowledge of alternative destination points; the numbers and species of animals in the area of operation, preferably compiled by official veterinarians (as they may issue or deny veterinary permits for eventual evacuation) and including georeferencing for large animals or flocks (alternatively, a low-cost solution may be photos taken by smartphones, which now include georeferencing information); early warning systems in place (as livestock is seldom factored in these systems); baseline animal health information (e.g. important local diseases); service providers (transport, animal health, feed suppliers, etc.); the value chain (to identify most stakeholder layers/levels); market prices

(to document price stability/instability times); feed and water needs, water permits (at alternative locations); state of access roads; loading ramps and turn-around points for transport trucks; and logistics such as equipment and training needs. All this information is vital to prepare and plan response efforts as well as eventual recovery efforts (FAO and ILO, 2009).

The aim while evacuating valuable livestock is to avoid chaos during evacuation and transport of livestock to other areas. The aim is to avoid endangering human lives and losing stock due to poor planning or disorganization, inadequate animal handling, transportation techniques, and road blockages.

In the case of rapid- and strong-onset eruptions, adequate participation in the planning stages as recommended by LEGS may not be possible due to the limited time available to save lives. However, this apparent vulnerability may still be reduced by preparing in advance and focusing on risk reduction, as demonstrated in Case Study 1.

3. Competencies – These are the roles, qualifications, and competencies that need to be covered in the preparedness plan and during the process with key stakeholders such as animal handlers and owners, community representatives, intermediaries, truck drivers, police, veterinarians and animal health professionals, civil defence, local government officials, volcanologists, road patrol, civil engineers, and even consumers.

4. Initial assessment and response identification – LEGS' systematic approach to this phase provides an understanding of the role and importance of livestock in livelihood protection vis-à-vis local policy and the economic context. For instance, assessment is done of the previous history of the volcano; history and economic profile of the livestock sector; insurance, agriculture, and emergency policies in place; and endemic animal diseases at the starting or final points of an eventual evacuation path, as well as available vaccine protocols needed for transport; transport needs; alternative pastures, water, shelters; and market prices, etc.

5. Technical analysis and intervention – Information from volcanologists on the chemical composition (toxicity potential) of each gas, ash, and *lahar* eruption episode needs to be factored in to identify interventions that would allow livestock owners and animals to live with the eruption. Using sound, transparent analysis methods, and selection of beneficiary livestock owners in the case of destocking, as well as agreeing on pricing guidelines for livestock with the value chain stakeholders, is an example of inclusiveness and participatory analysis.

Case Study 1: Capacity building at the community level, the Philippines, 2013

A strategic advantage for the enormous task of preparing small farmers near volcanoes is the amount of time and resources the Red Cross movement has already invested in the Philippines and in theory in Indonesia too (as well as in most countries in the world where national Red Cross chapters operate disaster risk reduction (DRR) programmes) in the training and capacity development of entire communities (*barangays* in the case of Philippines) on community risk mapping, DRR, coordination, and preparedness. In the wake of typhoon Haiyan in 2013, the author found these *barangays* well trained by Red Cross officials and well versed in disaster risk assessment and preparedness. They were making the necessary leap to include animals in their disaster risk management plans an easy step and natural evolution, rather than a significant undertaking of starting from scratch.

Teams focused on developing capacity at the local and official veterinary level to enable them to act as intermediaries and translators of information during the emergency response phase between civil defence, meteorological institutions, agriculture, municipal governments, and the *barangays* themselves, where families owning farms and working animals resided.

Source: Gerardo Huertas, personal communication.

6. Monitoring and evaluation and livelihoods impact – This is carried out on a continuing basis to allow the response to adapt to changing local needs and for small refinements to be made to the response actions as needed. Taking responsibility for record-keeping of monitoring, evaluation, and impact assessment information, and best practice documentation, is not a minor task. The first, natural reaction of most people during emergencies is to help rather than to document and keep track of detailed information. However, this information is and will be crucial to ensure the correct actions are being taken. It is also vital for future learning, preparedness, and response planning.

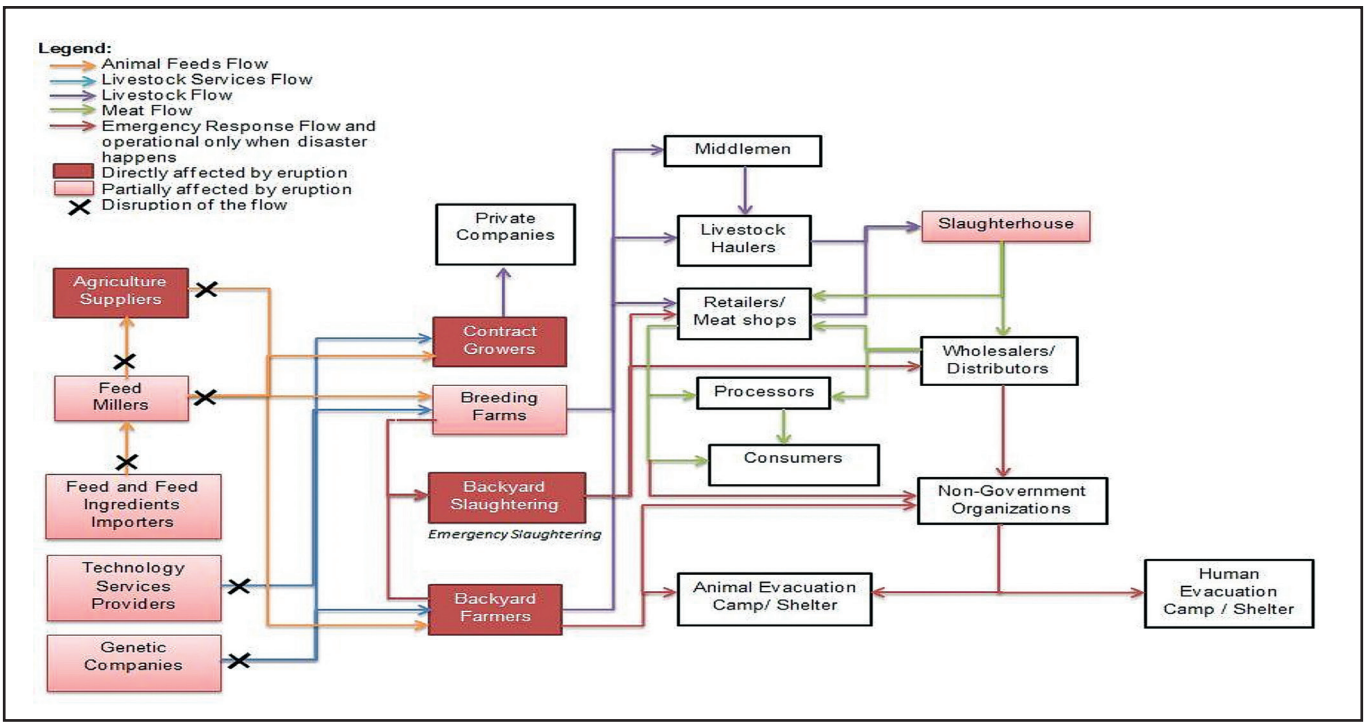
7. Policy and advocacy – Documenting possible policy obstacles is worth doing for later joint evaluation of the broader development and institutional context. For example, documentation should be undertaken on policies and emergency management tools and systems used by civil defence, volcanologists, agriculture, local and national governments, the private farm animal sector, the veterinary and animal health profession, and banking and insurance sectors managing or considering emergency funds and subsidized loans.

8. Coordination – To harmonize and complement other humanitarian interventions not directly involved with the protection of livestock-related livelihoods and avoid interference with human life-saving operations, coordination seeks to standardize emergency management methodologies (to secure livestock livelihoods for human benefit before, during, and after volcano eruptions) with other stakeholders whose focus is elsewhere in the humanitarian relief effort.

Considering the nature of the volcanic eruption context, many agencies may find themselves working together on different yet related pieces of humanitarian and livelihood support work. Thus communication and coordination at this level and point in time is critical. A strong and comprehensive representation of community stakeholders must be brought in, given the need for the buy-in of all stakeholders in the risk mapping and the LEGS Participatory Response Identification Matrix (PRIM) phases.[3]

Failure to do so may turn into a significant if not bigger threat to the livelihoods of the same community that agencies and non-government organizations (NGOs) may be trying to help, as the disruption and alienation of the value chains could be catastrophic for local economies, eroding the social and economic fabric. See Figure 2 for a schematic of value chain stakeholders.

Figure 2: Value chain scheme depicting the levels and complexity of stakeholders before and after the volcanic eruption (FAO, 2021b).



3 The Participatory Response Identification Matrix (PRIM) is a tool that uses the findings of the initial assessment to support discussion and decision making on what interventions to provide in an emergency.

Finally, and for effective coordination and sharing of information, alignment with the official command system set in place by civil defence, if present, may provide much sought-after harmony among the different actors, to expedite communication, share expertise and support between agencies, create synergies, and avoid duplication of efforts.

2.3 LEGS cross-cutting issues

Like the Sphere project LEGS addresses vulnerability through a focus on cross-cutting issues: gender and social equity, HIV/AIDS, and protection. Protection includes: avoid causing harm; ensure access to impartial assistance; protect people from violence; and assist with rights claims. These issues need to be considered and included when working with the community. Men, women, and children all have an important role in keeping livestock, while less-advantaged people, for example, merit special considerations and protection when adapting to living under the ash or when the time comes to evacuate.

LEGS' livelihood protection approach advocates for the adoption of set humanitarian standards and principles applied in the Sphere Handbook drawn from international humanitarian law and human rights. Volcano contexts, like other emergencies, require the protection of the affected population, and their livelihoods are given priority. Therefore, technical interventions undertaken must promote the dignity, integrity, and safety of the people and their livelihoods. A key consideration in the context of volcanoes is that planned livestock interventions such as evacuations in the early phase, or restocking in the recovery phase, should not increase the vulnerability of the affected communities or vulnerable groups.

Figure 3: Barangays trained in DRR by the Red Cross, the Philippines. Photo credit: G. Huertas

3.0 Response planning

3.1 Initial assessment

The initial assessment is the first step in an emergency, undertaken to establish the viability of livestock-based interventions and to develop response plans. Initial assessment forms the basis and background on which critical decisions will be made about whether to intervene or not. The initial assessment identifies appropriate technical interventions. It also helps identify other agencies assisting to ensure a coordinated response is in place for all the stages of the emergency response. The primary outcome of the initial assessment should be an assessment report that provides information about the viability of any response and, if viable, allows for a solid emergency response plan to be developed.

During the initial assessment and where possible, adequate participation should be ensured to have all groups of stakeholders involved and their views represented. Chapter 2 of the LEGS Handbook under Core Standard 1, Participation, provides guidance notes on how stakeholder representation can be achieved.

Volcano contexts can be rapid-onset events by nature, so the participatory element may not always be fully met at first. However, the goal of substantial participation must be met when possible, to ensure that the assessment report is adequate and encompassing enough to provide reliable information for responsible decision making.

The LEGS Handbook approaches the initial assessment with the following three broad areas of focus:

- Role of livestock in the livelihoods in the areas affected/to be affected;
- Nature and impact of the emergency;
- Situation analysis: In the case of a volcano eruption, situation analysis could include animal census/ inventories, welfare/health, previous volcano activity records, value chain configuration, prevalent low- and high-altitude winds, rain patterns that may carry the plume of ash in different directions depending on the season, available services, and key actors in the region.

For the initial assessment, the LEGS Handbook provides expanded information for each of the three broad areas above that can be applied in a volcano situation. Chapter 3 of the LEGS Handbook provides more information.

An initial assessment in a volcano context can be carried out in the following ways:

I. Reviewing existing historical information – especially in cases where data have already been collected during the preparedness phase in volcano-prone areas or from data and reports of previous eruptions;

II. Remote assessment – in areas where Disaster Liaison Officers may have been trained on assessment techniques, organizations intending to intervene may use such agents to provide important information from the volcano-affected areas to help shape their decision making on whether to intervene and the kind of technical interventions to organize;

III. Rapid assessment – commonly used by established organizations considering the onset of an eruption and the time constraints for paced or rapid interventions. It involves expert teams deployed to the volcanic scene to carry out a rapid assessment and generate a report. Rapid assessment may be done within 48–72 hours of arrival in the affected area.

3.2 The Participatory Response Identification Matrix (PRIM)

After the initial assessment is done and an assessment report generated, the proposed interventions undergo a discussion process of prioritization, supported by a LEGS tool called the Participatory Response Identification Matrix (PRIM). The PRIM is a tool used to 'filter' the set of proposed interventions to select the most appropriate, feasible, and timely interventions for achieving the relevant LEGS objective(s). The filtering is done through a participatory discussion process or in a workshop with the community representatives and key local stakeholders. There is no universally correct PRIM for all emergencies, so each PRIM needs to be tailor made, including in the case of volcanic eruptions. Eruption patterns may be different, and the composition of the ash may vary.

Figure 4: The PRIM (LEGS, 2014).

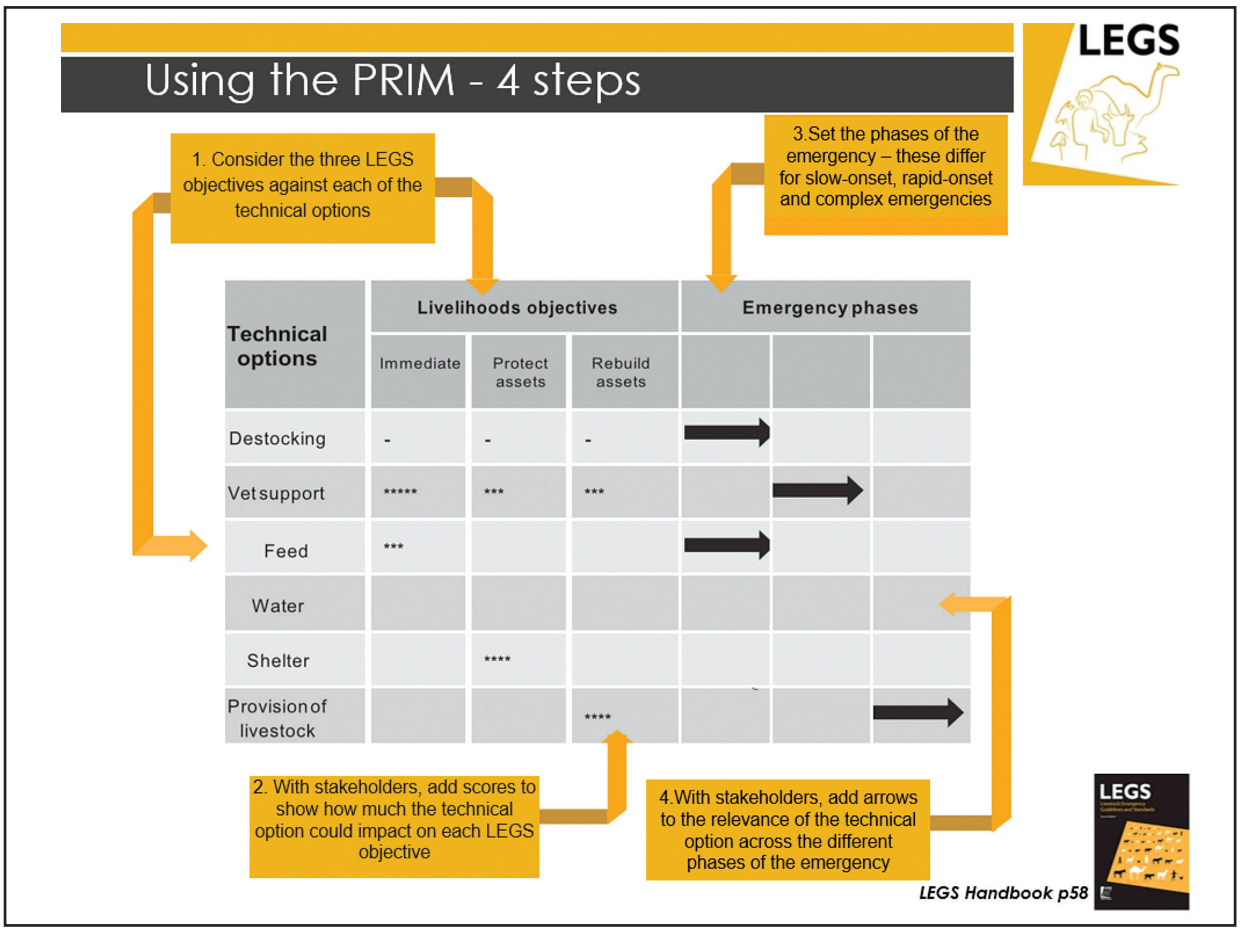


Table 2: Application of the PRIM for the technical intervention – provision of feed.

Livelihood objective	Technical intervention	Implications and issues
Provide immediate benefits to crisis-affected communities, using existing livestock resources	Feed provision (hay)	The community needs to jointly coordinate transport trucks and delivery to each farm on deteriorated roads, and for feed to be stored under a roof.
Protect key livestock-related assets of crisis-affected communities		Protect herd health and production

The PRIM is a participatory approach by nature. It is an ideal tool for ensuring that local voices are represented. It systematically covers all needs and stages of the several scenarios produced by different volcano eruptions. See Figure 4 for a depiction of how to use the PRIM.

Table 2 demonstrates how the PRIM is applied to one of the LEGS technical interventions, provision of feed.

3.3 Technical response options and standards

LEGS provides six technical response options and eight core standards to be considered in livelihood-based interventions. LEGS includes several tools for each technical intervention area. A description of the tools follows.

Technical assessment checklists: These tools are in the appendices to each LEGS chapter and are supplementary to the initial assessment checklists. They guide first-line responders in acquiring the necessary inventories and tools for a volcanic emergency. These tools include leaf blowers, plastic tarpaulins for providing shelter to the animals from the ashfall, and loading ramps and bedding for trucks. Responders working in volcanic emergencies to safeguard livestock livelihoods must also ensure their safety before considering the safety of the livestock. Other specific and supplementary checklists are provided in the appendices of each LEGS technical intervention (Benfield Hazard Research Centre and CARE International, 2005).

Advantages and disadvantages tables: These are used to illustrate the benefits and shortcomings of the various choices to be considered during an emergency. This tool helps in adopting options with better gains and lower risks and is similar to a strength, weakness, opportunities, and threats (SWOT) analysis. For example, timing is crucial for livestock evacuation, as it may be advantageous in one instance and disadvantageous in another, especially when coinciding with human evacuations, which is unacceptable for rescue experts.

Decision making tree: These are used in the decision making process to evaluate options. For instance, when considering restocking as a technical intervention, this tool evaluates the possible outcomes of adopting this intervention and guides in identifying mitigation measures to avoid increasing vulnerability of specific groups of livestock owners or livestock. For instance, if the process may risk introducing new pathogens that may result in the spread of disease to other livestock, this risk may be mitigated by ensuring preventive veterinary care and vaccinations protocols (veterinary health certification) are in place or carried out before the animals are distributed to farmers, time permitting.

Standards, key actions, and guidance notes: Each of the six technical chapters of the LEGS Handbook contains detailed standards, key actions, and guidance unique to each technical intervention. Standards provide justification and link to LEGS livelihood objectives for each technical intervention, while key actions provide a set of steps to be followed when adopting a technical intervention. Guidance notes also provide wider explanations and guidance on why and how each technical intervention is to be carried out. For instance, when adopting destocking, important considerations such as livestock's body condition score, timing, markets, security, and intervention exit strategy are explicitly covered in Chapter 4 of the LEGS Handbook.

4.0 Brief overview of the impact of volcanoes on livestock and livestock keepers

In the range of possible volcanic eruptions, two main scenarios opposite in the spectrum of intensity may dictate whether farmers gradually work towards adaptation of their animals and farms to the volcanic eruption activity or take the more dramatic action of emergency evacuation of their families and their animals as their most valued assets, leaving everything else behind. The latter includes facing the likelihood of drastically changing their subsistence means.

4.1 Sustained, low-to-mild eruptions of ash and gases

4.1.1 The impact

The difference between 'low' and 'mild' may be hard to assess. It may be influenced by the terrain, the duration, the composition of the gas, acid rain, and ash, and by wind and rainfall. An eruption may be considered low when gases, ash, and pyroclastic flows are hardly noticeable and do not seriously affect the people, the animals, production, livelihoods, and normal life in general.

A mild eruption is a step forward in intensity. It includes a few pyroclastic flows with volcanic material that is small in size, noticeable yet fine gases, and ash in the air, which starts to accumulate on the leaves, roofs, depressions, and water sources. Animals still behave as usual, even if their forage may start to be contaminated in small amounts. For mild eruption episodes, human and animal life and businesses may try to go on as usual. The determination that an eruption is a mild yet significant eruption may thus be hard to establish. At least, the determination may be a subjective one, as perceptions are by their nature subjective, and conditions and impact may vary in every situation.

Theoretically, with up to 5mm of ashfall, the fallen material may still allow livestock to feed on pastures and drink water with ash-contamination levels that will not immediately affect their digestive systems,[4] depending on the prevalence of rain and wind, both of which will affect how ash and gases are swept away. In the case of dairy cattle, the cows start to eat less, and milk production starts to reduce.

With the help of the rain, the wind, and other natural processes, volcanic ash enters the soil within one year, though trees may recover in weeks. With between 5–25mm of ashfall, tall pastures are affected, and trees need months to recover. This way of measuring the impact of a volcano may, however, be a deceptive approach, as the acid rain produced by volcanic gases may be more difficult to see or measure. While heavier episodes may deposit little or no ash, the effects of acid rain may be less visible yet worse for electrical grids, metallic infrastructure, pastures, people, and livestock.

Measuring impact will therefore come down to the receiving end (people and animals in our case) versus the chemical composition and duration of the eruption (materials, gas, acid rain, and ash falls) and exposure time and levels of contamination on the animals related to the toxic components of the eruption. The all-important direction of the winds, the season, and whether rainfall is present, as well as the animal species, age, and health, are all coupled with the accumulation of volcanic material in ecosystems and result in the overall exposure and the impact on pastures, water, people, and animals.

In short, a 'mild' eruption could be considered one in which livestock keepers may be able to live indoors, with short periods spent outdoors tending to their animals. Those animals – and their water sources and fodder – should in turn, including cut pastures or grains, be harvested, stored, and kept indoors (siloed). Sidewalls in animal shelters should be covered with plastic sheets and roofs kept as clean from ash and acid rain as possible. Adaptation efforts and investments ought to be considered with the hope that the eruption may recede soon enough for vegetation and animals to recover so livestock keepers are able to resume business as usual.

On the production animal side, the species, breed, age, and condition, plus the time animals may have to spend and feed outdoors, will provide information on what impact the eruption may have on them. Individual reports filed by farmers during past eruptions suggest starvation as the main perceived cause of death in smaller livestock such as sheep.

4 https://volcanoes.usgs.gov/volcanic_ash/conditions_after_ash.html

Initial impact: Local pastures and drinking water from natural springs will quickly become contaminated by acid rain and ash falls, sending harmful components straight into the feeding cycle of livestock. The only way to avoid this danger is if torrential, sustained rains wash the air and the pastures and increase drinking water volumes. Sadly, prolonged ashfalls can often outlast these rains.

Impact on animal health and production: Initially, health symptoms will appear in animals and people, with irritation of the eyes and ears. Animal power (in the form of equines carrying produce and people or oxen ploughing the land) and production of milk, cheese, wool, eggs, and meat in livestock and farm animals will decrease and then sink rapidly. Spontaneous abortions may start occurring in pregnant livestock and working animals. Then their digestive systems will become compromised, with the accumulation of ash and undigested organic matter in the rumen and abomasum in cattle and other ruminants. In ruminants, the abomasum is the fourth compartment in the stomach, with a distinct digestive function. Other animals such as horses with a single stomach compartment may show different symptoms of ash intoxication/accumulation, starting with the filing and erosion of their teeth.

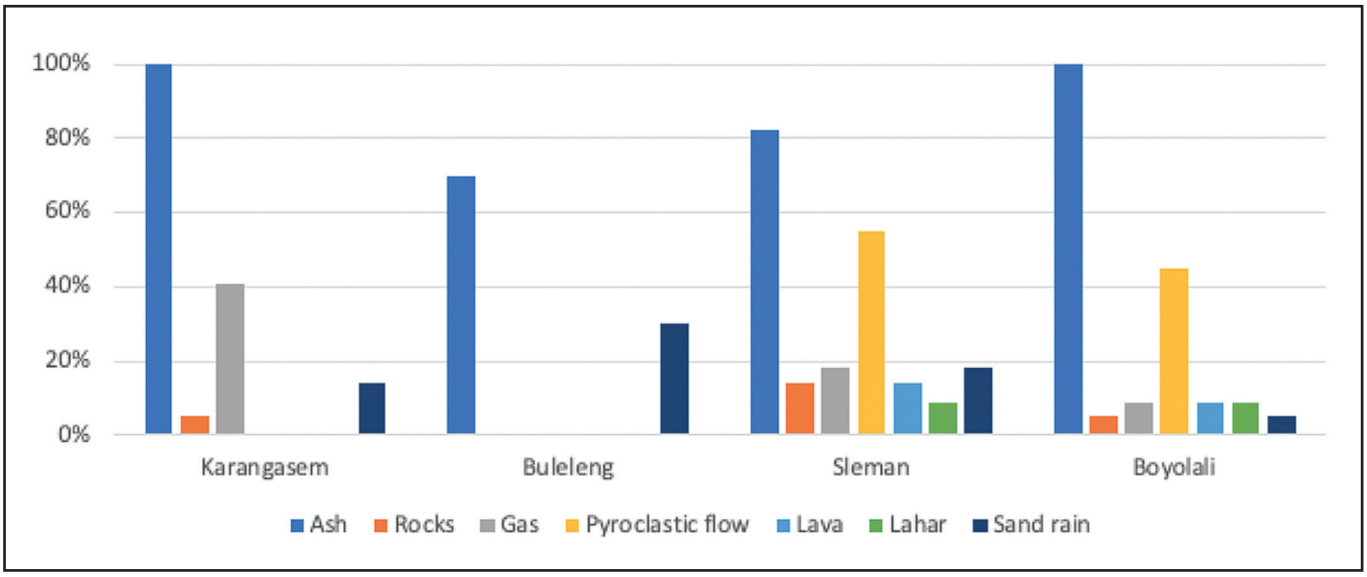
In the dairy sector, the long-term impact of ashfalls translates into economic losses due to reduced milk production, as observed in the 1995–1996 eruption of Mt. Ruapehu in New Zealand. In beef and mutton production, calf and lamb survival rates were greatly reduced due to poor weight gain, while wool came down in quality until it was eventually rejected by the local markets (Cronin *et al.*, 2003). These production losses can be devastating for smallholder farmers who depend on animals. See Figure 5 for volcanic hazards faced by farmers and their impact.

Impact on the community: During volcano eruptions, people living near the crater suffer significant levels of stress. During volcanic activity, living under the constant threat of eruption takes a heavy toll on their individual and collective state of mind.

In the last decade, however, communities living near volcanoes have been preparing and training in emergency response and disaster risk reduction (DRR), led by civil defence and the national chapters of the Red Cross, so much so that the concepts of preparedness, mitigation, risk reduction, and orderly evacuation are not as alien to them as they were two decades ago. Figure 3 shows local communities preparing a map of their area, following training in DRR. Therefore, in theory, integrating a livestock component in risk maps and as a livelihood priority into preparedness, emergency response, and risk reduction processes should not need to start from scratch in many countries anymore.

Animal deaths during mild volcanic eruptions should not be initially attributed to the effects of poisoning, starvation, or physical trauma due to the volcanic activity and/or the chemicals present in volcanic gases, ash, or pyroclastic flows, and thus carcasses for disposal

Figure 5: Volcanic hazards experienced by farmers. Merapi Volcano, Indonesia (FAO, 2021a).



should be treated as they usually are during normal operating times.

Geographical impacts: Ash and pyroclastic flows can significantly clog and contaminate stream and river flows in different ways, while heavy ashfalls can sterilize the soil. Pyroclastic flows and lava can kill people and animals as they move down the slope of the volcano. High up in the air, prevalent winds may naturally change direction from season to season, carrying the plume of gas and fine materials to unsuspecting areas, sometimes far away from the volcano's crater.

This is a significant factor, as livestock owners living tens or even hundreds of kilometres away from the volcano may find themselves affected by the unexpected arrival of the plume carried by high altitude winds prevalent in the season that deposit enormous amounts of material. New Zealand farmers situated 90km away from the vent lost thousands of ewes and lambs nine days after the animals consumed ash 1–3mm thick. The ash contaminated pastures with fluorine during the 1995–96 Ruapehu volcanic eruptions (Cronin *et al*., 2003).

Around the crater, however, ash and acid rain will be a common occurrence when the winds are still, corroding metal structures and roofs, and contaminating water sources and pastures.

Market impact: Intermediaries and markets will start worrying about and objecting to the possible contamination of dairy products with acid rain. This concern will translate into reduced prices and can lead to a sudden halt in sales or even in the opportunities for selling livestock. Eventually, livestock start getting sicker due to ash contamination of their respiratory and digestive systems or start to die from starvation from refusing to eat contaminated pastures or from being too unwell to eat. The market value of those animals' products will fall abruptly, and their value for meat will shrink by the day. This occurrence is especially evident in dairy cattle and sheep.

Farm impact: The first concern for any livestock kept indoors all the time or for extended periods is that the gas and the ash can enter and affect these animals through open-sided sheds. Plastic sheeting has been successfully used to passively prevent these volcanic materials from being carried in by the winds.

The second concern is the accumulation of ash on the roofs of shelters. Once the amount of volcanic material reaches a significant thickness, when mixed with the rain it can turn into a heavy concrete-like tombstone, likely to crush the structure and the animals below. The solution, of course, is for caretakers to periodically sweep or wash the roofs to prevent the accumulation of material.

Being conductive, volcanic ash mixed with night mist or rain will customarily deposit onto electric grids and provoke short circuits and power blackouts by accumulating in the transmission lines, insulation (flashovers) connectors, junctures, transformers, and connection meters at farm level. Even portable farm generators may suffer a similar fate if not carefully stored under a roof with filtered ventilation.

The outcome may be lengthy, sometimes catastrophic electricity failures that lead to problems with most electric-powered equipment such as water pumps, refrigeration equipment, lights, and even communications. Landlines and cellular phones may be seriously hampered during ashfall, as the ash interferes with antennas and microwave signals. Due to the abrasiveness of volcanic ash and the acids it carries, clogging and corrosion are greatly accelerated in vehicles, farm equipment, air conditioning units, and metallic roofs, devaluing the net worth and usability of the assets.

Access: During the rainy season, heavier volcanic ash accumulation in the soil near streams and small rivers may end up producing *lahars*, significantly affecting or even blocking access roads; clogging and overflowing bridges; and burying low-lying roads, thus jeopardizing access to and from farms and communities.

Point of no return: In the prolonged 'game' of attrition an extended volcanic eruption may become, communities and livestock keepers need to work together and agree during the assessment and planning states on the 'point of no return', which is the point in time when economic gains versus losses of trying to adapt to the new challenges no longer make economic sense. Communities will need to determine that it is time to sell and move on and away from the volcano.

To help identify the precise trigger moment or moments in time when decisions need to be executed

for animal and human (in that order) evacuation, the recommendation is to accompany or to gently coach the community and the stakeholders in the identification of the painful moment(s) when they will have to invest considerable efforts and funds in moving their animals away to safer grounds (or even sell them) while leaving their homes and farms behind.

This trigger should be identifiable as the moment when financial and physical efforts that are in place will likely fail, and lives (both human and animal) will be put in significant danger. For practical purposes, identifying the outside limits of this scenario may be easier, so the intellectual exercise of going backward in time from the rather catastrophic point when human and animal health may be compromised and evacuation will no longer be an alternative may help in the process of making the difficult decision to leave.

This decision is not an easy one to make, as it should include safely evacuating animals from point A (vulnerable) to B (safer). Animal evacuation should be done earlier than the human evacuation. For the sake of easier logistics and safer operations, several countries have adopted the practice of organizing urban community evacuations and allowing people to evacuate with 1–2 pet animals at the same time. When deciding on this point, different scenarios may need to be assessed, such as in the case of eruptions where people evacuate without their animals, under the assumption that they can come back soon. The eruption may worsen, not allowing for their return. As volcanic eruptions are very volatile, and often unpredictable phenomena, provisions need to be made when leaving behind livestock and domestic animals to make water available for a few days and then to allow them to fend for themselves and survive longer periods. An example of this is the case of domestic dogs. When they start starving, their survival instincts turn them feral. They form packs and start to prey on small livestock.

4.1.2 The response

The initial assessment phase needs to happen quickly, ideally applying the LEGS Core Standards (Participation, Preparedness, Competencies, Initial Assessment, Technical Analysis, Monitoring and Evaluation, Policy and Advocacy, and Coordination) as well as the four protection principles described in the Sphere Handbook and discussed elsewhere. The order of execution for specific LEGS interventions will therefore be dictated by the intensity and nature of the eruption.

The PRIM should be developed by emergency workers with local and strategic stakeholders, including farmers and community representatives, ensuring that vulnerable sections of the community are fully represented. Table 3 is an example of a PRIM for a mild volcanic eruption.

An essential prerequisite for developing the PRIM is that it be led by someone who is experienced in disaster management, the terrain, the volcano, and the local farming and production systems. Local knowledge is also imperative, while the technical side may be provided by a local government or agency worker or visiting NGO personnel. The PRIM leader/facilitator needs to be both trained in and willing to use the LEGS approach in livestock emergencies so they can contact community leaders to visit farms or meet with livestock owners at the start of the process.

Table 3: Example of a PRIM for low-to-mild volcanic eruptions

Technical interventions	**Livelihood objectives**			**Emergency phases**		
	Immediate benefits	**Protect assets**	**Rebuild assets**	**Immediate aftermath**	**Early recovery**	**Recovery**
Vet support	***	***	***	→	→	
Feed	*****	*****	*****	→	→	
Water	*****	*****	*****	→	→	
Shelter	*****	*****	*****	→	→	
Destocking	n/a	n/a	n/a	n/a	n/a	n/a
Provision of livestock	n/a	n/a	n/a	n/a	n/a	n/a

Then comes the advocacy task of inviting and involving external stakeholders such as ministry officials, bankers, and insurers to be involved. This level of stakeholder involvement is crucial for the longer-term, financially significant planning and reconstruction stage needed in any volcano intervention, to re-build farms, houses, and shelters with sturdier roofs that are more resilient to acid rain and ash falls.

The order of application and priority during slow eruptions is:

- **Ensuring feed supplies (Chapter 6 of the LEGS Handbook)**

This kind of intervention will start with existing pastures, which during mild ashfalls start to get contaminated with ash and acid rain. In the absence of sustained rains, the solution is to clean the ash mechanically from the pasture leaves with leaf blowers. This activity is likely to fall under the remit of civil defence system, government, and emergency responders since most livestock owners and communities are unlikely to have access to this equipment.

When pasture contamination is unavoidable, hay will need to be purchased elsewhere and transported in, stored under a roof, and provided to the animals also under roofed areas to protect them from wind-carried ash. During these periods, animals' ears, eyes, and muzzles should be inspected and rinsed to remove any ash before feeding time.

- **Provision of water (Chapter 7 of the LEGS Handbook)**

Water springs, canals, troughs, water holes, and open reservoirs may easily get contaminated by ash and acid rain acidification, increasing turbidity and ionic concentrations, and decreasing pH levels. Hence there is a need to keep drinking water sources covered and protected from ash and acid rain when possible. The bigger particles of silica in the ash may precipitate to the bottom due to gravity, but the rest will stay in suspension longer and start blocking the gastrointestinal system, while the chemical components will harm and poison the animals.

Underground water sources are of much help, as they should be relatively free of surface contamination. The covering of quality water sources is to be prioritized over water trucking for cost reasons. The supply of good-quality water remains a priority to sustain the health of livestock animals.

- **Veterinary support (Chapter 5 of the LEGS Handbook)**

Veterinary care should begin with making sure drinking water and fodder are free of ash, followed by inspection and topical treatments of irritations in the nostrils, mouth, ears, and eyes of animals exposed to ash and acid rain, and the cleaning of their hair/coats.

Veterinary support offered by animal health workers and veterinarians working with civil defence during volcano eruptions is key to the long-term survival of the stock, most importantly in evaluating options and offering technical advice on decisions to be made (evacuations and transport permits and interplay with the local government). When access to farm animals and farms becomes difficult because of *lahars,* ash, and rain on access roads, official veterinarians need to maintain close communication with the farmers to guide them and monitor animal health, prophylactic measures, and treatments.

Where possible, LEGS advocates for the use of local animal health service providers on a payment-for-services basis if appropriate. Cash and voucher schemes should also be considered for the most vulnerable sectors of the community. These approaches avoid competing with and undermining local services and support their long-term ability to deliver essential services.

- **Livestock shelter and settlements (Chapter 8 of the LEGS Handbook)**

Taking shelter from the ash may be the best initial prophylactic action farmers can take. Veterinarians may advise on the initial treatments for animals affected. Gates and windows must be kept shut, and particularly the roofs of these shelters must be checked and swept regularly, to avoid wet ash accumulating and causing roofs to collapse on the animals.

In the cases where the provision of naturally occurring water and pastures becomes unsustainable due to continued acid rain and ashfall, a solidarity scheme called *'sister villages'*, which entails using relatively nearby villages as alternative evacuation sites away from the eruption danger and the prevalent direction of the

winds carrying the plume of ash, has proved successful on at least two continents. Under this approach, it is paramount that animals be carefully screened, certified by veterinarians, tagged, and documented before arrival at the alternative hosting locations, to avoid the risk of both disease outbreaks initially and future disagreements and arguments about 'who owns the fattest animals' at the end of the emergency.

As time goes on, outstanding expenses and bills for pastures, veterinary care, minerals, etc. may be covered/paid in kind in a 'barter economy' way, by exchanging individual animals for the services rendered and/or pastures used. The hosting sister villages need to be examined *ex-ante* to guarantee access, document possible endemic diseases, and assess water availability, the carrying capacity of pastures, and other logistical considerations, to avoid turning one emergency into two.

- **Destocking (Chapter 4 of the LEGS Handbook)**

Destocking may be required to allow a nucleus herd, flock, or group of farm animals to be maintained and eventually rebuilt after the eruption. During light volcanic eruptions, local animal owners may not welcome this initiative, as the feelings of distrust and uncertainty about the likelihood of initial, vague official offers of support may seem tenuous or unworthy of trust.

4.2 Intense, strong eruptions of ash, gases, and pyroclastic flows

4.2.1 The impact

In this grim scenario, explosive eruptions, pyroclastic flows, toxic gases, and the amount of ash overwhelm every facility, structure, ecosystem, all living beings, and every adaptation effort, to the point that visibility on the ground is very poor and it is hard or even dangerous to breathe without gas masks. On many such dramatic occasions, entire communities have been evacuated in a rush, forced to leave everything behind due to the elevated threat level, including their animals. Nothing can be done, other than attempting risky rescue missions in the short sporadic volcanic activity windows.

Impact on animal health and production: During the onset of events of this magnitude in the towns of Chaitén in Chile or Plymouth on the Caribbean island of Montserrat for instance, the plumes near the crater were extremely hot and dangerous. When suspended in the air, weather conditions and convection streams could suddenly drop these plumes within a window of a few minutes, with hot gases and ash threatening to suffocate and boil alive all living organisms beneath them.

Communications are often impossible in this scenario, and pyroclastic flows threaten farms and animals directly or by clogging streams and waterways, and ways of access, up to the point of making roads and small bridges impassable. Other than pre-emptive evacuation, there is very little anyone can do to protect or salvage farms, animals, and equipment from pyroclastic flows, given the high volume of materials, temperatures, and the toxic materials these flows carry at considerable avalanche-like speeds.

If this kind of volcanic event hasn't obliterated everything immediately, surviving livestock left in high grounds – especially small, young, and old livestock – may start falling prey to respiratory diseases or to packs of hungry dogs left behind that have gone feral. The best option that World Animal Protection (WAP) utilized to reduce the threat of feral dogs with the communities of Turrialba volcano in Costa Rica was to include pre-emptive treatment and sterilization pushes for domestic pets as a risk reduction measure. Before the eruption, WAP worked to reduce their numbers, improve their health, and increase the animal-owner bond (Gerardo Huertas, personal communication).

In most volcanic eruptions during heavy ashfalls and eruptions, carcass disposal should not be an issue, as most carcasses get buried under the ash and eventually dry out. Vegetation withers and dies, covered and asphyxiated under thick layers of ash that can eventually become a cement layer of up to several metres when mixed with sporadic rains. This process sterilizes the soil and cuts the oxygen off, like a newly paved road would.

Farm animals will soon weaken, starve, and die if not kept and fed indoors. In the cases where the danger is posed by *lahars*, heavy ashfalls, and acid rain, the sheltering of animals is a temporary yet vital step; windows should be kept shut and drinking water and

fodder covered. In the past, the sides of sheds and even roofs made from plastic sheets have been successfully used to keep the animals away from the ash.

Access: Heavily affected areas will soon be left without access, power, and drinking water. These areas will be declared off-limits by civil defence, including the air space above in the case of planes, helicopters, and surveying drones, given the degree of danger volcanic eruptions present to engines and to rescue personnel and to anyone attempting to salvage assets, no matter how many agricultural assets may have been left behind.

Near the crater, there is always more danger from pyroclastic flows and lava running fast down the slopes. The walls of the crater may grow too high and too thin and eventually collapse in. Explosive eruptions or large avalanches will drop tons of deadly hot materials and gases downhill. That is when everything – people and animals – caught by these flows will be burned, dehydrated, and left petrified on the spot.

4.2.2 The response

The same considerations regarding the application of LEGS Core Standards, cross-cutting themes, and the PRIM covered under Section 3 apply to this context. However, when possible, the time frame should be shortened to allow as many animals as possible to be saved. The PRIM below in Table 4 focuses on both pre-evacuation needs (blue arrows) and post-evacuation needs (green arrows).

Veterinary support to allow livestock to live with the ash is important, but during a violent eruption evacuating may be crucial. At this point, fodder is not crucial at the affected location, as livestock will need to be moved out of there as quickly as possible. Fodder will be needed at the destination. Clean sources of water at the affected location, during transport, and more importantly, upon arrival are of course vital to their survival. Destocking and the subsequent provision of livestock should aim at closing the cycle of the emergency while fully protecting the livelihoods of the livestock owners.

Specific LEGS interventions during intense, strong eruptions

The order of application and priority during strong eruptions is:

- **Ensuring feed supplies (Chapter 6 of the LEGS Handbook)**

When pasture contamination is unavoidable and fields are covered and buried in thick ash, hay will need to be purchased elsewhere, trucked in, stored under a roof, and provided to the animals under roofed areas that are covered on the sides to protect them from wind-carried ash. During these periods, animals' ears, eyes, and muzzles should be periodically inspected and rinsed to remove any ash before feeding time. This period should be a short-lived one, however, as people and animals should be evacuated.

In the hilly terrains around volcanoes with narrow, steep roads and muddy corners, and especially during the rainy season, access for trucks transporting hay and fodder will get very difficult and dangerous as the eruption evolves, and visibility will be severely reduced. Together with the costs, these factors need to be assessed by emergency responders and livestock owners against the benefits of a dwindling business and an endangered livelihood.

Table 4: Example of a PRIM for violent volcanic eruptions

Technical interventions	Livelihood objectives			Emergency phases		
	Immediate benefits	Protect assets	Rebuild assets	Immediate aftermath	Early recovery	Recovery
Vet support	***	***	***	→	→	→
Feed	*	*	*	→	→	
Water	***	***	***	→	→	
Shelter	****	****	*		→	
Destocking	*****	*****	*****	→		
Provision of livestock	n/a	*****	*****			→

- **Provision of water (Chapter 7 of the LEGS Handbook)**

Local water sources will by now be severely contaminated by ash and acid rain unless pumped from the underground. If underground water is not an option, drinking water will also need to be trucked in and kept covered. The supply of good-quality water remains a priority to sustain the health of livestock from ash.

- **Veterinary support (Chapter 5 of the LEGS Handbook)**

Veterinary care should continue, making sure drinking water and fodder are free of ash, followed by topical treatments for treating ash-related lesions. Chronic conditions will play an important part here, with decisions to be made about animal euthanasia for the worse cases. The same guidance for veterinary support in mild eruptions also applies here.

Access to farms and livestock will become difficult because of the ash and rain on access roads, so official veterinarians will need to have put in place effective systems for close and constant communication with the farmers in order to guide them and monitor animal health and treatments, as well as to outline the preparatory steps for evacuation.

Veterinary health certificates for transport where appropriate, field supervision of the transport, unloading, monitoring the health of animals on arrival after evacuation, sorting of evacuated animals, and handling the eventual cases of euthanasia that may arise will be the priority order here.

Livestock evacuations and movements to safe areas during eruptions must avoid the risk of carrying animal diseases, including zoonotic ones. Ministry of agriculture representatives and official veterinarians should carry out transport approval protocols and when possible, even accompany the movement of animals, including close examination and *ex-ante* vaccination schemes and livestock health check-ups.

- **Livestock shelter and settlements (Chapter 8 of the LEGS Handbook)**

In this instance, and in addition to keeping the animals under roofed shelters, new destination shelters away from the volcano danger will form part of the preparatory work veterinarians will need to help with when preparing for the evacuation of animals.

Temporary shelters and corrals for evacuated animals need to be designed to host different groups of animals that cannot be corralled together. Security and biosecurity measures in the case of evacuation shelters for livestock merit another technical paper, but they should fall under the responsibility of government veterinary officers, with animal owners serving in supporting roles (cleaning, feeding, monitoring).

- **Destocking (Chapter 4 of the LEGS Handbook)**

During strong volcano eruptions, local animal owners may welcome this initiative, as they may have no other option and especially if destocking is closely tied to any restocking plans. Destocking may be the next best option to avoid large animal production losses in the short- to mid-term future. The steady impact of fluorine exposure may reduce productivity or even threaten the lives of the animals if their condition becomes chronic. The volcano may have affected wide areas of pastures, making significant numbers of livestock impossible to maintain. Veterinary health certificates to allow transport and travel while preventing the spread of endemic pathogens will need to be handled by the animal health service officials at the ministry of agriculture or the relevant ministry.

Ideally, when the decision comes to destock and sell animals, selling them to nearby communities unaffected by the eruption is the first option, followed by selling to middlemen, and finally selling to the nearest slaughter plants. Sadly, and in *'real'* life, selling animals as stock or for humane slaughter may be unavoidable once the point of no return has passed and the animals have spent a while under the ash, making them lose weight or become ill. Humane slaughter may be the only solution available for sick animals that cannot travel.

Selling livestock for their meat and/or at meagre prices and thus drastically changing the livelihoods of their owners and caretakers during volcano eruptions will be much easier if backed by specific government disaster funding that supports the restocking and uprooting of the owners to alternative lands when the emergency ends. That moment may take months to come, while the recovery of pastures and ecosystems may take years.

At every stage of this phase, the LEGS decision making tree is vital to help identify the best possible destiny or

price for the animals to be destocked (trade, commercial sale, slaughter), based on several factors, always with the subsistence of their owners in mind. Since scientists cannot predict when a volcano eruption is going to end, delayed decision making on the sale of livestock may result in economic losses due to the costs incurred by livestock owners in keeping their livestock and keeping production losses at bay. Deteriorating body conditions in livestock may result in animals obtaining low market prices, especially for sick, discarded dairy cattle that never do well in the beef cattle market.

The destination may be the sale of the animals to other livestock owners located in unaffected areas, to local traders (middlemen), or directly to nearby slaughterhouses, depending on the alternatives available and the cost/benefit analysis. If local abattoirs are available in the area to begin with, access to them may be limited or their functioning may be constrained by existing conditions during the eruption, so nearby alternatives need to be identified by local authorities that will allow meat to be produced free from contamination by the eruption. In the case of island states where food supply chains may depend on these facilities, emergency abattoirs may need to be considered/installed in areas safe from the eruption, to keep food security intact and working.

Destinations during animal transport should be as close as it is safe and practically possible, to avoid health and animal welfare issues. For longer hauls, those creating transport regulations for numbers, segregation, rest, and other considerations should seek expert guidance and refer to transport guidelines provided in *Livestock-Related Interventions during Emergencies* (FAO, 2016). Figure 6 shows livestock transport conditions that compromise animal welfare. In the first photo, the cow's

Figure 6: Poor livestock transport conditions, Cape Verde. Photo credit: G. Huertas

movement is too restricted, and in the second photo, the animals are not shaded from the sun.

Alternative access paths and roads for animal evacuation should be identified *ex-ante*. The evacuations may be either by foot or by truck. A detailed inventory of logistical needs will also be important at this point.

Animal evacuation by truck (for destocking or relocation)

Be it sponsored by the livestock owners and associated livestock stakeholders or by government agencies, animal evacuation needs to factor in access to the farms, as evacuation routes need to be cleared and maintained, with special attention to the historical paths of pyroclastic flows and possible secondary flows that may block bridges and ways of access.

Securing enough trucks to transport the animals is paramount, as is identifying alternative destinations with sufficient fodder and water supplies. Trucks need to have safety measures in place as a priority to ensure the bio-safety measures needed to keep different groups of animals segregated and to deal with large and potentially aggressive animals such as some dairy bulls. For instance, safety measures include bedding material in the trucks used to avoid animal injuries and deaths during transit, as well as water and feed and rest/check stops in the case of long hauls. In addition to the above logistical considerations at the farm level, there is a need to consider the availability of loading ramps that may accommodate trucks of different sizes and heights.

Animal evacuation on foot (for destocking or relocation)

In pastoral communities, on-foot evacuations may be done by leading livestock and equines to safer areas away from the places affected by volcanic eruptions. Safe passage may have been previously identified and granted by landowners. Fences may have been cleared and other obstacles removed. This procedure is to be executed before human evacuations. Evacuation on foot is not possible for pigs or birds. They will require transport.

Where no other alternative is available, animals should be brought out by foot to accessible areas to allow humane and safe evacuations, as truck drivers may be unable or reluctant to risk their vehicles getting stuck in the mud or getting caught behind impassable bridges

Figure 7: Evacuation of cattle, Costa Rica. Photo credit: G. Huertas

affected by secondary flows. Alternatively, truckers may end up hiking transport prices to untenable levels. Bringing animals out by foot to accessible areas permits low-stress movement of animals to the loading ramps, where transport trucks will be safely waiting. The approach also keeps roads close to the hazard zone decongested in case of rapid human evacuation needs.

- **Provision of livestock (Chapter 9 of the LEGS Handbook)**

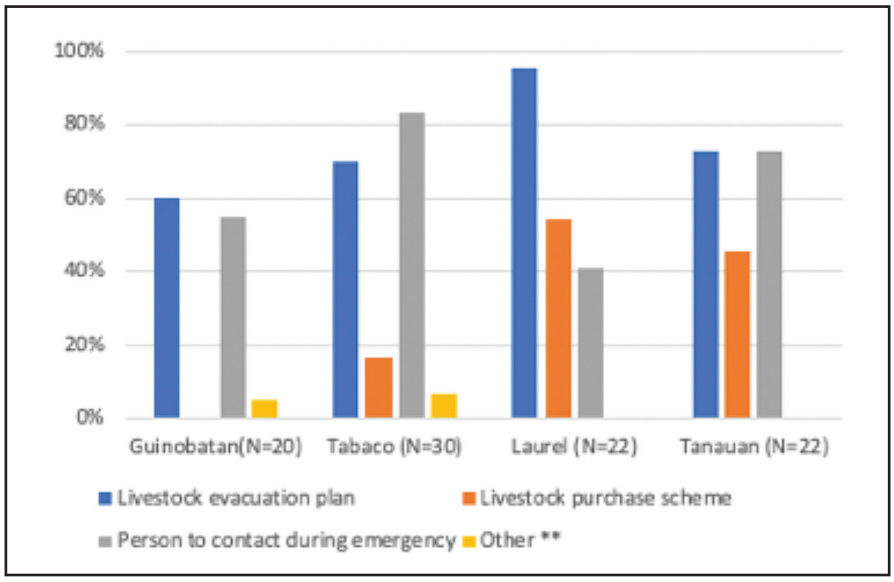
In the best-case scenario, the replacement of animals may occur when and if the eruption has stopped and pastures recovered, but that usually takes months or even years to happen. Planning for recovery needs to keep in mind that volcanic inactivity only means a state of dormancy that may last years, decades, or even centuries (Coto-Cedeño, 2019).

During the recovery phase and once the volcano is dormant again and pastures may have recovered, the provision of livestock, also referred to as restocking in some contexts, is recommended for smallholder farmers and livestock owners who depend on their livestock as their main livelihood source and as their traditional income source. Their culture may be intrinsically rooted in livestock, and people who sell their animals during destocking will need to be supported to restock. NGOs and government can use this phase as part of rebuilding the community's livelihoods and building back better by improving resilience to future eruptions at farm and community level.

The FAO's Philippines case study showed that in the early phases – preparedness and/or early mild eruption – farmers prioritized animal evacuation over destocking and subsequent eventual restocking in the preparedness phase (see Figure 8). However, during the later recovery phase, the charts show opposite results, and the farmers' perceptions in the early recovery phase changed with the change of events in the later phases, thus favouring purchase schemes over animal evacuation.

If it is eventually possible to bring back livestock to pasture lands that may have been affected by volcanic activity and that have returned to apparent normality once the volcanic activity has receded, detailed field assessments need to be carried out before bringing the animals back to make sure conditions are indeed safe for keeping and rearing livestock with an optimal degree of animal welfare and health.

Figure 8: Farmers' ranking of early preparedness actions, the Philippines (FAO, 2021b).



Case Study 2: Recovery from the impact of Irazú volcano eruption, Costa Rica

In Costa Rica after the Irazú volcano eruptions in 1963–65, the dairy industry was forced to move elsewhere, including to the tropical northern plains. It took dairy farmers nearly two decades to adapt their herds to the warmer climate and the increase in ectoparasites. Government-owned banks offered soft loans to replace the herd and to purchase seeds for better pastures. Eventually, once vegetation came back and the soils were fertile again, new agriculture and dairy farmers claimed back the Irazú slopes.

Source: Coto-Cedeño, 2019.

An example of potential hidden risks would be the checking of water rivers and streams to their sources, as the accumulation of volcanic materials may unleash flash flooding or mud floods at later stages that may in turn impact access roads, bridges, and structures during the rainy season. A more specific consideration in the case of the provision of new animals in the recovery phase is an assessment of endemic diseases versus the vaccination status of the new stock to prevent disease outbreaks.

As is usually the case, procuring new animals from nearby farms that are used to similar climates and pathogens is the recommended course of action to increase adaptation odds and reduce the risk of endemic diseases decimating the newly arrived animals. For prolonged or periodic eruptions, and in an ideal scenario, restocking would work best when done away from the volcano, in newly procured lands and pastures.

Although restocking in new lands is ideal, the significant financial resources needed to 'transplant' entire communities, farmers, infrastructure, access roads, and their animals to good lands away from volcanic danger and at roughly the same altitude, with good pastures with access to water, access to markets, schools, etc. requires huge investments and full government backing, without which this possibility is out of the question. Case Study 2 provides an example of relocation of dairy farms and the challenges faced by farmers.

These ideal instances have seldom been seen on the three continents where volcano eruption operations were implemented. The more pragmatic and predominant tendency has been to stay in place during volcanic periods of dormancy, hoping for these periods to be long-lived ones. There has been planning for the provision of livestock and when possible, the reduction of the possibility of future ash falls and acid rain contaminating water sources, pastures, and the animals by storing and keeping hay in siloes, covering water ponds, using plastic sheets on the sides of sheds, and building covered areas for animals to shelter under during acid rain or ash falls.

In short, successful *in-situ* restocking may be achieved during dormant volcanic phases when the volcano eruptions cease, vegetation recovers, and livelihoods resilience is increased for the survival of the newly procured animals. Farm and smallholder infrastructure needs to be restored and adapted to be able to withstand the next acid rain and ash falls, this time with composite plastics and building materials resistant to corrosion and future volcanic activity. This infrastructure includes corrals, chutes, and shelters. Maintaining and cleaning bridges against future mudslides and organizing community-level desk or field simulations once a year are also important. Community simulations (drills) are best practices for keeping people and systems up to date physically and practically. Desk simulations are also viable and cost-effective. When involving communities and stakeholders, they may be the best tool available, so much so that online simulations have been successfully put into practice during the COVID-19 pandemic. In the case studies in the Philippines and Indonesia (FAO, 2021a and 2021b), livestock was not included in previous field drills.

Figure 9: Livestock keeper cleaning fodder, mountains of Merapi, Central Java, Indonesia. Photo credit: iStock, smartseck

5.0 Logistical elements of the response

Logistical considerations and checklists are vital resources when time is of the essence, but they seldom are made available to farmers, official veterinarians, and civil defence authorities in charge in the theatre of operations during an eruption. They should ideally be considered and put together during 'peace times' when the volcano is dormant. A primary list to keep handy and use in the early planning stages of the work with stakeholders near volcanoes includes:

- Animal inventories, geo-referencing, and identification (if appropriate);
- Logistical needs examples: veterinary health certificates, goggles, and dust masks for handlers, humane handling equipment, trained handlers, ramps, transport, evacuation routes, stakeholder coordination for transport and alternative pastures, provision of water and fodder;
- Early warning and early coordination with civil defence (community-owned);
- Transport trucks, loading ramps, bedding;
- Provision of water and rest during transport and fodder on arrival;
- Status report of the state of roads and bridges;
- Alternative destinations (similar pastures, holding facilities, and shelters);
- Data on weather, season, and prevalent wind direction;
- Baseline production levels and market price stability (for eggs, milk, cheese, wool, meat);
- Coordination with animal health services, police, the Red Cross, road police, local and national governments, and private sector on policies and emergency funds, donors, and humanitarian/ development agencies;
- Checklists of equipment, skilled volunteers, keys to gate locks, important contact numbers, animal identification, and vaccination documents.

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Tungurahua volcano, Ecuador. Photo credit: iStock, xeni4ka

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