



Feed the Future Innovation Lab for Livestock Systems

Nepal:

Livestock Disease Management and Food Safety Brief

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1. Introduction

Nepal has an agrarian economy. The agriculture sector provides employment opportunities to 66% of the economically active population, and contributes about 34.7% to the national gross domestic product (GDP) (MoAD, 2012). The livestock subsector contributes about 14% of national GDP and 32% of agricultural GDP (AGDP) (MoAD, 2012). Nepal's livestock numbers are estimated to be 7.27 million cattle, 5.24 million buffaloes, 9.7 million goats, 0.8 million sheep, 50 million poultry, and 0.37 million ducks (MoAD, 2012). According to the Ministry of Agriculture and Development (MoAD, 2012), 87% of the country's 27 million people keep some form of livestock at home; with 5.8 heads of livestock and poultry per household, Nepal has one of the highest ratios of livestock to humans in Asia (FAO, 2005).

Despite the enormous potential of the livestock subsector to flourish in the country, growth has recently been declining. The Agriculture Development Strategy (ADS, 2014) has identified the core reason for the decline as low productivity of animals, mainly due to poor husbandry practices by farmers, the genetic inferiority of local breeds, and the poor condition of animal health.

As a realization of the importance of the livestock subsector, the Government of Nepal (GoN) has formed a separate Ministry of Livestock and Poultry Development (MLPD) in December 2015 to prioritize the activities of livestock subsector. Under the MLPD, the Department of Livestock Services (DLS) is responsible for promotion, administration, and coordination of the livestock activities throughout the country. DLS executes its plans and programs through four directorates: Directorate of Animal Health, Directorate of Livestock Production, Directorate of Livestock Market Promotion, and Directorate of Livestock Training and Extension; through five Regional Directorates; and through 75 District Livestock Services offices (DLSOs), which include 359 livestock service centers and 640 livestock subservices at each sub-district level (DLS, 2016).

2. Priority Diseases in Cattle

Major animal diseases—by species, trends, factors that influence prevalence, and impact on local and regional markets—are as follows:

Foot and Mouth Disease (FMD)

Foot and Mouth Disease (FMD) is endemic in Nepal since time immemorial and often results in heavy economic losses for farmers and communities. The laboratory diagnosis and serotyping of the FMD virus in Nepal was started with the establishment of National Epidemiological Laboratory for FMD in 1983 (DoAH, 2014). There are seven immunologically distinct serotypes of FMD virus, among which O, A, C, and Asia-1 have been reported in Nepal (Ferris et al. 1999). The compilation of 43 years of laboratory findings (1965-2009) on the diagnosis of FMD has shown that O is the most predominant serotype (74.5%), followed by Asia-1 (17.6%), A (6.6%), and C (1.3%) (DoAH, 2014). Studies on FMD virus serotypes from 2001 to 2010 revealed that the prevalence of serotype O an upward trend (+82%), followed by serotype Asia-1 (+15%), and serotype A (+3%) (DoAH, 2014). The results of genetic and antigenic typing of FMD virus isolates from Nepal submitted to the World Reference Laboratory for Foot-and-Mouth Disease (WRLFMD) at the Pirbright Institute, Pirbright, UK, revealed that serotype O isolates from Nepal belong to the Middle East-South Asia (ME-SA) topo type (Ferris et al. 1992). Serotyping of FMD virus has been done in 65 of the 75 districts in Nepal (DoAH, 2014).

Species-wise distribution of FMD outbreaks from 2000 to 2009 was highest in cattle (42%), followed by buffalo (32%), goats (19%), sheep (4%), and swine (3%) (DoAH, 2014). A look at the eco-zone distribution of FMD outbreaks revealed that the mid Hills region and the southern Terai are the areas most stressed by FMD. Out of an average 873 FMD outbreaks per year, the Hills region has the highest FMD outbreaks (45%), followed by the Terai (35%), and the Mountains region (20%) (DoAH, 2014).

The reasons for higher outbreaks of FMD in the Hills may be a higher density of animals, greater movement of animals for agricultural activities, and frequent use of common grazing and watering places. In Terai, the occurrence of FMD outbreaks is clearly associated with animal movement patterns along established trading routes across the open border with India.

Spatial distribution of FMD during 2000 to 2009 revealed that 74 of 75 districts are affected with FMD. Similarly, seasonal distribution of FMD showed that it occurred throughout the year; however, the peak levels of occurrence have been reported during April/May/June and September/October/November (DoAH, 2014).

Nepal's Directorate of Animal Health's (DoAH's) Veterinary Epidemiology Center has analyzed monthly epidemiological reports from 2000 to 2009 from 75 districts and has ranked FMD as the number one major infectious and invasive disease in Nepal. The national strategy for FMD control and eradication is to establish treatment zones based on levels of disease endemicity (DoAH, 2014). In addition, the government is undertaking a mass phased vaccination campaign in high endemic zones (Terai and Kathmandu Valley regions), strategic vaccination and animal movement control in medium endemic zones (mid Hills region), and animal movement control in low endemic zones (high Mountains region).

From 2001 to 2007, a total of 7,640 outbreaks, with an average of 1,092 outbreaks per year, were reported in the country (Table 1). This shows that FMD is a highly endemic disease in Nepal, causing substantial economic loss to the livestock industry.

Table 1. Outbreaks of Foot and Mouth Disease in Nepal (2001-2007)

Disease Year	No. of outbreaks	No. of cases	No. of deaths	Case fatality %
2001	1,904	51,003	861	1.7
2002	546	7,261	118	1.6
2003	2,078	57,076	1265	2.2
2004	879	19,525	202	1.0
2005	1,042	19,949	461	2.3
2006	710	17,389	105	0.6
2007	481	13,590	145	1.0

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

Mastitis

Mastitis is a disease that causes heavy economic losses in dairy cattle and is one of the most prevalent endemic diseases in Nepal. Mastitis is mainly reported in cattle, buffaloes, and goats in Nepal. Poor farm sanitation and unhygienic milking practices are responsible for the high prevalence of mastitis in Nepal. The prevalence rate of mastitis in buffaloes at the Institute of Agriculture and Animal Sciences (IAAS) Farm is 37.5% and 44% in farms in the vicinity of IAAS (Subedi and Dhakal, 2002). Likewise, the prevalence of subclinical mastitis in cows and buffaloes in the eastern Hills region of Nepal have been found at 18.8% and 21.3%, respectively (Jha et al. 1993). The rate of clinical mastitis was found to be 17.1% in Murrah cross breeds, 8.8% in local breeds, and 8.3% in local cattle in the western Hills region of Nepal (Joshi, Joshi and Shrestha, 1998). In Kathmandu Valley, 17.2% of 186 milk samples were found positive on the California Mastitis Test (CMT), and 81.18% of the milk samples showed high leucocyte counts (Khakural, 1996). Shrestha and Bindari (2012) studied the prevalence of subclinical mastitis (SCM) in cattle of Bhaktapur district (Central region) and found that in 200 samples from 50 dairy cattle, 52% of animals suffered from SCM. The samples that tested

positive on the CMT were cultured in nutrient agar, MacConkey agar, and blood agar. The bacteria isolated were *Staphylococcus* spp. (50%), *Streptococcus* spp. (27%), *Escherichia coli* (10%), *Corynebacterium* spp. (8%), *Salmonella* spp. (4%) and *Enterobacter* spp. (1%).

Bovine Tuberculosis

Bovine tuberculosis is another endemic disease in Nepal, and, in addition to being a threat to livestock, it is a zoonotic disease of public health importance. In Nepal, the overall prevalence of bovine tuberculosis in buffaloes and cattle has been found to be 9.08% and 5.78%, respectively (Joshi, Heidmann and Sollod, 1999). The prevalence of tuberculosis in buffaloes in Chitwan valley was recently recorded at 15.4% (Pandey et al., 2013). A total of 36 mycobacterial strains isolated from 39% of the buffaloes (14 of 36) and 34% of the cattle (11 of 32) were found positive on the single intradermal cervical tuberculin (SICT) test (Jha et al., 2007). Of the 36 strains, 13 were identified as *Mycobacterium bovis*, and these strains were isolated from 17% of the buffaloes (6 of 36) and 16% of the cattle (5 of 32).

Brucellosis

Brucellosis is another endemic disease of public health importance in Nepal. In a recent study conducted by Pandeya et al. (2013), the average seroprevalence of brucellosis was 12% (14 out of 103) in several species of livestock in Kailali district (Far-West Nepal): 13.59% (16/50) of cattle, 13.4% (9/67) of buffaloes, and 2.6% of goats (3/113) were found to be seropositive for brucellosis. From 2003 to 2013, the Central Veterinary Laboratory tested the serum of cattle, buffaloes, and goats suspected for brucellosis through the Rose Bengal Plate Test. Out of 5,057 samples, 75 samples (1.48%) were found to be positive (DoAH, 2014).

In an epidemiological survey among farmers who sold milk to local milk producers cooperatives society (LMPCs) in central Nepal, 70 of 302 single samples (23.17%), 46 of 153 pooled samples (30.06%), and 13 of 45 mixed samples (28.88%) were found milk ring test (MRT) positive for brucellosis (Joshi, 2000). The same study looked at animal brucellosis in and around the Kathmandu Valley: 660 milk samples (pooled) of buffaloes and cows from the private Dairy Development Corporation (DDC) of Kathmandu were tested for brucellosis by Brucella ring test (BRT), with a positive reaction found in 4.69% (31/660) of the pooled samples. Similarly, the study examined 4,229 single milk samples of buffaloes and cows from DDC centers, milk vendors, and villages in Kathmandu Valley and around the Valley (Panchkhal, Bhaktapur, and Banepa), which were 1.25% positive by MRT. Joshi (2000) also collected serum from 53 cows and buffaloes that had aborted in advanced stages of pregnancy, which tested 3.8% (2/53) positive using a Brucella plate agglutination test.

Fascioliasis

Fascioliasis, caused by flatworms *Fasciola hepatica* and *Fasciola gigantica*, is a major, economically important production problem of domestic ruminants in Nepal. The climate and farming practices in Nepal favor the survival of the *Gastropoda* (snail) intermediate hosts necessary for completion of the *Fasciola* life cycle. Rice straw, which is the principal forage of large ruminants during the dry season (December-April), is a primary source of *Fasciola* infection as it contains *Fasciola* metacercariae (cysts). Pre-monsoon and monsoon seasons are the major time for *Fasciola* infestation in Nepal. In a 1987 study of fascioliasis in eastern Hills region of Nepal, the highest prevalence was recorded after the monsoon season when rice straw heavily infested with metacercariae was available for grazing (Morel and Mahato, 1987). In an epizootiological survey of fascioliasis in cattle, buffaloes, and goats in the Mahottari and Dhanusha districts of Nepal (southern Plains region bordering India), the overall prevalence of fascioliasis was 51% in cattle, 86% in buffaloes, and 47% in goats. The mean egg count per gram of feces was 66 in cattle, 118 in buffaloes, and 54 in goats (Yadav et al., 2015). In Nepal, methods to control fascioliasis include strategic application of anthelmintics, strategies for reduction of the number of intermediate host snails through drainage, and reduction of potential infection by practicing efficient farm and grazing management. However, the problem of fascioliasis is still increasing in all parts of Nepal, calling for new intervention strategies to be developed and adopted.

Hemorrhagic Septicemia

Hemorrhagic Septicemia (HS) is an acute, contagious, highly fatal disease of cattle and buffaloes caused by *Pasteurella multocida*. In Nepal, the disease is endemic, and outbreaks have been reported throughout the year in all parts of the country. The disease is more prevalent in the southern Plains region bordering India. Mixed farming, lack of routine vaccination, and live animal trading are the main causes of HS in Nepal. The disease appears annually with the monsoon rains, with the highest occurrence in the summer/rainy season (May-August), followed by the spring season (January-April). The fewest outbreaks are during the winter season (September-December; DoAH, 2014). In Nepal, buffaloes are highly susceptible to HS. The national control strategy for HS in Nepal involves use of the HS+BQ (black quarter) combined vaccine. The DoAH's Central Biological Production Laboratory has been producing HS+BQ combined vaccine since 1999 (DoAH, 2014). At present, the government annually offers free vaccination to all animals throughout the country.

3. Priority Diseases in Small Ruminants

Peste des Petits Ruminants (PPR)

Peste des Petits Ruminants (PPR) was first reported in 1994 in Bara district of the eastern Terai. Today, PPR is endemic in the Terai and the mid Hills region. Frequent outbreaks of PPR are reported in these areas due to unrestricted movement of small ruminants across the border and within the country.

Spatial distribution of PPR during the past 10 years (2000-2010) shows that 63 of 75 districts have recorded outbreaks (DoAH, 2014). The disease frequency is less towards the western parts of the country; however, rampant animal movement, especially during the festivals, has increased threats of disease anywhere. With rapid spread of PPR in Nepal, the government launched the National PPR Control Program in 2002. Since then, the disease outbreaks have started to decline, with frequent sporadic outbreaks in different areas that have been controlled through ring vaccination (DoAH, 2014). Though vaccination coverage for PPR is better than for other diseases, it is still below the expected level and needs to be extended. Nepal was the first country to manufacture the PPR vaccine in Southeast Asia; production by DoAH's Central Biological Production Laboratory began in 2000 (DoAH, 2014). A National PPR control program was launched in 2001, with major interventions of mass vaccination and serosurveillance that have so far provided encouraging results (DoAH, 2014). However, PPR showed an upward trend beginning in 2005, which may be due to the cross-border movements of small ruminants, especially sheep and goats. During spring and early summer, small ruminants (especially sheep and goats) move from Nepal onto the Tibetan Plateau for grazing, and then return to Nepal in the late summer and early winter when the temperature drops. Small ruminants like sheep and goats also are imported from Tibet and India into Nepal around the time of large religious festivals, which take place in September and October.

The current control strategy for PPR diseases in Nepal is vaccination against PPR for all susceptible animals, mass vaccination in high endemic zones, compulsory vaccination of all goats at the border quarantine check-posts, and point vaccination of migratory flocks in strategic locations (DoAH, 2014).

From 2001 to 2007, epizootiology of PPR revealed that there were 2,327 outbreaks of the disease in the country in which 89,537 animals were affected and 28,663 affected animals died (Table 2).

Table 2. Outbreaks of Peste des Petits Ruminants in Nepal (2001-2007)

Disease Year	No. of outbreaks	No. of cases	No. of deaths	Case fatality %
2001	1,037	59,916	23,256	38.8
2002	366	11,580	1,487	12.84
2003	293	4,670	421	9.01
2004	12	210	35	16.66
2005	56	4631	1,458	31.48
2006	243	6798	1,506	22.15
2007	320	1,732	500	28.86

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

Sheep and Goat Pox

Sheep and goat pox is another endemic disease of small ruminants in Nepal. It is the most important of all pox diseases of small ruminants, causing high mortality in kids and lambs. This disease has also been reported as one of the main causes of abortion in pregnant ewes. Sheep and Goat Pox is an economically important disease, as it lowers the quality of wool and leather (DoAH, 2014). It also poses a major obstacle in intensive rearing of goats and greatly hampers international trade. Sheep and goat pox has been reported all over the country, particularly in Terai districts bordering India.

From 2001 to 2007, epizootiology of the disease revealed that there were 151 outbreaks of sheep and goat pox in the country in which 2,723 animals were affected and 113 affected animals died (Table 3).

Table 3. Outbreaks of Sheep and Goat Pox in Nepal (2001-2007)

Disease Year	No. of outbreaks	No. of cases	No. of deaths	Case fatality %
2001	34	1245	81	6.5
2002	12	104	0	0
2003	14	102	1	0.98
2004	12	290	1	0.34
2005	29	604	30	5
2006	46	278	0	0
2007	4	100	0	0

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

4. Priority Diseases in Swine

Classical Swine Fever

Classical Swine Fever (CSF) is endemic in Nepal; however, due to lack of laboratory diagnosis, many outbreaks in the field go unreported, making it difficult to know the actual status of the disease. Based on clinical signs and postmortem findings from 2000 to 2009, 184 outbreaks of CSF were reported (DoAH, 2014). The first laboratory confirmation of CSF in Nepal was made in 2011, when the samples from a suspected outbreak on pig farms located at Makwanpur and Bhaktapur (Central Nepal) were investigated in the National FMD and Transboundary Animal Diseases (TADs)

laboratories (Jha, Karna and Singh, 2012). The test results were confirmed by further testing performed at the European Union (EU) and Office International des Epizooties (OIE) Reference Laboratory for CSF, Hannover, Germany (Jha, Karna and Singh, 2012).

Although CSF vaccine is produced in Nepal, the coverage of vaccination is low and there is no control strategy for infected animal movement. Because there is no routine vaccination against CSF, herd immunity against the disease is very low (DoAH, 2014). From 2001 to 2007, epizootiology of the diseases revealed that there were 135 outbreaks of CSF in the country in which 1,719 animals were affected and died (Table 4).

Table 4. Outbreaks of Classical Swine Fever in Nepal (2001-2007)

Disease Year	No. of outbreaks	No. of cases	No. of deaths	Case fatality %
2001	11	41	21	51
2002	31	70	41	58.6
2003	15	114	58	51
2004	6	70	41	58.6
2005	19	1,085	982	90.5
2006	23	1,111	271	24.3
2007	30	936	305	32.6

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

5. Priority Diseases in Poultry

Newcastle Disease

Newcastle Disease (ND) is widespread in Nepal, causing substantial economic losses to the poultry industry. Vaccination against ND in commercial poultry is in practice; however, control of the disease in local poultry is difficult because of inadequate vaccination. The Central Biological Production Laboratory has been producing ND vaccines (particularly the La Sota strain) since 1998 (DoAH, 2014). Because of frequent power outages in Nepal, there is a need for a thermo-stable vaccine that can be extended to rural poultry. Many vaccines that need a refrigerated chain of delivery lose their potency. As a result, many vaccine-prevented diseases continue to emerge and spread, which is a serious problem for livestock and poultry in Nepal. From 2001 to 2007, epizootiology of the disease revealed that there were 864 outbreaks of ND in Nepal in which 272,007 birds were affected and 31,317 affected birds died (Table 5).

Table 5. Outbreaks of Newcastle Disease in Nepal (2001-2007)

Disease Year	No. of outbreaks	No. of cases	No. of deaths	Case fatality %
2001	211	39,319	7,713	19.7
2002	190	61,296	6,123	10.0
2003	135	44,447	6,573	14.8
2004	48	57,321	1,239	21.7
2005	147	27,479	3,532	12.9
2006	87	36,645	4,940	13.5
2007	46	5,500	1,197	21.8

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

Highly Pathogenic Avian Influenza

In January 2009, Nepal faced the first localized outbreak of highly pathogenic avian influenza (HPAI) in the Jhapa district (eastern Nepal), which borders the western part of India. The outbreak was contained when more than 23,000 chickens, as well as hundreds of pigeons, ducks, and parrots, were culled (DoAH, 2014). Since 2009, mirroring trends in neighboring countries, Nepal has suffered over 234 perennial H5N1 (HPAI-A strain) outbreaks in poultry, causing tremendous damage to the poultry industry. In 2013, there were 204 outbreaks of HPAI in Nepal, particularly in the Kathmandu Valley where the human density is highest, thus risking human health (DoAH, 2014).

Nepal is always in danger of HPAI outbreaks as the country lies in the migratory route of wild birds and is also the winter habitat for migratory birds. India and China lie along the same flyway and have histories of recurrent H5N1 among poultry and wild birds (Karmacharya et al., 2015). The illegal trade of poultry and the movement of poultry products and wild birds across the porous border between Nepal and India continually pose as dangers of influenza virus introduction.

In 2006, the GoN initiated the Avian Influenza Control Project (AICP), which implemented a Joint Health and Agriculture National Avian Influenza and Influenza Pandemic Preparedness and Response Plan (NAIIPPRP) focusing on knowledge and attitudes of poultry workers (Neupane et al., 2012). A mass media campaign informing communities and workers about risks and motivating them to adopt protective behaviors started soon after the 2003 HPAI outbreak in Asia and was intensified when HPAI reached Nepal in early 2009. Since then, Nepal has put HPAI under the active surveillance system.

6. Documented Impacts of Priority Diseases

Foot and Mouth Disease

FMD has been reported in all 75 districts of the country and confirmed by laboratory testing in 61 districts (Gongal and Karki, 2000). The economic loss of FMD in terms of decreased milk yield and meat production is estimated to be US\$66 million per year in Nepal (Gongal, 1998). However, the actual loss could be much higher when reduced breeding efficiency, decreased draft power of affected animals, and costs required to control the outbreaks are included. FMD accounts for 26% of the overall economic losses in livestock production in Nepal (Lohani and Rasali, 1992).

As a member of the World Trade Organization (WTO), the presence of FMD in Nepal has been a major barrier in international trade of livestock and livestock products (DLS, 2016). China barred a Nepalese dairy product (butter) in 2002 due to presence of FMD in Nepal (DoAH, 2014). Similarly,

there is a restriction of trans-frontier grazing of high-mountain Nepalese cattle at the border of China (Tibet). Although improved breeds of cattle, buffaloes, and pigs are highly susceptible, indigenous breeds are equally prone to FMD, causing substantial economic loss to Nepal's livestock industry (DoAH, 2014).

Mastitis

The economic impact of clinical mastitis in buffaloes is US\$63 per buffalo per lactation, due to reduced milk yield, quality, shelf life, and fat content. The economic impact includes US\$30 for treatments, veterinary services, and extra labor to care for sick livestock (Dhakal and Thapa, 2002). Most of the economic losses due to mastitis in Nepal are related to subclinical mastitis (SCM). SCM can last a long time and is difficult to detect. SCM alone is responsible for over two-thirds of the decreased milk production and accounts for 30-80% of economic losses in the dairy industry. In Nepal, the bacteria responsible for mastitis are *E.coli*, *Staphylococcus aureus*, and *Streptococcus agalactiae*, which also have public health importance. These bacteria have been implicated in human cases of gastroenteritis, epidemic diarrhea in infants, and food poisoning.

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7. Foodborne Diseases and Zoonoses

Foodborne parasitic zoonoses cause serious diseases and deaths in humans and animals and are of significant public health and economic concern in Nepal. Of more than 300 zoonotic diseases globally, about 60 have been identified in Nepal as emerging and re-emerging infectious diseases. The following zoonotic diseases are most relevant in Nepal.

- **Bacterial Zoonoses:** brucellosis, anthrax, leptospirosis, tuberculosis, campylobacteriosis, salmonellosis, botulism.
- **Viral Zoonoses:** Japanese encephalitis and rabies.
- **Parasitic Zoonoses:** echinococcosis/hydatidosis, taeniasis, visceral leishmaniosis, schistosomiasis, trichinosis, toxoplasmosis, filariasis, and others.

Brecht et al. (2014) examined the burden of parasitic zoonoses in Nepal through a systematic review of data from 2000 through 2012 (Table 6).

Table 6. Status of Parasitic Zoonoses in Nepal

Probably endemic and quantifiable	Probably endemic and nonquantifiable	Potentially endemic	Probably not endemic
Cystic echinococcosis	Diphyllobothriosis	Alveolar echinococcosis	<i>Anisakidae</i> infections
Cysticercosis	Foodborne trematodosis	Angiostrongylosis	Zoonotic schistosomosis
Toxoplasmosis	Taeniosis	Capillariosis	Zoonotic trypanosomosis
	Toxocarosis	Dirofilariosis	
	Trichinellosis	Gnathostomosis	
	Zoonotic intestinal helminth infections	Sparganosis	
	Zoonotic intestinal protozoal infections	Zoonotic leishmaniosis	

Data Source: Brecht et al., 2014

Salmonella and other pathogens in meat products

Meat-borne zoonotic diseases are highly prevalent in Nepal with inadequate animal slaughtering facilities and poor meat handling practices greatly contributing to the spread of these diseases. Although Nepal has the highest rate of meat consumption in Southeast Asia, little research has been done concerning meat-borne diseases and the risks that they pose to consumers and the general public. In Nepal, 64% of the meat consumed is buffalo, followed by goat (20%), pork (7%), poultry (6%), and mutton (2%; MOAD, 2012). Goat and poultry meat is consumed by the general population, while buffalo meat is consumed mainly by the Newar ethnic group. Pork was previously consumed only by people belonging to lower castes; however, it has recently earned a wider acceptance among the general public due to a more relaxed caste system. In an effort to enforce hygienic conditions in slaughterhouses and meat production, the government created the Slaughterhouse and Meat Inspection Act 1999; however, its implementation is commonly poor. Most slaughterhouses do not follow the minimum standards of hygiene outlined in the act, and monitoring of slaughterhouses is inadequate at best and predominantly nonexistent. A period of more intense monitoring seems to be in September and October during the largest Nepalese festival, Dashain, when meat consumption is highest.

Meat-borne zoonoses are reported from all over the country but particularly from Kathmandu Valley where more than one-quarter of the country's population lives. Surveys reveal unsatisfactory sanitation conditions in the local meat markets of Kathmandu. Upadhaya et al. (2012) conducted a study in retail meat supply in the Kathmandu Valley with an emphasis on isolation and identification of *Salmonella* bacteria. A total of 123 raw meat samples (55 chickens, 37 buffaloes, and 31 goats) were collected and analyzed during the season of high demand. *Salmonella* spp. were found in 11.4% (14/123) meat samples. Eight samples of chicken (14.5%), five samples of buffalo (13.5%), and one sample of goat (3.3%) were found to be positive for *Salmonella*. *Salmonella* prevalence revealed *Salmonella pullorum* in 3.3% samples, *Salmonella gallinarum* in 0.8%, *Salmonella typhi* in 1.6%, and *Salmonella choleraesuis* in 0.8%; as well as *Salmonella* subgenus I or II in 4.9% samples. More than 80% of the meat samples microbiologically processed also indicated coliform contamination. Seasonal prevalence of *Salmonella* was highest in the months of April and May.

Another study conducted by Maharjan et al. (2006) in retail meat markets in the Kathmandu Valley (central region) showed noticeable contamination of meat with *Salmonella* spp. A total of 492 environmental swab samples (164 chopping board samples, 164 knife samples, and 164 table

samples) from 82 retail meat shops were analyzed, with 40.2% of the shops testing positive. The isolation rates of *Salmonella* were as follows: chopping boards (36.0%); knives (32.9%); and tables, (25.0%). *Salmonella typhimurium* (54.5%) was the most common serotype found in retail meat shops, followed by *Salmonella enteritidis* (16.9%), *Salmonella haifa* (13.6%), *Salmonella virchow* (10.4%), *Salmonella agona* (3.9%), and *Salmonella enterica* (0.6%). The results of this investigation revealed that retail meat shops, to a significant extent, are *Salmonella* contaminated with a considerable degree of cross-contamination between meats, personnel, and equipment during a day when meats are processed.

In another study, Shrestha et al. (2013) looked at raw poultry samples from the local meat market of Chitwan Valley (the poultry hub in Nepal), with an emphasis on *Salmonella*. A total of 90 raw meat samples were collected and analyzed, and *Salmonella* spp. were found in 17 out of 90 (18.88%) samples.

Salmonella and other pathogens in milk products

Milk borne zoonoses are highly prevalent in Nepal. A large proportion of raw milk is sold for human consumption in the country; only a small fraction of pasteurized milk is sold by the government and private dairies. Even pasteurized milk sold by commercial dairies is found to be contaminated by coliforms and other microorganisms.

Arjyal et al. (2004) conducted a study of the presence of microbes in raw milk marketed in Kathmandu Valley. Almost all of the samples showed the presence of bacterial growth, including coliform bacteria. The bacterial isolates were of seven different genera: *E. coli* was the most frequently isolated organism (92%), followed by coagulase negative *Staphylococci* (CNS) (24%). The 129 samples of milk were positive for *E.coli* (25%), *Salmonella* spp. (37.2%), *Shigella* spp. (5.4%), *Klebsiella* spp. (7.7%), *Citrobacter* spp. (18.6%), and *Pseudomonas* spp. (1.6%). The study results, indicated that the situation is critical and needs real improvement in processing of milk. A recent milk market investigation conducted by the Department of Food Technology and Quality Control (DFTQC), a government regulatory body, has found coliform present in raw milk marketed in Kathmandu valley up to 2400 CFU/100 ml, which is much higher than acceptable level of 1000 CFU/100 ml (DFTQC, 2013).

Health burden of Zoonoses in humans

There are cases of zoonotic diseases reported in human hospitals from all over Nepal. Human and porcine teniasis/cysticercosis is reported to be one of the major public health problems in Nepal, with the highest incidences in eastern Nepal, where pig farming is common. In a study conducted by Sah et al. (2014) in a tertiary hospital in eastern Nepal (B.P. Koirala Institute of Health Sciences, Dharan) from 2005 to 2013, 114 cases of neurocysticercosis were reported. Most cases were from Sunsari District (eastern Nepal) where pig farming is common.

The national Tuberculosis Control program reported 37,025 cases of tuberculosis (TB), 51% of which were pulmonary TB. The overall prevalence of bovine TB in buffaloes and cattle was 9.08% and 5.68% respectively in Nepal (Joshi et al., 2012). Since livestock is an indispensable part of Nepal's agricultural system, buffaloes and cattle are often kept close to each other, which increases potential spread of *M. bovis*. Pandey et al. (2013) found that in Chitwan district (southern Terai) bovine TB was found in 15% of cattle and buffaloes. The study was also conducted on cattle and buffaloes that were raised by farmers who were under directly observed treatment (DOT), which indicates that TB may have been acquired from the animals (Pandey et al., 2013).

In Nepal, *Salmonella* paratyphoid A (*Salmonella paratyphii*) is an emerging infection and is the main cause of enteric fever, a feco-oral transmissible disease that is usually transmitted via contaminated food and water. Most cases of enteric fever manifests as a severe, prolonged febrile diseases. Enteric fever is endemic in Nepal. In addition, in October and November 2009, Israeli travelers returning from Nepal were tested and shown to be positive for *Salmonella paratyphii*. The strain was identified

as originating at a food venue located in Kathmandu (Meltzer et al., 2014). Table 7 summarizes the deaths and disability-adjusted life years (DALYs) associated with food-borne zoonoses in Nepal.

Table 7. Deaths and Disability-Adjusted Life Years (DALYs) with Corresponding 95% Credibility Intervals (CrI) for Foodborne Zoonoses in Nepal

Zoonosis	Deaths	(95% CrI)	DALYs	(95% CrI)
<i>Parasitic Foodborne Zoonoses</i>				
Cryptosporidiosis*	248	(128–504)	18,885	(8628–41,720)
Cysticercosis	149	(89–230)	11,816	(8475–15,825)
Toxoplasmosis, acquired	0	(0–0)	8,193	(5597–11,086)
Ascariasis*	18	(0–85)	5,065	(3247–10,330)
Toxoplasmosis, congenital	7	(3–13)	2,387	(1224–4081)
Giardiasis*	0		428	(60–1237)
Cystic echinococcosis	4	(1–8)	320	(157–570)
Fasciolosis	0		19	(6–47)
Paragonimosis	0		18	(5–47)
Alveolar echinococcosis	0.2	(0–0.5)	6	(1–21)
Trichinellosis	0		0.20	(0.07–0.35)
<i>Bacterial foodborne zoonoses</i>				
Salmonellosis, nontyphoidal	544	(331–1039)	38,274	(20,604–82,567)
Campylobacteriosis	244	(109–508)	22,102	(10,106–45,484)
Brucellosis	152	(0–986)	9672	(2–64,153)
Listeriosis	26	(0–149)	968	(0–5538)
Bovine tuberculosis	8	(3–16)	470	(192–902)
STEC infection**	2	(0–8)	184	(10–678)

Estimated by the Foodborne Disease Burden Epidemiology Reference Group (FERG)

*Not 100% foodborne, **STEC: Shiga-toxin producing *Escherichia coli*

Disease priorities

Outbreaks of highly pathogenic avian influenza (HPAI) have been spreading across the globe since 2003. Nepal is particularly at risk because outbreaks have been recorded in China to the north and in India to the south, and because migratory birds, known to carry diseases such as avian influenza (AI), pass through Nepal annually (Karmacharya et al., 2015). To enhance the country's capacity for the prevention and control of infectious diseases that transmit between animals and humans (zoonoses), the Nepal Zoonoses Control Project (NZCP) was started in 2009. The project has prioritized six zoonotic diseases through participatory multi-stakeholder assessments and consultations: HPAI, brucellosis, leptospirosis, toxoplasmosis, cysticercosis, and hydatidosis. Strategies have been developed for the priority diseases. NZCP has two types of interventions: planning and preparedness, and prevention; and four main components which are as follows:

1. Develop institutional capacity to support legislation for prevention and control of animal diseases and to create a "One Health" strategy and action plan.
2. Create and implement programs to refurbish laboratories, provide equipment, and train staff.
3. Strengthen live animal markets via response-and-control capacity building; for example, the modernization of live bird markets, increasing biosecurity awareness, and upgrading quarantine facilities.

4. Develop a project management unit to support overall project implementation.

In addition, the project has developed a mechanism for communication and information sharing at the national level and in all 75 districts. In sum, NZCP is improving resilience and reducing vulnerabilities by building government capacity to prevent and control zoonotic diseases.

8. On-going Control Programs and Their Impact

The Directorate of Animal Health (DoAH) is an apex body in the country responsible for executing disease control programs, assessing their effectiveness, and making necessary adjustments as per the assessment of the program. Under DoAH, there is a well-organized network of national veterinary services at central, regional, district, and subdistrict levels. At the central level, DoAH is responsible for giving guidance and coordinating overall animal health related activities throughout the country. Under the Directorate, Veterinary Diagnostic Laboratories, Vaccine Production Laboratories, Animal Quarantine Offices, Veterinary Public Health Office, Veterinary Drug Administration and Quality Control Office, Central Veterinary Hospital, and Veterinary Epidemiology Center provide veterinary services to the concerned stakeholders.

At the regional level, Regional Livestock Directorate Offices, Regional Veterinary Laboratories, and Animal Quarantine Offices work to deliver veterinary services. Moreover, at each district and subdistrict level, 75 District Livestock Services Offices (DLSOs), along with 359 livestock service centers and 640 livestock subservice centers, provide veterinary services at grassroots level (DLS, 2016). At present, DoAH conducts the national PPR control program activities in 67 districts, veterinary inspection in 75 districts, FMD control program in 19 districts, Newcastle diseases control program in 28 districts, and classical swine fever control program in 16 districts, through its well-coordinated channels from central to grass-roots levels (DoAH, 2014).

Actors and major stakeholders

DoAH and offices under DoAH play a key role in the diagnosis, prevention, and control of animal diseases in Nepal, along with the development and application of international standards for veterinary quality control. The Slaughterhouse and Meat Inspection Act of 1999 and the Animal Health and Livestock Services Act of 1999 are the major livestock-related legislation in Nepal. The VS structure in the country includes actors such as DoAH (nationally), RLDs and RVLs in regions, DLSOs in districts, and LSC/LSCCs within districts. The Nepal Veterinary Association, veterinary drug and feed importers, and other organizations are working in the livestock sector in Nepal. Actors for food safety are MoAD's Department of Food Technology and Quality Control (DFTQC), veterinary inspectors, consumer's rights forums, and other organizations. However, issues of food safety have not yet had a significant focus in Nepal.

The Department of Livestock Services (DLS) under the Ministry of Livestock and Poultry Development is an apex body of veterinary services in Nepal involved in policy making, formulating plans and programs, and facilitating veterinary-related activities in the country. Under DLS, DoAH is responsible for implementing the programs of animal health related activities throughout the country. DoAH implements veterinary programs through the network of various veterinary related offices at central, regional, district, and service center levels (DoAH, 2013/14, 2014). Veterinary Diagnostic Laboratories, Vaccine Production Laboratories, Central Animal Quarantine Offices, Veterinary Public Health Office, Veterinary Drug Administration and Quality Control Office, and Central Veterinary Hospital and Veterinary Epidemiology Center deliver veterinary services at the central level. At the regional level Regional Directorate of Livestock Services (RDLS), Regional Veterinary Laboratories (RVLs), and Regional Animal Quarantine offices deliver veterinary services. In addition, at the district and subdistrict levels 75 DLSOs and LSC/LSCCs provide veterinary services. The DLSOs and the service centers provide livestock-related services including animal health, animal breeding, animal nutrition, training, and Extension activities.

National Peste des Petits Ruminants (PPR) control program

As mentioned, there have been frequent outbreaks of PPR in goat and sheep herd in the country. Goat enterprises are flourishing in the country as the government is prioritizing goat enterprises as a means to alleviate poverty. However, frequent outbreaks of PPR are threatening the sustainability of goat enterprises. As a result, the government of Nepal’s DoAH launched a national PPR control project in 2001 (DoAH, 2014). The national control strategy for PPR is mass vaccination (“ring” vaccination) and serosurveillance of PPR virus. This intervention strategy against PPR virus has given encouraging results, with significant reduction in the number of outbreaks. However, outbreaks of PPR still have been reported. Unrestricted movement of diseased animals, comparatively low coverage of vaccination against a high risk herd, and rapid replacement of vaccinated herds are more threats for outbreak of PPR in Nepal.

During 2013-2014, a PPR mass vaccination program was conducted in 67 districts (Table 8). To increase the coverage of vaccination, PPR vaccine banks maintained at all five regional laboratories were strengthened and the outbreaks in various districts were controlled using the mass vaccination approach.

Table 8. Peste des Petits Ruminants Control Program Activities in Nepal for 2013-14

SN	Activity	Units	Target	Progress
1	PPR mass vaccination	Dose in 000	3500	3500
2	Sero-monitoring	No in 000	18	18
3	Vaccine Bank Management	Dose in 000	250	250
4	PPR Elisa Test Kit Procurement	Times	1	1
5	Publication of awareness materials (leaflets, brochures)	Times	2	2

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

National Foot and Mouth Disease (FMD) control program

To effectively control FMD, the government of Nepal’s DoAH launched a national FMD control program in 2001-2002. The national control strategy for FMD is zonation based on endemicity. To begin the program, the national FMD control program selected 10 districts beyond Koshi River in the eastern Terai as a pilot area for FMD control. Those districts were selected based on the natural barrier of the large Koshi River.

Ilam district, a hilly district in eastern region, is a major dairy area and has been free of FMD for more than five years. Mass vaccinations in the areas bordering Ilam district were carried out. Surveillance activities were carried out in all ten districts by involving stakeholders such as milk cooperatives. Results of this intervention were encouraging, with a significant reduction in the number of outbreaks in the selected areas. However, movement of animals and comparatively low coverage of vaccination remain as major threats for outbreaks of FMD (DoAH, 2014). The control strategies for FMD varies as per the endemicity of the disease in different regions (Table 9):

1. Mass phased vaccination campaigns in high endemic zones – Terai (Plains) and Kathmandu Valley regions.
2. Strategic vaccination and animal movement control in medium endemic zones – mid Hills region.
3. Animal movement control in low endemic zones – high Mountains region.
4. Strengthening of the diagnostic procedures and quality of the vaccine product.

Table 9. FMD Control Program Activities in Nepal for 2013-14

SN	Activity	Unit	Target	Progress
1	FMD mass vaccine procurement	Dose in 000	500	500
2	FMD vaccination	Districts	6	6
3	FMD Surveillance	Month	19	19
4	Sero-monitoring/Sero-survey	No in 000	5	5
5	Meeting with Dairy Cooperatives/ Stakeholders	Times	3	3
6	Publication of awareness materials (leaflets, brochures)	Times	3	3
7	Program Orientation Workshop	Times	1	1

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

National Newcastle Disease control program

Table 10. Newcastle Disease (Ranikhet) Control Program Activities in Nepal for 2013-14

SN	Activity	Unit	Target	Progress
1	Ranikhet vaccination of local birds (28 districts)	Dose in 000	300	300
2	Sero-monitoring	No in 00	5	5
3	Program orientation workshop	Times	1	1
4	Preparation of Ranikhet control implementation guideline (Karyabidhi)	Times	1	1
5	Publication of awareness materials (leaflets, brochures)	Times	3	3

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

National Classical Swine Fever control program

Table 11. Classical Swine Fever Control Program Activities in Nepal for 2013-14

SN	Activity	Unit	Target	Progress
1	Swine fever vaccination (16 districts)	Dose in 000	300	300
2	Sero-monitoring	No in 00	15	15
3	Program orientation workshop	Times	1	1
4	Preparation of swine fever control implementation guidelines	Times	1	1
5	Publication of awareness materials (Flex, brochures)	Times	3	3

Source: Directorate of Animal Health, Veterinary Epidemiology Center, Tripureswor, Kathmandu

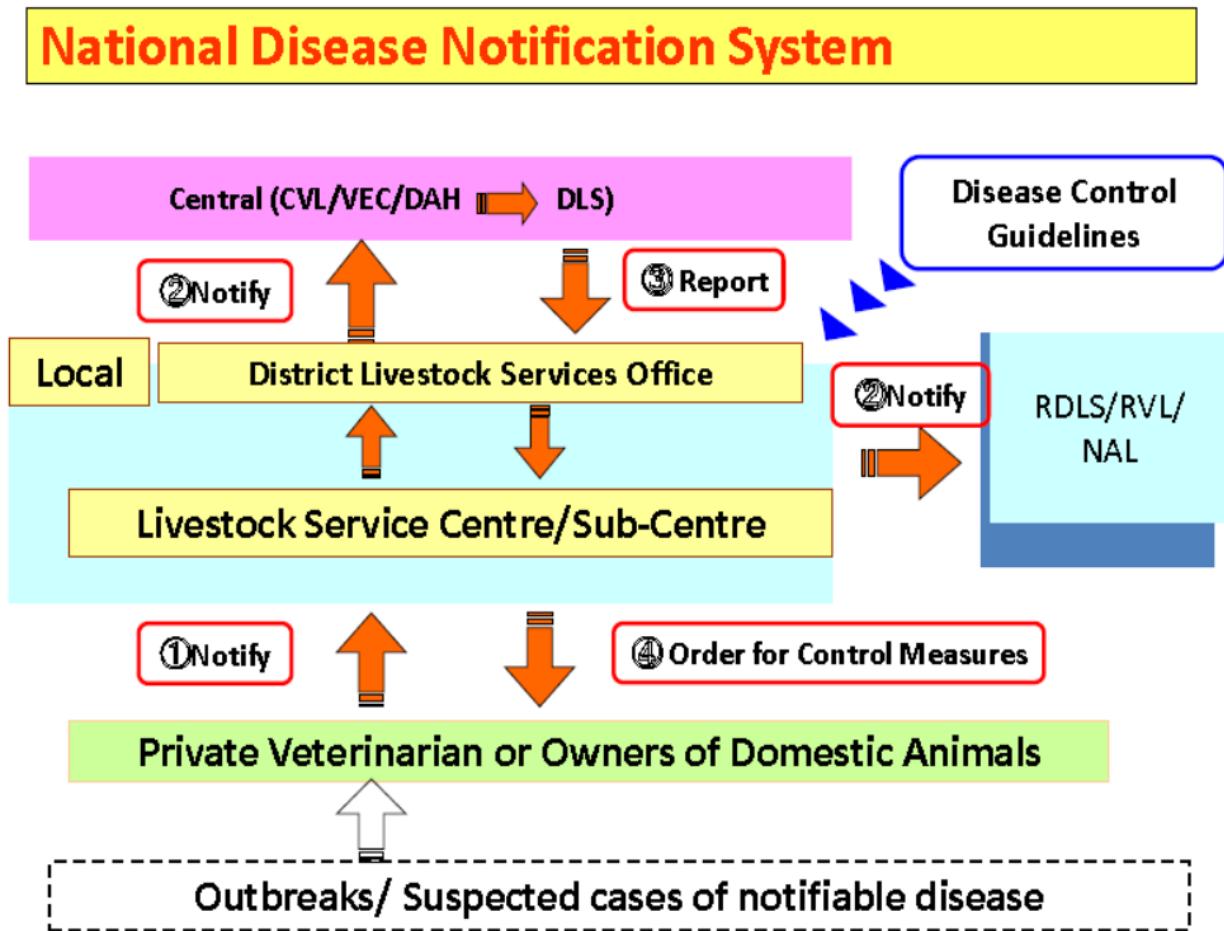
9. Current Animal Health Surveillance Activities

Under the organizational structure of the Directorate of Animal Health (DoAH), the Veterinary Epidemiology Centre (VEC) was established as an independent organization with the responsibility of conducting animal disease surveillance and maintaining a national animal health database (DoAH, 2013/14, 2014). The VEC utilizes information from the Animal Health Information System to provide timely and accurate information on animal health status. It also provides information on the animal disease surveillance and control systems.

The Nepal government has published a list of notifiable diseases, which are: anthrax, atrophic rhinitis, Aujeszki's disease, FMD, sheep and goat pox, bovine tuberculosis, PPR, buffalo pox, caprine and ovine brucellosis, classical swine fever, Contagious Bovine Pleuropneumonia (CBPP), Contagious Caprine Pleuropneumonia (CCPP), avian influenza, avian tuberculosis, chicken anemia virus infection, duck virus enteritis, and bovine brucellosis. The reporting system of these notifiable diseases is different than that of non-notifiable diseases. In the case of notifiable diseases, the Animal Quarantine Office (AQO) and District Livestock Office (DLSO) report to the Regional Veterinary Lab (RVL), Regional Directorate of Livestock Service (RDLS), and VEC/DoAH and to the Ministry of Livestock and Poultry Development through "flash reports" via any effective means of communication (e.g., telephone, email, Fax) (Figure 1). The reporting form is completed and signed by a veterinarian or a senior technician (DoAH, 2014).

In the case of non-notifiable diseases, the disease outbreak is reported from the lowermost unit of Livestock Service Center/Livestock Service Sub-Center (LSC/LSSC) to the DLSO and then to the VEC/DoAH. At the LSC/LSSC, diseases need not to be diagnosed by the veterinarian and an animal health technician can submit monthly reports to the district. Using information supplied from LSC/LSSC and based on the clinical post-mortem and lab tests, the DLSO veterinary officer will submit reports to the Regional Livestock Directorate. The VEC then implements an investigation and epidemiological survey and utilizes laboratory information in order to develop an appropriate disease control plan.

Figure 1. Nepal National Disease Notification System for Notifiable Veterinary Diseases



Source: Dr. Prabhakar Pathak, Department of Livestock Services, Government of Nepal

Available diagnostic capacity

As a member of World Trade Organization since 2004 (WTO, 2016), Nepal should comply with scientific procedures and evidence in the course of diseases diagnosis and food production. However, the diagnostic capacity of veterinary services in the country is limited. In Nepal, the Central Veterinary Laboratory (CVL) conducts epidemic investigations during outbreaks of diseases. CVL, along with laboratories in each of the five development regions and the National Avian Laboratory, are responsible for laboratory diagnosis of livestock and poultry diseases (DoAH, 2014) (Table 12).

CVL acts as a referral laboratory that also strengthens and coordinates the regional and district level veterinary laboratories. CVL develops standard diagnosis procedures, test protocols, and a quality guidelines manual, and also collaborates with international reference laboratories for providing diagnostic services in Nepal.

Table 12. Laboratory Diagnostic Facilities under the Directorate of Animal Health in Nepal

Central Veterinary Laboratory, Kathmandu

- Rapid test- Flu A, ND, IBD, JE, Rabies
- HA/HI test - Flu A, H5, H9, ND
- Real time PCR and Conventional PCR - Flu A, H5, H7, and H9
- ELISA test
- Antibody detection test - Flu A, CAV, AEV, IB, IBD, JE, ND,EDS, H1N1, PRRS, Leptospirosis, Toxoplasmosis, and PPR
- Antigen detection test - ALV, PPR
- Agglutination test - Brucella, Salmonella, Mycoplasma
- Virus isolation- ND, fowl pox

National Avian Laboratory (NAL) & All Regional Veterinary Laboratories (RVL)

- Rapid test -Flu A, ELISA

FMD and TADs lab

- ELISA test: FMD, BT and CSF virus lab test, PCR for FMD diagnosis
-

Data collection, analysis, reporting

Data from outbreaks, abattoirs, quarantine stations, and monthly epidemiological reports are collected from all 75 districts. The lowermost unit of VS LSC/LSSC collects data about disease outbreaks and submits monthly reports to concerned DLSOs. The DLSO then compiles and analyzes monthly reports received from the LSC/LSCC, utilizes information from PM exams and lab reports, and submits monthly reports to concerned RLDs, which then forward reports to the VEC. The VEC biannually publishes reports about diseases outbreaks in each development region, eco-zone, and the country as a whole.

On receiving monthly epidemiological reports from DLSOs through RLDs, the VEC analyzes the data. Epidemiological data are analyzed on the basis of development region, geographical region, district, season, year, and species of animals. VEC biannually publishes an epidemiological bulletin and also submits monthly reports on FMD and other notifiable diseases to the regional office of OIE in Tokyo, Japan.

The surveillance information is used to understand the overall situation and trend of animal health in the geographic regions of Nepal and throughout the country in general. Prompt action is initiated when exotic diseases are introduced. The surveillance information is used to prioritize disease interventions and monitor the effectiveness of disease control and eradication programs.

As a member of FAO's South Asian Association for Regional Cooperation (SAARC), Nepal participates in various consultative workshops on highly pathogenic and emerging diseases (HPEDs) in South Asia. Nepal also actively participates in laboratory diagnosis trainings for emerging and infectious diseases.

One Health platforms

In 2009, scientists working across the field of human, livestock, and environmental health in India, Pakistan, Bangladesh, and Nepal formed a network called One Health Alliance of South Asia

(OHASA) (Dhama et al., 2013). OHASA is a transdisciplinary and intergovernmental alliance with the goal of tackling the challenges of emerging and endemic zoonotic diseases by promoting One Health strategies, facilitating collaboration, and coordinating scientific research. As a member of OHASA, Nepal organized the first One Health workshop in 2012, bringing scientists and policy makers from animal, human, and environmental health together to find ways forward for cross-sector collaboration.(Kathmandu, 2008). Attendees from all sectors recognized the relevance and significance of One Health approaches in disease surveillance, prevention, and control programs. As a result of this workshop, the One Health Association of Nepal (OHAN) was formed as a nonprofit organization registered with the government of Nepal (Kathmandu, 2008) Today, Nepal One Health Hub serves as a coordinating and professional networking center connecting people and organizations involved in One Health across Nepal and across the South Asia region.

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