

Review on Common Impact and Management of Transboundary Animal Diseases



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Abstract

Livestock contribute 40 percent of the global value of agricultural output, 5 percent of total food energy and 25 percent of dietary protein, and support the livelihoods and food security of almost a billion people. There are more than 1.3 billion cattle, 1.7 billion small ruminants, 900 million pigs and 15 billion poultry in the world. Ethiopia is one among the nations that possesses the largest number of livestock population in the African continent estimated to be 56 million cattle, 29 million sheep and 29 million goats. In contrast to the huge livestock resource, the livestock productivity is found to be very low. Animal diseases seriously limit the potential contribution of the livestock sector. The diseases impact food supplies, trade and commerce, and human health and well-being in every part of the world. TADs like Foot and Mouth Disease (FMD), Peste des Petits Ruminants (PPR) and Swine Influenza cause a direct economic impact by reducing agricultural and animal production. The 2001 FMD outbreak in the United Kingdom was estimated to have cost more than \$12 billion [1]. Devastating losses were caused by the 2003-04 highly pathogenic avian influenza (HPAI) outbreaks that occurred in Asia, Europe, Canada, and the USA; the 2002-03 Newcastle disease (ND) incidence in USA; and the 2000 Rift Valley Fever attack in the Arabian Peninsula. Contagious bovine pleuropneumonia (CBPP) costs 27 Africa countries an estimated losses of up to \$2 billion annually. In 1994, Rinderpest killed an estimated 40,000 cattle and yaks in Pakistan. Similarly, the Egyptian trade ban of animal and animal products, in 2005/2006, caused Ethiopia a loss of more than 14 million \$US. In response to the destructive effects of TADs, different countries implement various TADs management strategies. The international approach to management of TADs is based on the assumption that most can be eradicated. However, in developing countries, eradication of most TADs is difficult for a variety of technical, financial and logistical reasons. General TADs combating strategies include prevention, early warning, early detection and early control.

Keywords: Transboundary animal diseases; Impact; Management

Abbreviations: FMD: Foot and Mouth Disease; PPR: Peste des Petits Ruminants; HPAI: Highly Pathogenic Avian Influenza; ND: Newcastle Disease; CBPP: Contagious Bovine Pleuropneumonia; TADs: Transboundary Animal Diseases; AIDS: Acquired Immunodeficiency Syndrome; RVF: Rift Valley Fever; GIS: Geographic Information System

Introduction

Livestock contribute 40 percent of the global value of agricultural output, 5 percent of total food energy and 25 percent of dietary protein, and support the livelihoods and food security of almost a billion people [2]. There are more than 1.3 billion cattle, 1.7 billion small ruminants, 900 million pigs and 15 billion poultry in the world [3]. Ethiopia has one of the largest inventories in Africa with livestock currently supporting and sustaining the livelihoods of an estimated 80 percent of the rural poor. The country has an estimated 56.7 million cattle, 29.3 million sheep, 29.1 million goats, and 9.86 million equines, 1.2 million camels and 56.7 million chicken [4]. In Ethiopia, the sub-sector contributes 45% of agricultural GDP, 15-18% of national GDP, and 5-17% of total exports.

Animal diseases seriously limit the potential contribution of the livestock sector [5]. The diseases impact food supplies, trade and commerce, and human health and well-being in every part of the world [6]. Changes in agro-ecological conditions and global marketing increased incidences of animal diseases. Especially, Transboundary Animal Diseases (TADs) pose the most serious consequences. These are epidemic diseases which are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, causing serious socio-economic and possibly public health consequences [5,7].

Commonly, TADs are introduced to a new geographical location through entry of live diseased animals and contaminated animal products. Rinderpest was introduced to Ethiopia in 1887, when Italians imported infected cattle into the country from

India [8]. Similarly, SAT-1 FMD virus was introduced to Ethiopia from Sudan along the border with Surma woreda in Bench Maji zone, southern Ethiopia [9]. Contaminated vaccines, infected people, migrating birds, insect vectors or wind current can spread TADs [5,7,10]. In addition, climate change is creating new ecological platform for the entry and establishment of TADs from one geographical region to another [11].

TADs like Foot and Mouth Disease (FMD), Peste des Petits Ruminants (PPR) and Swine Influenza cause a direct economic impact by reducing agricultural and animal production [5,12]. The 2001 FMD outbreak in the United Kingdom was estimated to have cost more than \$12 billion [1]. Devastating losses were caused by the 2003-4 highly pathogenic avian influenza (HPAI) outbreaks that occurred in Asia, Europe, Canada, and the USA; the 2002-03 Newcastle disease (ND) incidence in USA [13] and the 2000 Rift Valley Fever attack in the Arabian Peninsula. Contagious bovine pleuropneumonia (CBPP) costs 27 Africa countries an estimated losses of up to \$2 billion annually [6]. In 1994, Rinderpest killed an estimated 40,000 cattle and yaks in Pakistan [14]. Similarly, the Egyptian trade ban of animal and animal products, in 2005/2006, caused Ethiopia a loss of more than 14 million \$US [15].

Apart from causing suffering and mortality in susceptible population, TADs adversely affect food safety, human health, rural livelihoods and international trade. The national economy is directly influenced due to reduced access to international markets for the agricultural products and higher costs of regulatory compliance involved with inspection, treatment, among others [10,13]. When rinderpest was introduced into Ethiopia for the first time, it had decimated about 90% of the cattle population of the country. Hence shortages of draft oxen had caused subsequent drop in agricultural production. The Great Famine of the country which occurred from 1888-1892 was due to massive death of draft oxen as a result of rinderpest [8].

In response to the destructive effects of TADs, different countries implement various TADs management strategies. The international approach to management of TADs is based on the assumption that most can be eradicated. However, in developing countries, eradication of most TADs is difficult for a variety of technical, financial and logistical reasons [16]. General TADs combating strategies include prevention, early warning, early detection and early control. Cross-boundary cooperation in disease surveillance, diagnosis, epidemiology and containment play key role in addressing this menace [10,14]. However, rinderpest is the first animal disease eradicated in the world, and smallpox the only human disease eradicated by the medical profession [17].

Objectives

This paper reviews the impacts of common TADs and the various management strategies are highlighted.

Literature Review

Transboundary animal diseases (TADs) may be defined as those epidemic diseases which are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, causing serious socio-economic and possibly public health consequences. These diseases cause high morbidity and mortality in susceptible animal populations and constitute constant threat to the livelihood of livestock farmers and national economies [7].

Important characteristic features of TADs include sudden, acute or rapid onset and widespread attack and losses. Individual farmers and private veterinary services are relatively powerless to manage TADs outbreaks. The responsibility for prevention, control and elimination of TADs therefore falls squarely on the shoulders of the public sector, notably government veterinary services and may require high public investment. Furthermore these endeavors are only likely to be successful if government veterinary services are very well organized and prepared for these tasks. TADs have cross border effect and therefore need to be tackled on a regional basis, with cooperation between countries and harmonization of their prevention and response programs. An international approach also allows better advantage to be taken of natural geographical barriers and broader epidemiological patterns for the diseases [7,14].

The common ways of introduction of animal diseases to a new geographical location are through entry of live diseased animals and contaminated animal products. Rinderpest was introduced to Ethiopia in 1887, when Italians imported infected cattle into the country from India [8]. Similarly, SAT-1 FMD virus was introduced to Ethiopia from Sudan along the border with Surmaworeda in Bench Maji zone, southern Ethiopia [9]. Other introductions result from the importation of contaminated biological products such as vaccines or germplasm or via entry of infected people (in case of zoonotic diseases). Even migration of animals and birds, or natural spreading by insect vectors or wind currents, could also spread diseases across geographical borders [7,14].

There are many emerging TADs meaning a new presentation of a previously recognized disease, or an existing disease that shows up in a new geographic area. The term emerging disease first was used to describe several new entities in humans that surfaced in the early 1980s, the most notable example of which was Acquired Immunodeficiency Syndrome (AIDS). Since then, the number of emerging diseases in humans has continued to increase, but this trend is even more pronounced in animals. Therefore, TADs exhibit a great deal of dynamism. New diseases emerge, and old diseases re-emerge. They show a great propensity for sudden and unexpected spread to new regions, often over great distances. Several underlying factors inherent in modern society are responsible for the increasing trend in TADs [7,14].

a. Globalization and international transport: The most important method of spread of TADs is by movement of potentially infected livestock and meat and other animal products. There have been very substantial increases in such international movements due to better sea, land and air transport of people, animals and goods and in response to marketing opportunities for livestock and their products. Nomadism, transhumance, and the movement of refugees and their animals away from wars and civil disturbances also contribute very substantially to the spread of infectious animal diseases. These all place a great strain on countries in maintaining effective quarantine barriers at airports, seaports and along international borders [7,14].

b. Environmental changes: The emergence of new diseases is related to environmental changes. Habitat destruction, causing animal populations to cluster in hitherto less preferred environments, has opened new possibilities for the spread of pathogens and has created many problems in recent years. Climatic events presaging changes in vector populations also can lead to the emergence of disease. The 1998 Rift Valley fever animal epidemic in east Africa was in part determined by the El Niño-Southern Oscillation phenomenon, which created increased precipitation and amplification of mosquito vector populations. Global warming trends may change rainfall and weather patterns in a number of regions, affecting particularly the global distribution of insect vectors, e.g. mosquitoes and *Culicoides* midges and the important viral and protozoal transboundary animal diseases that they transmit.

c. Ecological interface: As new species come into contact with one another for a variety of reasons (such as tourism and human migration, ecological disruption, shows, trade, introduction of new genetic material, and keeping wild species in captivity), potential pathogens from one species may move into another, with subsequent disease and dissemination in the new host population. The opportunities for this transfer to take place continue to increase as species are moved around and confined to ever-dwindling available natural spaces. Canine distemper in lions on the Serengeti Plain in Africa is a prominent example in which a normally canine-only virus migrated from domesticated dog populations into large cats to cause disease [18]. The coronavirus of SARS presumably moved into the human population from an animal reservoir; the species remains to be determined but the civet cat is suspected. A recent review cataloged almost 1,000 pathogens of selected domestic animals [19].

d. Husbandry and technological changes: Bovine spongiform encephalopathy is a striking, painful example of how seemingly simple changes in agricultural technology can have far-reaching impacts on animal agriculture, human health, and economies. The emergence of antibiotic-resistant strains of bacteria is being attributed, factually or not, to feeding animals growth-promoting antibiotics. The practice of aquaculture and

the stocking of streams for anglers also are not exempt from disease emergence.

e. Spread of livestock farming into new ecosystems: In some regions of the world, tropical rain forests and other wilderness areas are being converted to livestock farming. This places human communities and their farm animals into close contact with a completely new range of infectious diseases which may have previously only circulated in wild life reservoirs and which may be completely unknown. Some of these diseases may be transmittable to humans and/or livestock, in which they may spread very rapidly in the new, fully susceptible hosts.

f. Break in animal health service and infrastructure: In many countries public funding of veterinary services is poor and even declining, resulting in uncontrolled livestock movements, poor diagnostic capacity and the inability to react quickly and effectively to disease outbreaks. Farmers are usually not compensated for disease losses and thus often tend to sell still healthy-looking livestock to reduce their financial losses when a disease problem is occurring on their farm. As a proportion of these apparently healthy animals may be in early stages of infection where clinical signs are not yet apparent, this behavior of farmers may significantly contribute to the spread of disease.

Impacts of TADs

TADs problems have significant influence on animal populations, the environment, and the health of humans, both directly-through transfer of zoonotic agents-and indirectly-through impacts on trade that decrease the availability of animal protein. TADs like Foot and Mouth Disease (FMD), Peste des Petits Ruminants (PPR) and Swine Influenza cause a direct economic impact by reducing agricultural and animal production [5,12]. The 2001 FMD outbreak in the United Kingdom was estimated to have cost more than \$12 billion [1]. Devastating losses were caused by the 2003-4 highly pathogenic avian influenza (HPAI) outbreaks that occurred in Asia, Europe, Canada, and the USA; the 2002-03 Newcastle disease (ND) incidence in USA [13]; and the 2000 Rift Valley Fever attack in the Arabian Peninsula. Contagious bovine pleuropneumonia (CBPP) costs 27 Africa countries an estimated losses of up to \$2 billion annually [6].

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Apart from causing suffering and mortality in susceptible population, TADs adversely affect food safety, human health, rural livelihoods and international trade. The national economy is directly influenced due to reduced access to international markets for the agricultural products and higher costs of regulatory compliance involved with inspection, treatment, among others [10,13]. When rinderpest was introduced into

Ethiopia for the first time, it had decimated about 90% of the cattle population of the country. Hence shortages of draft oxen had caused subsequent drop in agricultural production. The

Great Famine of the country which occurred from 1888-1892 was due to massive death of draft oxen as a result of rinderpest [8] (Table 1).

Table 1: Major Trans-boundary Animal Diseases and their Distribution [7,14].

TBA Disease	Animals Affected	Geographical Distribution	Remarks
Foot-and-mouth disease (FMD)	Cattle, buffalo, shoat and pigs	Africa, Middle East and Asia	Present in Ethiopia
Peste des petits ruminants (PPR)	Sheep & goats	Africa, Middle East and Asia	Present in Ethiopia
Classical swine fever (CSF)	Pigs	South and South-East Asia	
African swine fever (ASF)	Pigs	Sub-Saharan Africa, West Africa, parts of Europe and Latin America	
Blue tongue (BT)	Sheep & cattle	Australia, USA, Africa, Middle East, Asia and Europe	
Rift Valley Fever (RVF)	Cattle & shoat	Africa	
Contagious bovine pleuropneumonia (CBPP)	Cattle	Eastern, Southern and West Africa, parts of Asia	Present in Ethiopia
Lumpy skin disease (LSD)	Cattle	Africa	Present in Ethiopia
Sheep and goat pox	Shoats	South Asia, China, Middle East, Africa	Present in Ethiopia
Bovine spongiform encephalopathy (BSE)	Cattle	UK and other parts of Europe	
Venezuelan Equine Encephalomyelitis	Equines	Central American and South American countries	
Newcastle disease (ND)	Poultry	Asia and Africa	Present in Ethiopia
Highly pathogenic avian influenza (HPAI)	Poultry	Asia, Europe and Africa	
Hendra virus (HeV) infection	Horses	Australia	
Nipah virus (NiV) infection	Pigs	Malaysia and Singapore	

Generally, TADs have the potential to: Threaten food security through serious loss of animal protein and/or loss of draught power increase poverty levels particularly in poor communities highly dependent on livestock farming causes major production losses for meat; milk and other dairy products; wool and other fibers and skins and hides, thereby reducing farm incomes restrict opportunities for improving production potential by limiting the utilization of susceptible exotic breeds significantly add to the cost of livestock production through costly disease control measures inhibit national/international trade of livestock and livestock products, thereby causing major losses in national export income cause public health consequences - TADs capable of transmitting to humans cause environmental consequences through die-offs in wildlife populations in some cases, and cause pain and suffering for affected animals [7,10,14,16].

Historical impacts of TADs

- o **1997:** FMD seriously affected the commercial pig industry in Taiwan province of China, where 4 million pigs were slaughtered in order to control the epidemic.
- o **1994:** Rinderpest killed an estimated 40,000 cattle and yaks in Pakistan.

- o **1977:** Rift Valley fever (RVF) in Egypt caused an estimated 200,000 human cases of the disease with some 600 deaths as well as large numbers of deaths and abortions in in sheep and cattle and other livestock species.
- o **1997-98:** RVF outbreak in East Africa caused livestock losses and human deaths and also seriously disrupted the valuable livestock export trade to the Middle East.
- o **1995:** Contagious bovine pleuropneumonia (CBPP) in Botswana. As part of the eradication campaign, all cattle in an area of northern Botswana had to be slaughtered at a direct cost of \$100 million, although indirect losses would have been much higher. Hog Cholera, A serious outbreak of the disease in the Netherlands led to the death or slaughter of some 12 million pigs as part of the eradication campaign. The cost of the Dutch outbreaks was estimated to be \$US 2.35 billion.
- o **1996:** African swine fever in Cote d’Ivoire killed 25% of the pig population and cost the country between \$US 13 and 32 million.
- o **1983-1984:** Highly pathogenic avian influenza (HPAI) in Pennsylvania, USA caused direct costs of eradication \$US 64

million, and indirect costs to consumers \$500 million through increased prices of product.

- o **2005/2006:** RVF OUT BREAK IN EAST AFRICA, Ethiopia lost 14 million USD from Egyptian trade ban.

Management Of TADs

Due to multiple adverse impacts, it is necessary to effectively manage the TADs. If an introduction of TADs can be recognized early whilst it is localized and then a disease control program be quickly implemented, the prospects for eradication of the disease with minimal production losses and other costs are markedly enhanced. Conversely, if the disease is allowed to become well established in the country, eradication may be very costly and difficult. Accordingly, there are two key TADs combating principles early warning and early reaction [5].

a. Early warning: This refers to rapid detection of the introduction of, or sudden increase in the incidence of TADs. It embraces all initiatives, mainly based on disease surveillance, reporting and epidemiological analysis that would lead to improved awareness and knowledge of the distribution and behavior of disease outbreaks and which allow forecasting of the source and evolution of the disease outbreaks and the monitoring of the effectiveness of disease control campaigns [5].

b. Early reaction: This means to carry out without delay the disease control activities needed to contain the outbreak and then to eliminate the disease and infection in the shortest possible time frame and in the most cost-effective way, or at least to return to the status-quo [5].

Management challenges of TADs

The international approach to management of TADs is based on the assumption that most can be eradicated. However, in developing countries, eradication of most TADs is impossible for the foreseeable future for a variety of technical, financial and logistical reasons. An effective national animal quarantine system should prevent the entry and establishment of TADs. However even the most sophisticated quarantine service cannot provide an absolute barrier. A disease outbreak in the neighboring country is always an immediate threat [14,16]. Generally, multiple factors challenge TADs combating efforts: Requirement of novel systems having capacity of real-time surveillance of emerging diseases. This requires need based research and service oriented scientific technology at regional levels. Need for epidemiological methods to assess the dynamics of infections in the self and neighboring countries/regions, which should again be of real-time utility. Need for research and development of disease diagnostic reagents which do not need refrigeration (cold chain). There are many diseases for which there is inadequate supply of vaccines or there are no vaccines available. Required availability of cost-effective intervention or disease control strategies. Even if a technology is available, it is expensive to adopt at the point of use. Need for ensuring

public awareness of epidemic animal diseases. Many farmers are unaware of the emerging diseases. As such, unless reported to concerned regional authority, an emerging disease may go unnoticed. Shortage of government and private funding for research on emerging animal disease problems. Inadequate regulatory standards for safe international trade of livestock and livestock products. Long period bans from international trade/markets which is: 36 months for LSD and SGP, 24 months for CBPP and PPR, 12 months for FMD, CCPP, CSF and NCD. Difficulties in elimination of trade barriers caused by diseases. Obtaining disease free status for the country is time consuming. Freedom from one of the diseases still doesn't allow exporting. Complex eradication of all diseases is virtually impossible [11,16,20].

TADs management strategies

The international approach to management of TADs is based on the assumption that most can be eradicated. Though after strong challenges, the global eradication of rinderpest was a remarkable achievement for veterinary science and a victory for the international community. However, Rinderpest is the only animal disease eradicated in the world, to date [17,21]. As the epidemiology and biology of PPR virus has much in common with rinderpest virus, progressive control of PPR is underway in Ethiopia [22]. An effective national animal quarantine system should always be in place to prevent the entry and establishment of TADs. Countries therefore need a second line of defense, which is the development of contingency plans and capabilities to respond quickly to TADs should they enter [5,7,10]. Collective efforts and multiple management strategies are needed to prevent or control TADs. The Key strategies are: Strong Border Control: This encompasses preventing incidence of TADs and disease transmitting vectors; minimizing the movement of animals across the borders and prompt practice of quarantine protocol. Geographic information system (GIS) and remote sensing could be utilized as early warning systems and in the surveillance and control of infectious diseases [23].

Early warning/Early reaction: Ensuring appropriate preparedness and response capacity to any emerging disease. Keeping in view that emerging infectious diseases are a constant threat, it is necessary to have early disease detection capacity and then implement a timely response [20].

Breaking disease transmission cycles: The human-livestock-wildlife transmission of infections should be interrupted and surveillance of TADs must focus at the wildlife-livestock interface must [24].

Regional/International Cooperation: this involves establishing regional biosecurity arrangement with capacity for early disease warning system for surveillance, monitoring and diagnosis of TADs [12]. Since TADs are a concern globally, cumulative effort is needed at international level to minimize cross border transmissions [20]. **Strong Policy Support:**

government policies should work hard to enhance animal research and capacity building, and technological development [12].

Breeding management: Undertaking animal breeding strategies to create disease resistant gene pools. Enhancing host genetic resistance to disease by selective breeding of resistant animals is a smart strategy to improve natural immunity of animals to counter invading infections [25].

Environmental Protection: Global warming and climate change predispose animals to newer infections. Therefore, man-made disasters that have adverse implications on climate should be reduced or avoided [11].

Animal diseases management networks

International coordination is essential for the control and elimination of TADs. Rinderpest was eradicated due to the concerted efforts by national authorities; the support of reference laboratories for confirmatory diagnosis or vaccine development and quality control and investment by the international community in the establishment of regional approaches and networks of laboratories and epidemiological units [21].

Surveillance and monitoring of animal diseases and international disease control programs are divided among three organizations: the OIE, the Food and Agriculture Organization of the United Nations (FAO), and the World Health Organization (WHO). The OIE Animal Health Information System provides official information for early warning purposes and details of the worldwide situation for more than 100 animal diseases and zoonoses. The FAO provides technical assistance in dealing with TADs. The WHO has an “alert and response team” for human diseases, including zoonoses. In addition, there are unofficial networks such as ProMED-mail, which is an electronic outbreak reporting system that monitors emerging infectious diseases globally [6].

There is Global Early Warning and Response System for Major Animal Diseases including Zoonoses (GLEWS), a joint FAO, OIE and WHO initiative which combines the strengths of the three organizations to achieve common objectives. Through sharing of information on animal disease outbreaks and epidemiological analysis the GLEWS initiative aims at improving global early warning as well as transparency among countries. The response component of the GLEWS will be complementing the existing response systems of FAO, OIE and WHO (in the field of zoonosis) in order to deliver rapid coordinated international response to animal disease emergencies. Jointly, the three organizations will be able to cover a wider range of outbreaks or exceptional epidemiological events with the provision of a wider range of expertise [26-28].

Conclusion and Recommendations

Livestock constitutes an important component of global agriculture. Increasing movement of human population,

livestock and livestock products within and across countries, and climate changes, have worsened the impact of TADs. TADs reduce production and productivity, disrupt local and national economies, and also threaten human health. This imposes far-reaching challenges for agricultural scientists on the critically important need to improve technologies in animal production and health in order to ensure food security, poverty alleviation and to aid economic growth. TADs can be introduced into a country or region by various means, mainly through legal and illegal importation of animals and animal products. TADs are no respecters of national boundaries. The control and eradication efforts of individual countries may be continually frustrated by re-introduction of disease across their borders. The eradication of TADs therefore can only be achieved through international cooperation and carefully coordinated regional and global programs. The eradication of rinderpest was a typical indicator of such coordination. Consequently, border control is considered an excellent defense against occurrence of many TADs. There is a need for increased ability to detect the clinical signs of highly contagious diseases and the ability to differentiate them from similar afflictions. Thus disease knowledge and awareness on the part of animal health professionals and livestock producers are important steps in preventing the spread of TADs.

Therefore, integrated TADs management measures are required to safeguard the livestock industry and to uphold safe international trade of livestock and their products. To this end, the following points are recommended:

- Veterinary legislation should be enforced with special focus on provisions related to surveillance and early detection of TADs.
- The capacities of veterinary services should be strengthened with focus on laboratory and border control quarantine networks.
- Standard capacity building and technical skills for detection and diagnosis of TADs using OIE-listed tests.
- Laboratory based surveillance of TADs need to be implemented.
- Mounting on lessons learnt from Rinderpest control.

References

1. Anderson I (2002) Foot and Mouth Disease: Lessons to Be Learned Inquiry Report. The Stationery Office, London. Pp.186.
2. FAO (2009) FAOSTAT statistical database. Rome.
3. FAO (2006) Livestock Report 2006. Rome.
4. CSA (2015) Federal Democratic Republic of Ethiopia. Central Statistical Agency, Agricultural Sample Survey Report on Livestock and Livestock Characteristics. Ethiopia.
5. FAO (2004) Transboundary Animal Diseases. Assessment of socio-economic impacts and institutional responses. Livestock policy discussion paper No 9. Otte MJ, Nugent R, et al. (Eds.), Food and Agriculture Organization. Livestock Information and Policy Branch, AGAL, p. 46.

6. CAST (2005) Global Risks of Infectious Animal Diseases. Council for Agricultural Science and Technology, USA.
7. Otte MJ, Nugent R, McLeod A (2004) Trans-boundary animal diseases: Assessment of socio-economic impacts and institutional responses. Livestock policy discussion paper No. 9. FAO, Rome, Italy.
8. MoARD (2009) Ethiopia Freed from the most dangerous Cattle disease. Ministry of Agriculture and Rural Development. Animal and Plant Health Regulatory Directorate. Addis Ababa, Ethiopia.
9. Legesse Y, Asfaw Y, Sahle M, et al. (2012) First confirmation of foot and mouth disease virus serotype SAT-1 in cattle and small ruminants in Ethiopia in 2007/08. *Trop Anim Health Prod.* Springer.
10. Basagoudanavar SH, Hosamani M (2013) Trans-boundary Diseases of Animals: Mounting Concerns. *Vetscan* 7(2) 119.
11. FAO (2008) Expert meeting on climate - related trans-boundary pests and diseases including relevant aquatic species. FAO headquarters, Italy.
12. Rweyemamu MM, Musiime J, Thomson G, Pfeiffer D, Peeler E (2006) Future control strategies for infectious animal diseases- Case study of the UK and sub-Saharan Africa. In: UK Government's foresight project, infectious diseases: preparing for the future, pp. 1-24.
13. Karihaloo JL, Pattnaik B, Pathak KML (2013) Expert Consultation on Managing Trans-boundary Diseases of Agricultural Importance in the Asia-Pacific - Proceedings and Recommendations. Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), India. p. 56.
14. FAO, OIE (2004) Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs). Version approved as basic text. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. World Organization for Animal Health (OIE), Paris, France.
15. Leforban Y (2005) Report of a Mission on FMD in Ethiopia, Proposals for Strategic Plan for a Control Program oriented to exports. Addis Ababa, Ethiopia. pp: 1-43.
16. Thomson GR (2009) Currently important animal disease management issues in sub-Saharan Africa. *Onderstepoort J Vet Res* 76(1): 129-134.
17. OIE (2011) Rinderpest Eradication. World Organization for Animal Health.
18. Griot C, Vandeveldel M, Shobesberger M, Zubriggen A (2003) Canine distemper, a re-emerging morbillivirus with complex neuropathogenic mechanisms. *Anim Health Res Rev* 4(1): 1-10.
19. Cleaveland SM, Laurenson K, Taylor LH (2001) Diseases of humans and their domestic mammals: Pathogen characteristics, host range and the risk of emergence. *Philos Trans R Soc Lond B Biol Sci* 356(1411): 991-999.
20. Hitchcock P, Chamberlain A, Van Wagoner M, Inglesby TV, O'Toole T (2007) Challenges to global surveillance and response to infectious disease outbreaks of international importance. *Biosecur Bioterror* 5(3): 206-227.
21. FAO (2011) The Global Rinderpest Eradication Programme. Progress report on rinderpest eradication: Success stories and actions leading to the June 2011 Global Declaration.
22. FAO-Ethiopia (2012) Strategy for Progressive Control of PPR in Ethiopia. Food and Agriculture Organization of the United Nations and Ethiopia. Addis Ababa, Ethiopia.
23. Martin V, De Simone L, Lubroth J (2007) Geographic information systems applied to the international surveillance and control of trans-boundary animal diseases, a focus on highly pathogenic avian influenza. *Vet Ital* 43(3): 437-450.
24. Siembieda JL, Kock RA, McCracken TA, Newman SH (2011) The role of wildlife in trans-boundary animal diseases. *Animal Health. Res Rev* 12(1): 95-111.
25. Gibson JP, Bishop SC (2005) Use of molecular markers to enhance resistance of livestock to disease: A global approach. *Rev Tech Sci* 24(1): 343-353.
26. FAO, OIE, WHO (2006) Global Early Warning and Response System for Major Animal Diseases, including Zoonoses (GLEWS). World Health Organisation, Geneva, Switzerland.
27. Penrith ML, Thomson G (2012) Analysis of the Status of Transboundary Animal Diseases and their Control in the SADC Region During the Period 2005-2011, Focusing on the Five Countries that Contribute Land to the Kavango Zambezi (KAZA) Transfrontier Conservation Area (TFCA). Technical Report to the Wildlife Conservation Society's AHEAD Program, pp. 74.
28. WHO (2004) Terrestrial Animal Health Code. (12th edn), World Organization for Animal Health (OIE), Paris, pp. 554.



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