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Review on the Socio-Economic Impacts of Trypanosomiasis

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Abstract

Trypanosomiasis is a parasitic disease that causes Animal African Trypanosomiasis, also known as nagana in animals and zoonotic Human African Trypanosomiasis, also referred to as sleeping sickness in humans. Tsetse flies are the primary vectors of African Trypanosomiasis, a disease of paramount importance to both humans and animals across the continent of Africa. The disease can also be mechanically transmitted by a number of biting dipteran flies such as Stomoxys calcitrus and Tabanus species. Tsetse fly occurs in 37 sub-Saharan countries covering nearly 10 million km^2, an area approximately equivelent to one-third of Africa's total land area. The fly and the disease occur in the world's poorest countries with 32 out of the 37 affected countries being ranked the poorest in the world. In Kenya, approximately 138,000 km^2 of land is tsetse infested with 38 out of the 47 counties being affected. Tsetse infested land coverage is roughly 25 percent of Kenya's arable land, which limits livestock production and agricultural development affecting over 11 million Kenyans who are at risk of the disease. Tsetse infestation and trypanosomiasis infection have negative impacts on wildlife health and therefore affects tourism. In the past ten years, Human African Trypanosomiasis cases have been reported in tourists who had visited National Parks/Reserves and also among the local populations. Importation of costly drugs for treatment affects foreign exchange while the disease impacts on the country's agriculture due to reduced milk and meat production, reduced live animal disposal value and reduced work efficiency of oxen used for cultivation. African Trypanosomiasis is considered the most important economically debilitating diseases which mostly contribute to poverty, hunger, and underdevelopment in the affected countries. Human infections affect labour resources and impacts negatively on school children performance which has an effect on their professional advancement later in life. In conclusion,African Trypanosomiasis poses serious threats to the lives and livelihoods of rural communities in Kenya. Therefore there is a priority need to control the disease to open up the affected underdeveloped areas to economic improvement and thus improve the lives of the residents.

Keywords: Trypanosomiasis, Tsetse Fly, Vectors, Economic Impacts

INTRODUCTION

Tsetse flies are the primary vectors that transmit African Trypanosomiasis (AT), a disease of paramount importance to both humans and livestock across the continent of Africa (Devisser & Messsina, 2009). Tsetse flies are of medical and veterinary importance since they are known to be cyclical vectors of trypanosomes parasites which are the causative agents of Animal Africa Trypanosomiasis (AAT) or nagana in animals and Human Africa Trypanosomiasis (HAT) or sleeping sickness (SS) in humans (Kasozi et al., 2021). AT is a neglected disease because it mainly affects poor people and frequently the disease shows a chronic presentation (Gashururu et al., 2021).

Trypanosomes are single celled haemoprotozoan (Devisser et al., 2010, Gona et al., 2016) parasites belonging to the genus *Trypanosoma* (Nthiwa et al., 2015) in the family Trypanosomatidae. The parasite lives and multiplies extracellularly in the blood and tissue fluids of mammalian hosts and are transmitted by a bite of an infected fly (Matthews et al., 2015), mostly by infected tsetse flies.

The causative agents of AT in both human and animals are classified into three most important sub genera; Subgenus *Nannomonas* which comprise of *Trypanosoma congolense*, subgenus *Duttonella* which include *T. vivax and T. evansi* (Kasozi et al., 2021) are the only trypanosome parasites species that can be transmitted both biologically by tsetse flies and mechanically by biting flies, hence these parasites are distributed worldwide even in non-tsetse infested areas (Bouyer et al., 2018).

Subgenus *Trypanozoon* include the sub species *T. brucei brucei, T. brucei rhodensiense* and *T. brucei gambiense. T. b. brucei,* causes AAT whereas the other two sub species *T. b. rhodensiense* and *T. b. gambiense* causes HAT (Nthiwa et al., 2015). Although the two sub species causes Sleeping Sickness (SS) are morphologically similar, they can be distinguished by their distinct disease patterns in humans, clinical signs and differences in disease management regime (Franco et al., 2014). *T. b. gambiense*, causes chronic form of HAT also known as *Trypanosoma brucei gambiense* (gHAT) disease (Surdashi & Brown, 2015). The gHAT is known to occur in Central and West Africa and it accounts for 98% of SS cases reported in the affected regions (Wamwiri & Changasi, 2016). In 2012, Democratic Republic of Congo (DRC) reported the highest number of gHAT cases, contributing up to 84% of all endemic cases that were reported (Crump et al., 2021). Whereas *T. b. rhodesiense* (rHAT) occurs in 13 East and South Africa countries (Büscher et al., 2017), causing acute African trypanosomiasis also known as rHAT and it accounts for less than 2% of all reported cases (Lehane et al., 2016). Both of these parasites sub-spcies are non-pathogenic in domestic animals but the animals are epidemiologically important as they act as reservoirs hosts of the human infective trypanosomes (Hamill et al., 2017; Büscher et al., 2017). The persistent and long-term presence of *T. brucei rhodesiense* in cattle as a reservoir of human infection is of major public health importance with spillover from other domestic livestock causing human rHAT (Muhanguzi et al., 2014). The third subspecies *T. b. brucei* is a parasite primarily of cattle and other domestic and wild animals (Büscher et al., 2017). Exceptionally, Uganda has the distinction of being the only country which has reported both *r*HAT and *g*HAT (Hamill et al., 2017). In Uganda, *Glossina fuscipes fuscipes* (Gff) is the main vector of HAT, where it transmits *g*HAT in the northwest and *r*HAT in central, southeast and western regions.

Chagas disease is another form of Human Trypanosomiasis also considered as a Negleted Tropical Disease (NTD) that is a major public health problem in Brazzil and Latin America and an emerging problem in North America and Europe due to increasing international migrations (Martins-Melo et al., 2014). Chagas disease, also known as American Trypanosomiasis is a chronic infection caused by *Trypanosoma cruzi*. In contrast to Africa where Trypanosomiasis is mainly transmitted by tsetse flies, *T. cruzi* parasites in the Americas are transmitted by insect vector known as triatomine bug, also known as ‘kissing bug' by enabling host contact with infective faeces or urine of the triatomine bug (Martins-Melo et al., 2013).

Transmission of African Trypanosomiasis

AT is a vector-borne disease transmitted biologically by different species of *Glossina* tsetse flies (Degneh et al., 2018) and mechanically by a number of biting dipteran flies such as *Stomoxys calcitrus* and *Tabanus* species ((Kasozi et al., 2021) by acting as flying syringe (Bouyer et al., 2018). Tsetse is a haematophagous insect, and both sexes feed on mammalian blood and thus male and female flies can transmit trypanosomes (Franco et al., 2014). Tsetse is viviparous, and the female fly deposits a fully developed larva that burrows into the soil, pupates, and emerges as an adult fly a month later (Büscher et al., 2017).

The three main species of tsetse flies that transmit trypanosome parasites are *Glossina morsitans,* which is found in the open land of the savannah, *Glossina palpalis*, found in the shaded habitats adjacent to rivers and lakes (Lehane et al., 2016) and Glossina *fusca*, which prefers the highly dense forested areas (Muse et al., 2015; Nthiwa et al., 2015). Some biting flies have been shown to be the mechanical vectors of trypanosomiasis and they include dipteran flies of the genus *Tabanus*, *Haematopota*, *Liperosia, Stomoxys* and *Chrysops* flies which have also been implicated in the transmission of trypanosomiasis (Nthiwa et al., 2015; Kasozi et al., 2021)

Tsetse fly are non host specific disease vectors, showing a wide range of blood feeding preferences with ability to feed on other species of animals in absence of their preferred host (Munang'andu et al., 2012). Tsetse distributions, relies on the presence of ecologically suitable habitat, including suitable climatic conditions and land cover types (McCord et al., 2012**).** Habitats with suitable land cover range from the tropical rain forest to semi-arid grass savannah and wet mangrove, to riparian and woody savannah ecosystems which are most preffered sites for tsetse in order to mitigate the effects of high temperatures and/or dry conditions (McCord et al., 2012).

Eight species of tsetse fy are historically reported to be present in Kenya: *G. brevipalpis*; *G. longipennis* and *G. fuscipleuris* (fusca/forest group, subgenus Austenina); *G. pallidipes*; *G. austeni*; *G. swynnertoni* and *G. morsitans submorsitans* (morsitans/savannah group, subgenus Glossina (sensu stricto)); and *G. fuscipes fuscipes* (palpalis/riverine group, subgenus Nemorhina) (Ngari et al., 2020).

Distribution of African Trypanosomiasis

Trypanosomiasis is endemic in tropical regions of Africa, parts of Asia, and South America (Kasozi et al., 2021). However, *T. brucei s.l., T. congolense, T. simiae*, *T. vivax T. evansi* and *T. uniforme* are transmitted within the tsetse belts of Africa whereas *T. cruzi* is present in South America while *T. theileri* is distributed worldwide (Kasozi et al., 2021).

Tsetse fly occurs in 37 sub-Saharan countries (Wamwiri et al., 2013; Albert et al., 2015; Meyer et al., 2016) covering nearly 10 million km^2, an area which corresponds approximately to one-third of Africa's total land area (Mattioli et al., 2004). The tsetsefly and the Trypanosomiasis disease mostly occur in the world's greatest poor countries with 32 out of the 37 tsetse infested countries being ranked the poorest in the world (FAO, 2002). In Kenya for example, approximately 138,000 km^2 of land is tsetse infested with 38 counties out of the 47 counties being tsetse infested (Ngari et al., 2020). Eight species of *Glossina,* namely; *G. longipenis, G. pallidipes, G. brevipalpis, G. austeni, G. swynnertoni, G. fuscipes fuscipes G. fuscipleuris, and G. morsitans submorsitans* (KENTTEC, 2019) are found in Kenya and are distributed in what is known as tsetse fly belts (Cheruiyot, 2013) dictated by local weather conditions.

In regard to AAT, the major trypanosome species afecting livestock in Kenya are *T. congolense*, *T. vivax*, *T. brucei* and *T. simiae*. Mechanical vectors are known to contribute to the transmission of trypanosomes, especially T. vivax.

Spatial and temporal tsetse distribution patterns correspond to fluctuations in temperature and relative humidity during the dry and wet seasons, especially in semi-arid areas. The tsetse fly belts in Kenya include North and South belts near Mt. Kenya, the South Rift, Lake Victoria basin, Central

Kenya, Trans Mara-Narok, and the Coastal belts.

Articles with the following terms were reviewed; tsetse fly OR African Trypanosomiasis, human African trypanosomiasis OR Animal African trypanosomiasis, Social economic impact of tsetse and trypanosomiasis.

RESULTS

Socioeconomic Impacts of Tsetse and Trypanosomiasis

The African and American trypanosomiasis remains significant global health challenge in human, domesticated animal, and wildlife populations (Kasozi et al., 2021). Livestock production plays a significant economic and socio-cultural role in the livelihoods of rural households in Africa, such as source of food and nutrition supply, and source of draught power, employment income, soil fertility, and capital accumulation (Abro et al., 2021). Livestock production accounts for 40% of total household income across all livestock production systems in SSA (Abro et al., 2021).

Swallow (2000) notes that livestock sector is the key in the entire agricultural production sector by providing animal draught power, meat protein and milk for improved nutrition, income generation and providing green energy (biogas) to households. Abro et al., (2021) further reported that the potential impact of trypanosomiasis on productivity losses is high, reducing meat and milk productivity by 36% and 34% respectively. Livestock sector provides households and communities with healthy foods and enhanced crop production through the use of organic manure from the animals used for improved farming (Gashururu et al., 2021). Studies from Gambia point out that trypanosomiasis reduces milk yield from trypanotolerant cattle by 10-26% (Swallow, 1999). Swallow (1999) additionally expounded that the key effects of trypanosomiasis is that it reduces the lambing rates and kidding rates of trypanotolerant sheep and goat.

Tsetse and Trypanosomiasis (T&T) challenge to livestock and humans is mostly coupled to the wilderness conditions with tsetse breeding sites where farmers perform their daily routine farming activities. This situation upsurges the exposure of people and livestock to tsetse bites in farming zones (Gashururu et al., 2021). AAT is measured as the greatest constraint to livestock and mixed crop-livestock production in tropical Africa (Bouyer et al., 2011). The disease occurs in poor and vulnerable settings of Africa, where it's still disregarded by foreign funders and even by the governments in the endemic countries (Gashururu et al., 2021). The disease causes serious economic losses in livestock due to anemia, loss of condition and effects on their reproduction. Losses in cattle are especially prominent compared to other domestic animals including camel, goats and sheep (Swallow, 2000).

The disease has a significant negative impact on economic growth in most tsetse infested countries in Sub-Saharan Africa (SSA) (Degneh et al., 2017). SSA houses nearly 309 million livestock keepers who live below US$ 2 per day (Abro et al., 2021). About 50 million cattle and other livestock species are at risk of contracting the disease (Alemayehu et al., 2012). AT causes annual mortality of an estimate 3 million cattle (Grady et al., 2011) and other domestic livestock (Alemayehu et al., 2012). Degneh et al., (2017) stated that the indirect economic loss due to trypanosomiasis in SSA is projected to be 4.5 billion USD of GDP per year with an annual direct economic loss of US$ 1–1.2 billion in cattle (Abro et al., 2021). The disease lowers livestock productivity by 20% to 40% costing livestock producers and consumers in Sub-Saharan Africa an estimated loss of billions of dollars annually (Devisser et al., 2010). Ilemobade (2009) estimated that Africa loses up to US$1.5 billion annually due to the impact of tsetse and trypanosomiasis.

Trypanosomiasis also acts as a major block to livestock breed improvement and the intensification of animal production in

Africa, especially where it occurs alongside tick-borne diseases (Meyer et al., 2016). Bukachi et al. (2017) further indicated that African trypanosomiasis reduces animal labour resources and prevents growth of the livestock industry given that high yielding animals are less likely to survive the disease. This therefore affects availability of meat and milk and deprives farmers of draught animal power. Furthermore, Swallow (1999) observed that the impacts of the disease are enormous by causing morbidity and mortality in livestock populations. A sample of livestock owners in the Yalé Province of Burkina Faso were interrogated before and after tsetse control was effected in their area. The livestock owners were Fulani pastoralists who had recently settled in the area with their Zebu cattle. The results indicated that the majority of respondents recognised that there was a substantial reduction in the number of cattle dying due to trypanosomiasis. Livestock owners estimated the rate of mortality in their herds as 63% in 1993 and in 1994, prior to control, and 7% in 1996 and 1997, when the control measures had been implementated (Swallow, 1999).

Besides the productivity losses incurred from trypanosomiasis infection, the fiscal cost of treatment and control of the disease is high. Governments in tsetse infested countries spend US$ 44 million per annum to control the disease (Abro et al., 2021). Annually, almost 70 million doses are procured by farmers in sub-Saharan Africa (Kulohoma et al., 2020). At an average purchase price of $1 per dose and the largest percentage of those treatments are perhaps administered on oxen and cows. Greatest treatments are given to clinically sick animals, not necessarily to animals infected with trypanosomes (Swalow, 1999).

As a result of scanty knowledge on HAT among the rural dwellers others associate the disease with witchcrafts and other associate it with AIDs because of the similarities in the symptoms of the disease. Those symptoms include weight loss, itching, rashes, joint pains, headache, stiff neck, nausea, partial blindness, stomach-ache and paleness of skin colour (Büscher et al., 2017). Households spent a lot of money seeking for treatment from different diviners (Bukachi et al., 2017) before correct diagnosis of disease is well known. Bukachi et al. (2017) in the study showed that the interviewed respondent believed that their HAT disease was as a result of witchcraft because of the different and complicated symptoms it manifests. The respondent incurred a lot of money seeking for treatment from different diviners; for instance, the first diviner consumed 84.81 USD with no positive response in the patient. They then switched to another diviner who also tried in vain because exact cause of the disease is not tackled. Patients take about a month or more before seekig proper medication from sleeping sickness hospital for instance in Kenya at Alupe HAT Referral Hospital.

Besides the treatment cost incurred in treatment households still suffer other secondary expenses such as transport costs to visit the patient, loss of occupation time and loss of income.

Animal trypanosomosis constitutes a major threat to food security and livestock production in several parts of Sub-Saharan Africa (Degneh et al., 2018). It retards agricultural development in large areas of the continent in terms of increased animal mortality, abortion, reduced animal fertility, reduced animals' capability to provide traction power and the need for more frequent treatments of affected animals using preventive and curative doses of costly trypanocidal drugs (Ilemobade, 2009). The use of trypanocidal drugs among the farmers depends principally on the four factors; the type of cattle breeds that they own, whether or not they practice transhumance, their knowledge of the disease and its treatment, and their ability to pay (Swalow, 1999).

Tsetse and trypanosomiasis (T&T) are major impediments to the development of sustainable agricultural systems in the regions where they occur, hitting the poorest of the poor rural people in the most indebted countries in Africa (Ilemobade, 2009).

Swalow (1999) in a study that evaluated the impact of T&T on oxen traction power reported that households outside the tsetse controlled areas do not own oxen and hence unable to cultivate any land using animal traction. Those that have their oxen in these areas can cultivate 0.5 additional hectares. In T&T controlled areas, household without oxen are able to cultivate up to an hectare of land using their own oxen or their neighbours' animals. Farmers cultivate an additional of 0.8 hectares of land for each additional oxen they own. Increase in the size of cultivated land translates to increase agricultural output. As agriculture becomes more productive, output per unit of land and per capita rises resulting in increase household incomes,reduced poverty. Thus finally translates to improved household food security status that leads to reinvestment in the rural economy.

In the deprived rural setting AAT reduces food security by limiting the exploitation of animal draught power and by constraining the optimal utilization of fertile lands (Cecchi et al., 2014). Putt & Shaw (1982) carried out comprehensive studies in Sokwa and Durra districts in Nigeria that showed that there was underutilization of tsetse infested areas. The Sokwo district lies in the Sudan vegetation zone of Nigeria on the east bank of the Katagum River, the flood plains of which were infested with both *G. morsitans* and *G. tachinoides*. The presence of *G. morsitans* severely limited the extent to which valuable dry season grazing in the riverine flood plain could be utilized by livestock. The presence of *G. tachinoides*, which earlier had been incriminated as the vector of exceptionally virulent outbreaks of sleeping sickness in the district, effectively discouraged the cultivation of the fertile riverine areas. Burra district is located in the Northern Guinea Savannah. Although Durra is also infested with *G. morsitans* it had been little affected by sleeping sickness and, because of the hilly nature of much of its terrain, little areas were cultivated. Prior to 1959, this district had been free of *G. morsitans* and it had been extensively utilized as a grazing area. Over the years however, the district was invaded by *G. morsitans* as part of a widespread advance of a tsetse belt. The whole district became infested and was almost completely abandoned by the livestock sector (Putt & Shaw, 1982).

T&T affects the number of tourist visiting the National Parks and Reserve which negatively effect revenue collection of a country (Gamba et al., 2021). Worldwide records show that from 1995 to 2010 a total of 75 international HAT cases involved travellers that had once visited African countries (Muse et al., 2015; Büscher et al., 2017). Between 2000-2010, 94 HAT cases were reported in non-endemic countries. Specifically, 72% of cases were due to the Rhodesiense HAT, and 28% due to Gambiense HAT (Simarro et al., 2012). Rhodesiense HAT classically occurs in tourists visiting the game parks of East and South Africa (Surdashi & Brown, 2015) which affects the tourism sector.

For the period 2012–2016, 22,281 new HAT cases were reported, 87.3% of which could be mapped at the village level of Africa (Franco et al., 2018). Franco et al. (2018) further documented that in West Africa, Guinea continues to be the most affected country and in Central Africa, active screening activities have continued to be routinely carried out and this has helped detect passive cases. Active screening has been erratic in Central African Republic (CAR) owing to important security constraints, and disease cases that are reported rely only on a weak passive surveillance (Franco et al., 2018). Thus, in African countries where there is insecurity, economic impacts of trypanosomiasis have not been determined.

Migrants from countries affected by HAT could pose diagnosis challenges to health services in countries where the disease is not endemic (Surdishi & Brown, 2015).

Tanzania, Zambia and Zimbabwe continue to report low numbers of cases, nevertheless HAT surveillance in these countries has declined in recent years (Franco et al., 2018). In Kenya, no autochthonous case has been reported over the last 10 years, despite an operational surveillance system. The last two cases reported in 2012 were tourists infected during visits to the Masai-Mara National Reserve, and were diagnosed in Germany and Belgium. In Tanzania, out of 13 cases declared during the same period, 5 cases were diagnosed in tourists in non-endemic countries including Sweden, South Africa, Spain, Italy and Netherlands. In Zambia, out of a total of 37 cases declared, 9 were diagnosed among travelers in non-endemic countries with 2 in South Africa, 2 in USA and 1 from each of the following countries; France, Argentina, United Kingdom, India and Canada (Franco et al., 2018).

African trypanosomiasis occurs in remote rural areas where health structures are weak or non-existent and tends to affect economically energetic people (Bukachi et al., 2017). Trypanosomiasis, especially HAT is limited to specific geographic foci (Welburn et al., 2016) characterized by remoteness as well as neglect, besides political instability in the area and armed conflict such as in South Sudan and Somalia (Tong et al., 2011).

The disease affects the world's poorest country and occur in areas where there are no specialized doctors, no drugs, no diagnostic equipment and expertise. In addition, it occurs in area where hunger is greatest, incomes sources are lowest, human needs are greatest and food security is least assured (Bukachi et al., 2017) this affects diagnosis and treatment of disease.

The resulting burden of HAT infection is heavy on families since infected individuals become unproductive and also close relatives have to spend time taking the sick for treatment and looking after them in hospital and at home. Time and money spent on seeking treatment seriously drains the family resources. If the disease is left untreated, the final outcome for the patient is death, but equally devastating is its effect on households and communities quality of life resulting from its insidious and debilitating nature. Economically, the effects of the disease are costly for young and developing economies, the situation in most African countries, which are predominately dependent on agriculture (Bukachi et al., 2017).

Poor academic performance in school is experienced by children either directly or indirectly affected by HAT. The children who suffered from HAT had to miss school several times due to ill health. Direct impact of HAT is that children who suffer the disease have to miss school several times due to their ill health. Others of the HAT patients of school going age were forced by circumstances of ill health to miss school while others eventually dropped out of school.

Children whose parents or family members suffered from HAT also experienced schooling problems as a result of the families trying to cope with the financial constraints experienced as a result of seeking treatment. This led to diversion of school fees to seeking treatments and for providing the needs of the sick hence contributes to school absenteeism and even culminate in dropping out (Bukachi et al., 2017). This in turn results in increased crimes in rural areas and cities, drug addiction increased unemployment due to unskilled personnel and even low life expectancy rate (Njenga, 2007).

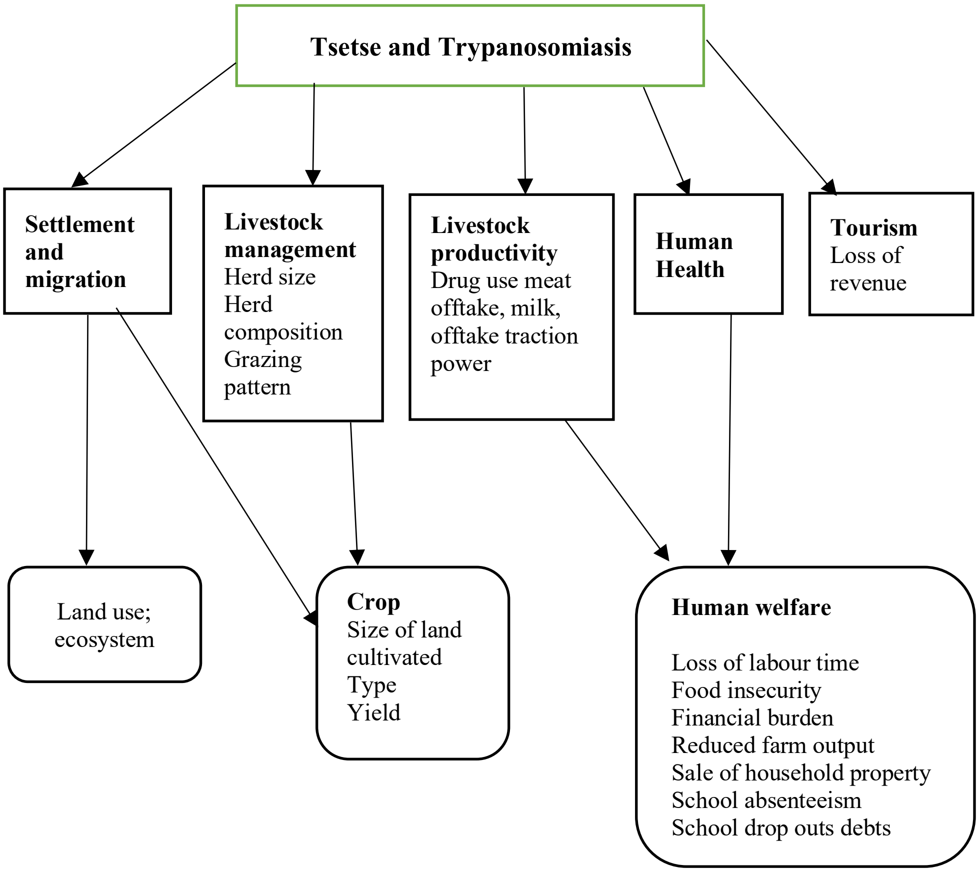

Figure 9: Impacts of tsetse and trypanosomiasis.

The economic losses interrelated to AAT and HAT led to initiation of Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC). Tsetse and trypanosomiasis control campaigns (Simo et al., 2015). PATTEC was coordinated by the African Union in-country officials (Ngari et al., 2020). Campaign was initiated by the African Heads of State and Government in 2000 with an aim to eradicate tsetse and trypanosomiasis from Africa. Kenya embarked on the initiative and in 2005 it established the PATTEC Unit under the Department of Veterinary Services. The PATTEC project spearheaded efforts to eliminate tsetse and trypanosomiasis in Kenya until 2011 (Ngari et al., 2020). Through the PATTEC, the AU envisions a continent with no trypanosomiasis. PATTEC assisted countries by providing financial, policy, and institutional support to reduce the impact of trypanosomiasis. AU in collaboration with Food and Agriculture Organization (FAO) provided technical and financial support to eradicate the disease (Abra et al., 2021). In spite several efforts by multilateral institutions to eradicate the problem, trypanosomiasis remains a threat to SSA and the problem may further be worsened by climate change as it may increase the incidence of tsetse fly in traditionally non-tsetse fly areas.

To achieve Sustainable Development Goals (SDGs) in SSA the livestock sector's limitation needs to be addressed as it is one of the key sources of livelihood for poor rural people. SSA is one of the world's developing regions where food insecurity and malnutrition are widespread and controlling trypanosomiasis is one potential avenue to improve livelihoods in the households and communities.

Introduction of dairy breeds to tsetse freed areas is possible. The tsetse and trypanosomiasis interventions in Mwea National Reserve and its environs is one of the successful interventions where tsetse flies have reduced below detectable levels (Ngari et al., 2020). This has up land for agricultural production and dairy farming. Over 1,000 exotic dairy animals have been introduced into areas by the communities and commercial farms have come up in areas previously infested. For example, Thiba Farm in Mwea has over 100 dairy cattle and goats employing over 200 youth and women from the area (Gamba et al., 2021).

No vaccine is currently available to control African animal trypanosomiasis and therefore control continues to depend on chemoprophylaxis, chemotherapy and environmental management against the vectors (Gamba et al., 2021). Drug prophylaxis is an effective trypanosomiasis control method (Lehane et al., 2016). Some of the older drugs such as the Quinapyramine derivatives Antrycide and AntrycideProsalt are still useful and give effective protection against *T. brucei* infection in horses, camels, and cattle (Franco et al., 2014). The drug Pyrithidium bromide is useful in the prophylaxis of *T. vivax* and *T. congolense* infections in cattle, sheep, and goats and a dose can give protection for up to 6 months (Lehane et al., 2016).

The most widely used of the newer drugs is Isometamidium chloride and Homidium bromide have also been found to be effective drugs in Kenya (KENTTEC, 2019), and the newly introduced arsenical Cymelarsan is effective in treatment of *T. brucei* infection (Cheruiyot, 2013). A very widely used drug is Diminazine aceturate, which is effective against all three African Animal Trypanosomes (Franco et al., 2014). The Isometamidium drugs are also excellent chemotherapeutic agents as are the quaternary ammonium compounds Antrycide Ethidium and Prothidium (Lehane et al., 2016).

CONCLUSION

Tsetse and trypanosomiasis causes enormous economic losses in Africa, Therefore, successful tsetse and trypanosomiasis control would result in lower livestock morbidity and mortality losses, will save farmers from trypanosomiasis treatment costs. This will lead to extra livestock productivity in terms of higher meat and milk production due to the ability of cattle populations to fully exploit the dry season grazing of the flood plains in tsetse freed areas. Animal draught power will enable cultivation of more land.

Tsetse and trypanosomiasis control will also allow introduction of improved most productive livestock and introduction of trypanosomiasis endangered wildlife like White Rhino in the parks. This will increase revenue from farming and from tourism.

Human populations freed from tsetse and trypanosomiasis will result in healthy and more productive population. This will result in improved livelihood and better school performance in children and in their career preparation.

Trypanosomiasis affects the economies of SSA by reducing the productivity of livestock, human labor, and animal draught power. Eradicating the disease would contribute to poverty reduction and achievement of sustainable development goals. It will also result in increased meat and milk production in SSA, where malnutrition and food insecurity are limiting factors to human labor productivity.

RECOMMENDATIONS

Tsetse and trypanosomiasis remains a threat to livestock farmers in Sub Saharan African and this challenge calls for innovative control techniques that are financially sustainable and environmentally friendly to address the needs of the poor livestock farmers in African countries which are affected. There is need to strengthen Pan African eradication programmes in all affected countries to ensure that no areas are left behind that will act as reservoirs for the transmission of the disease.

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