

# **Report of the first WHO stakeholders meeting on rhodesiense human African trypanosomiasis**

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Report of the first WHO stakeholders meeting on rhodesiense human African trypanosomiasis

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Cover page: Illustration from the original "Positif dans la moelle osseuse" by Nestor Favre-Mossier, owned by the Perez Simarro family

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## **ABBREVIATIONS AND ACRONYMS**

AAT	animal African trypanosomiasis
AO	acridine orange
BIIT	blood incubation infectivity test
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
COCTU	Co-ordinating Office for Control of Trypanosomiasis in Uganda
CSF	cerebrospinal fluid
DIB	development impact bond
DFID	Department for International Development (United Kingdom)
DFID RIU	DFID Research Into Use programme
DNDi	Drugs for Neglected Diseases initiative
DVO	district veterinary officer
ECF	East Coast fever
ECG	electrocardiogram
ELISA	enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization of the United Nations
FIND	Foundation for Innovative New Diagnostics
GMA	game management areas
HAT	human African trypanosomiasis
g-HAT	gambiense human African trypanosomiasis
IAEA	International Atomic Energy Agency
ICIPE	International Centre of Insect Physiology and Ecology
IDM	Innovative and Intensified Disease Management
IFAT	indirect fluorescent antibody test
IRD	Institut de Recherche pour le Développement
ISG	invariant surface glycoprotein
KALRO	Kenya Agricultural and Livestock Research Organisation
KETRI	Kenya Trypanosomiasis Research Institute
LAMP	loop-mediated isothermal amplification
LSTM	Liverpool School of Tropical Medicine
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
mAECT	mini-anion exchange centrifugation technique
mAECT BC	mAECT on buffy coat
mHCT	micro-haematocrit centrifugation technique
MoH	Ministry of Health
MoHSW	Ministry of Health and Social Welfare
MoLFD	Ministry of Livestock and Fisheries Development
MSC	modified single centrifugation

NASBA	nucleic acid sequence-based amplification
NGO	nongovernmental organization
NSSCP	National Sleeping Sickness Control Programme
NTD	neglected tropical disease
OIE	World Organisation for Animal Health
PAAT	Programme Against African Trypanosomiasis
PATTEC	Pan African Tsetse and Trypanosomiasis Eradication Campaign
PCR	polymerase chain reaction
QBC	quantitative buffy coat
r-HAT	rhodesiense human African trypanosomiasis
RAP	restricted application protocol
RBC	red blood cells
RBC lysis-AO	red blood cell lysis – acridine orange
RDT	rapid diagnostic test
RIME	repetitive insertion mobile element
RRTT	rapid response technical team
SACEMA	South African Centre for Epidemiological Modelling and Analysis
SAT	sequential aerosol technique
SEEG	Spatial Ecology & Epidemiology Group
SIT	sterile insect technique
SRA	serum resistance-associated gene
SRUC	Scotland's Rural College
STAG	Strategic and Technical Advisory Group
SOS	Stamping Out Sleeping sickness
UTCC	Uganda Trypanosomiasis Control Council
VSG	variant surface glycoprotein
WBC	white blood cell
WHO	World Health Organization
ZAWA	Zambia Wildlife Authority

# 1. Introduction

In response to a dramatic resurgence of human African trypanosomiasis (HAT) by the end of the 20th century, joint efforts by the World Health Organization (WHO) and partners since 2000 helped reverse the epidemic and led to a progressive decline in the number of new cases reported annually.<sup>1</sup> These efforts led also to scientific and technical advances in several domains, including epidemiology, diagnostic and therapeutic tools, and vector control.

In May 2007, representatives of HAT-endemic countries endorsed the goal of elimination of the disease as a public health problem.<sup>2</sup> In 2011, the WHO Strategic and Technical Advisory Group (STAG) for neglected tropical diseases (NTDs) judged elimination to be technically feasible and HAT was included in the WHO Roadmap on NTDs (“the Roadmap”), with a target for elimination as a public health problem by 2020.<sup>3</sup>

In January 2012, a number of partners from the public and private sectors launched the largest coordinated effort against NTDs and issued the *London Declaration on Neglected Tropical Diseases*,<sup>4</sup> a renewed, coordinated approach for accelerating the eradication, elimination or control of 10 NTDs by 2020. The partners pledged to work together to improve the lives of the 1.4 billion people affected by NTDs worldwide by enhancing the supply of existing medicines, stimulating collaborative research for new treatments and increasing funding for control or elimination activities. They targeted HAT for elimination alongside five other diseases, and endorsed the Roadmap.

In December 2012, national sleeping sickness control programmes (NSSCPs), experts from WHO collaborating centres and the STAG-NTD formulated the strategies, tools, monitoring indicators and milestones for the process of eliminating gambiense HAT (g-HAT). They considered elimination of g-HAT as a public health problem as an intermediate objective that should be followed by the elimination of the disease, defined as the absence of transmission resulting in zero cases reported in all foci, and proposed 2030 as the deadline for this new outcome of elimination.<sup>5</sup>

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<sup>1</sup> Simarro PP, Diarra A, Ruiz-Postigo JA, Franco JR, Jannin J. The Human African Trypanosomiasis Control and Surveillance Programme of the World Health Organization 2000–2009: the way forward. *PLoS Negl Trop Dis.* 2011;5:e1007.

<sup>2</sup> Report of a WHO informal consultation on sustainable control of human African trypanosomiasis. Geneva, 1–3 May 2007. Geneva: World Health Organization; 2007 (WHO/CDS/NTD/IDM/2007.6; [http://whqlibdoc.who.int/hq/2007/WHO\\_CDS\\_NTD\\_IDM\\_2007.6\\_eng.pdf](http://whqlibdoc.who.int/hq/2007/WHO_CDS_NTD_IDM_2007.6_eng.pdf)).

<sup>3</sup> Accelerating work to overcome the global impact of neglected tropical diseases: a roadmap for implementation. Geneva: World Health Organization; 2012 (WHO/HTM/NTD/2012.1; [http://www.who.int/neglected\\_diseases/NTD\\_RoadMap\\_2012\\_Fullversion.pdf](http://www.who.int/neglected_diseases/NTD_RoadMap_2012_Fullversion.pdf)).

<sup>4</sup> The London Declaration on Neglected Tropical Diseases ([http://www.unitingtocombatntds.org/downloads/press/london\\_declaration\\_on\\_ntds.pdf](http://www.unitingtocombatntds.org/downloads/press/london_declaration_on_ntds.pdf)).

<sup>5</sup> Report of a WHO meeting on elimination of African trypanosomiasis (*Trypanosoma brucei gambiense*). Geneva, 3–5 December 2012. Geneva: World Health Organization; 2013 (WHO/HTM/NTD/IDM/2013.4; [http://apps.who.int/iris/bitstream/10665/79689/1/WHO\\_HTM\\_NTD\\_IDM\\_2013.4\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/79689/1/WHO_HTM_NTD_IDM_2013.4_eng.pdf)).

In April 2013, a WHO Expert Committee on human African trypanosomiasis control and surveillance updated the epidemiological patterns of the disease, diagnostic approaches and new therapeutic regimens. The Committee addressed the recommendations for achieving disease elimination and conversely to g-HAT, being rhodesiense HAT (r-HAT) – a zoonosis with both domestic and wild hosts – its elimination as total interruption of transmission was therefore not considered technically feasible at that time.<sup>6</sup> Elimination of r-HAT requires a tailored, multisectoral approach not necessarily the same as that developed for g-HAT.

In view of this situation, WHO convened two separate meetings of stakeholders: one related to g-HAT and the other to r-HAT. In March 2014, WHO held the first stakeholders meeting on the elimination of g-HAT, which was complemented in October 2014 by this meeting of the main stakeholders working to fight r-HAT. This meeting updated the status of r-HAT transmission at the country level and the challenges of health ministries in tackling the disease (see Agenda in Annex 1). The meeting was intended to reinforce the cohesion of stakeholders and the spirit of cooperation through the different sectors concerned with the prevention and control of r-HAT.

## **2. Objectives**

The objectives of the meeting were:

1. To update the current status of the disease transmission, country capacities and plans for tackling the disease.
2. To understand the epidemiology including disease distribution and risk, the models for estimating under-detection, the geographical variations of in clinical presentation, the roles of domestic and wild animal reservoirs and the subsequent different transmission patterns and control approaches, including vector control.
3. To update current research and development efforts for improving diagnostic and treatment tools.
4. To define the goals for achieving the control of r-HAT, the need for a multisectoral approach and to discuss the strategy for controlling r-HAT and the coordination mechanisms.

## **3. Opening remarks**

Dr Dirk Engels, Director, WHO Department of Control of Neglected Tropical Diseases, welcomed the participants on behalf of Dr Hiroki Nakatani, Assistant-Director General,

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<sup>6</sup> Control and surveillance of human African trypanosomiasis: report of a WHO Expert Committee. Geneva: World Health Organization; 2013 (WHO Technical Report Series, No. 984; [http://apps.who.int/iris/bitstream/10665/95732/1/9789241209847\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/95732/1/9789241209847_eng.pdf)).

HIV/AIDS, Tuberculosis, Malaria and Neglected Tropical Diseases. He recalled that this meeting was the second of two on the control and elimination of HAT; the first meeting (March 2014) had considered the gambiense form. He highlighted the tremendous progress for this complicated disease, with no ideal tools, as a leading example for other NTDs. He emphasized the particular challenges of r-HAT as it is an acute zoonotic disease with epidemic potential. Finally, he expected the meeting to allow a review of the new tools in the pipeline and to anticipate what progress could be achieved towards the elimination of r-HAT as a public health problem.

Dr Jean Jannin, Coordinator, Innovative and Intensified Disease Management (IDM), WHO Department of Control of Neglected Tropical Diseases, recalled the historic fight against HAT and the key dates, the 20 years of collaboration with the Food and Agriculture Organisation of the United Nations (FAO) and the almost 15 years of collaboration with the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC). He welcomed the attendance of more participants from the private sector as observers. Elimination of r-HAT as a public health problem is part of the Roadmap for 2020. However, its low prevalence today could underestimate the real situation (owing to misdiagnosis and underreporting) and the risk of epidemics remains, as it has happened in the past. Challenges include the zoonotic aspect of the disease, implying mandatory collaboration between the veterinary and human public health sectors to sustain progress; the existence of a wildlife reservoir that cannot be removed, posing the highly challenging task of interrupting transmission; and the reduction in the number of cases, leading to the loss of both medical expertise and governmental commitment. The first stakeholders meeting on the elimination of g-HAT (March 2014) had opened a new era for HAT. The current meeting provided a unique momentum for needed decisions on the successful coordination of r-HAT activities.

Dr Pere Simarro, Head, HAT control and elimination programme, IDM, WHO Department of Control of Neglected Tropical Diseases, announced those participants who had declared a conflict of interest.

Professor Peter Holmes, the current Chairman of the STAG-NTD, was elected as the Chairman of the meeting. He emphasized the progress made against g-HAT yet the persistent challenges in the control of r-HAT, the zoonotic form of the disease. He then introduced the agenda and recalled the objectives of the meeting.

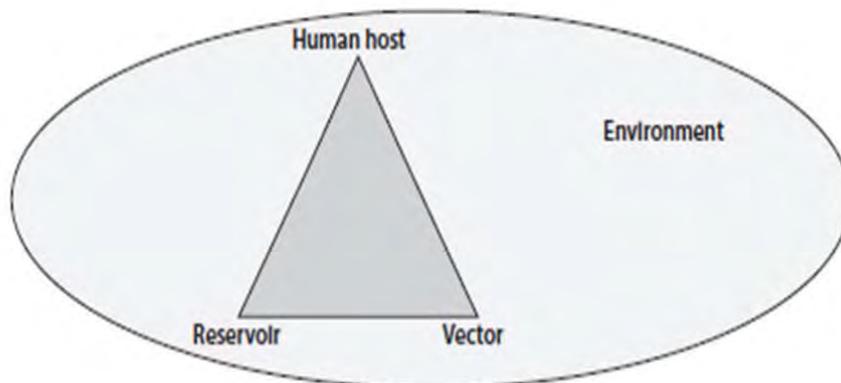
The meeting was attended by high-level representatives of most of the stakeholders involved in the fight against r-HAT (see List of participants in Annex 2).

#### **4. Epidemiology of r-HAT**

The transmission cycle of r-HAT, like that of g-HAT, involves obligate development of the trypanosome in a tsetse fly. In both forms of HAT, infection requires association of the three elements of the “epidemiological triangle”: human host, reservoir and tsetse fly in an appropriate environment (Figure 1). But whereas for g-HAT the main reservoir is human

beings, r-HAT is a **zoonotic disease**, i.e. it requires a non-human reservoir for maintaining its population.

**Figure 1.** Epidemiological triangle for the transmission cycle of human African trypanosomiasis<sup>a</sup>



<sup>a</sup> Source: WHO Expert Committee on control and surveillance of human African trypanosomiasis, 2003.<sup>7</sup>

This zoonotic characteristic of r-HAT has huge implications on its epidemiology and for its control. The first stakeholders meeting on r-HAT therefore began by considering what is a reservoir, which are the reservoirs for r-HAT and how the parasite can be controlled inside these populations.

## 4.1. Animal reservoir for r-HAT

### 4.1.1. General considerations

The term “reservoir” commonly refers to an animal that harbours a human disease, implying that a reservoir is a host. However, for a zoonotic disease, the reservoir should have an epidemiological role in transmission to humans.

There are three sub-terms of relevance concerning the definition of a reservoir (see also Figure 2):

A **reservoir host** is one or more epidemiologically connected populations or environments in which a pathogen can be **permanently maintained** and from which **infection is transmitted to the target population**.

Some reservoirs can comprise a structured set of connected host subpopulations capable of maintaining the pathogenic agent, termed a “maintenance population”.

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<sup>7</sup> Control and surveillance of human African trypanosomiasis: report of a WHO Expert Committee. Geneva: World Health Organization; 2013 (WHO Technical Report Series, No. 984).

→ *Example in r-HAT: Cows may constitute a large population, capable of maintaining T. b. rhodesiense alone; if transmission occurs from cows alone to humans, cows are both a reservoir and a maintenance population.*

If one considers a different target, the reservoir may change (flexible definition). In r-HAT, humans are considered as the target population.

A **liaison host** is one that is capable of acquiring an infection, and by virtue of its natural history, has a **significant role in transmitting** that infection (to humans), but is not capable of sustaining the pathogen long-term (and indeed “relies” on the reservoir host population to do so).<sup>8</sup>

- Liaison host populations create greater opportunities for transmission, but they are not a reservoir.

→ *Example: pig?*

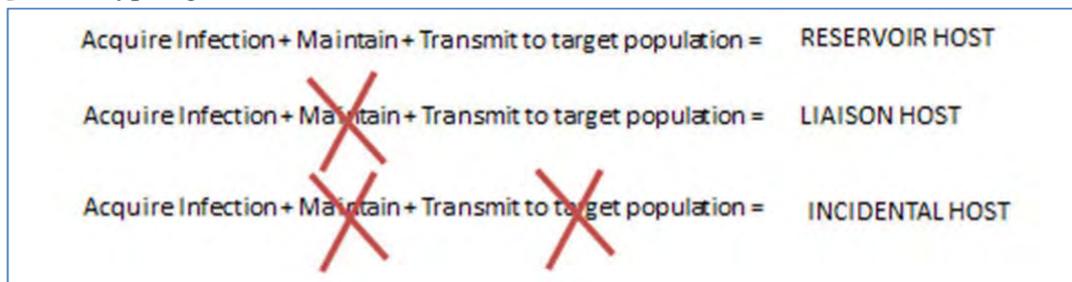
- *Pigs may constitute a small population, incapable of maintaining T. b rhodesiense alone – because the pig population is below the critical community size for the pathogen*
- *Effectively, there is not enough “pig-only environment to live in” (analogous to an endangered bird species becoming extinct – because of deforestation of its habitat)*
- *However, pigs + others generate a more sustainable habitat for the pathogen to persist*
- *Pigs are part of the reservoir but are not a maintenance population*

An **incidental host** is one that may acquire an infection but plays **no significant role in either sustaining the pathogen or transmitting** it (to humans).

- Incidental hosts may be part of the reservoir population as long as they contribute to transmission in the target population.

→ *Example: monitor lizard.*

**Figure 2.** Typologies of “hosts”



<sup>8</sup> Begon M. Disease: health effects on humans population effects on rodents. In: Singleton GR, Hinds LA, Krebs CJ and Spratt DM, editors. Rats, mice and people: rodent biology and management. Canberra, Australian Centre for International Agricultural Research; 2003 (Monograph No. 96).

Several animal species have been identified as hosts of the trypanosomes infective to humans, but an important distinction must be drawn between *infection* or *carriage* and *epidemiological role in transmission*.

To be able to define the reservoir, different types of **studies are required**. In some locations, good-quality data are available, whereas in others such studies have never been formally undertaken:

- Natural history studies to describe what species are infected, to what extent and where
- Case control studies to identify risk factors (e. g. association with particular species)
- Longitudinal studies to look at host and parasite survival over time, studies of within-host dynamics (e.g. population structure and transmissibility)
- Modelling of transmission and persistence

#### **4.1.2. Animal reservoir**

##### **a. Domestic animals**

A number of domestic species can be hosts of *T. b. rhodesiense* (pigs, dogs, goats, sheep and cattle). The prevalence of *T. b. sensu lato* and *T. b. rhodesiense* in cattle has probably been underestimated. Since, initially, veterinary active surveillance was based only on use of field microscopy, which is insensitive for low parasitaemia and cannot differentiate species or subspecies of trypanosome. Progress was made with the arrival of DNA-based tools, which were more sensitive for low levels of parasitaemia and could differentiate species, but could not differentiate between human infective *T. b. rhodesiense* and non-human infective *T. b. brucei*. However, since 2001, an SRA (serum resistance associated gene) has been identified and adapted to a near field tool, enabling more accurate estimation of *T. b. sensu lato* and *T. b. rhodesiense* prevalence.

Many studies have shown the importance of **cattle** as epidemiological reservoirs in Uganda. The basic reproduction number ( $R_0$ ) has been defined for single-host pathogens as the expected number of secondary cases arising from a primary case in a wholly susceptible population. Its estimates for r-HAT are relatively low and cattle appeared essential for disease maintenance even if the relative role of each host is difficult to estimate. Over the past 2 decades, livestock trade has been the single most important cause of the geographical spread of *T. b. rhodesiense* in south-eastern Uganda.<sup>9,10</sup> It represents the principal cause of recent outbreaks in Uganda. Cattle movements have always occurred in Uganda, but lately the large programme of post-conflict restocking of livestock leads to extensive commercial movements

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<sup>9</sup> **Spread** is defined as “the translocation to a previously unaffected location and establishment of new focus”, conversely to expansion, which is the increase in the superficies of historically stable foci.

<sup>10</sup> Fèvre EM et al. The origins of a new *Trypanosoma brucei rhodesiense* sleeping sickness outbreak in eastern Uganda. *Lancet*. 2001;358: 625–8.

in the opposite direction than in the past, conveying cattle northwards from endemic to non-endemic areas.

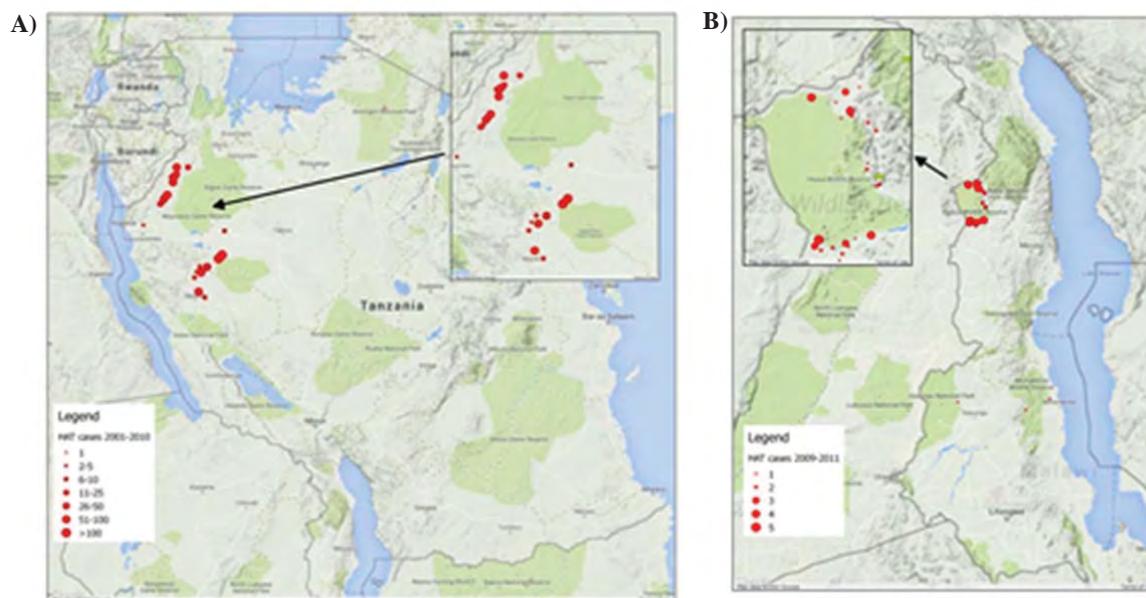
The increasing **pig** population in many livestock-keeping areas of eastern Africa could also represent a threat. Indeed, pigs have been found with significant prevalence of *T. b. rhodesiense* (up to 3% in some studies, with higher odds of infection than cattle<sup>11</sup>). In addition, they are highly interactive with human populations.

### **b. Wild animals**

In several countries in east and southern Africa, r-HAT cases are predominantly associated with wildlife areas, as they are located around national parks (Figure 3) or clustered in tourists visiting national parks. The role of wildlife as reservoirs is difficult to prove definitively. However, the same *T. b. rhodesiense* have been isolated in wildlife and human cases and *T. b. rhodesiense* from wildlife species was shown to infect people. Few robust studies have been conducted identifying risk factors for human infection, but there is considerable correlative and anecdotal evidence linking wildlife infection to human disease.

In addition, the role of cattle in wildlife–livestock–human interface zones is unclear.

**Figure 3.** Mapping of r-HAT cases, 2001–2011<sup>a</sup>

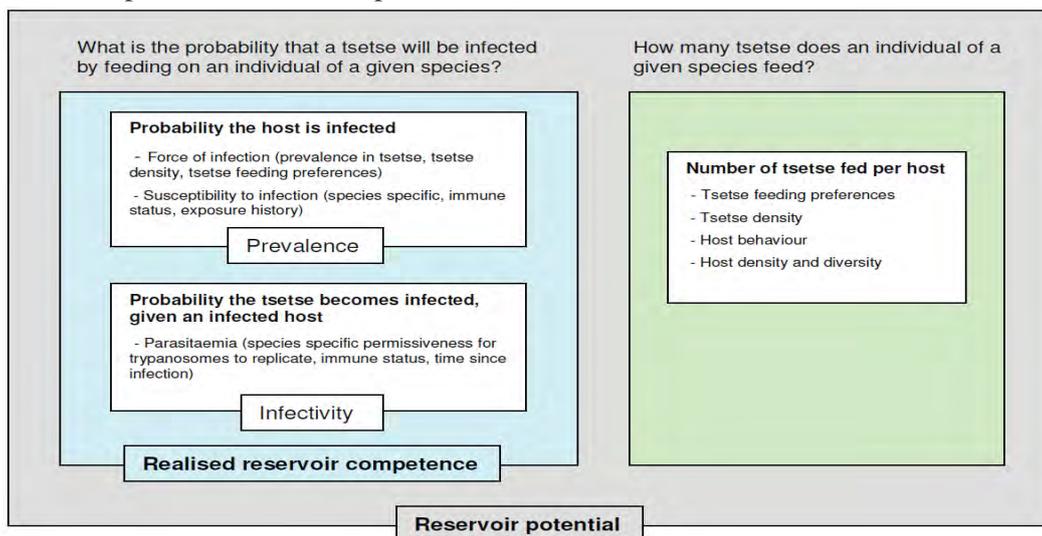


<sup>a</sup> Source: H. Auty; maps courtesy of FIND. (A) Tanzania, 2001- 2010; (B) Malawi, 2009-2011

<sup>11</sup> von Wissmann B, Machila N, Picozzi K, Fèvre EM, de C Bronsvort BM, Handel IG et al. Factors associated with acquisition of human infective and animal infective trypanosome infections in domestic livestock in western Kenya. PLoS Negl Trop Dis. 2011;5: e941.

The **potential** for a species to be a reservoir depends on its **competence** as a reservoir, i.e. the probability that the host is infected (**prevalence**) and the probability that the susceptible feeding tsetse becomes infected (**infectivity**), as well as on the **tsetse feeding preferences** (Figure 4).

**Figure 4.** Components of reservoir potential<sup>a</sup>



<sup>a</sup> Source: adapted from JL Brunner et al., 2008.<sup>12</sup>

○ **Is wildlife infected by *Trypanosoma brucei rhodesiense*?**

*T. b. sensu lato* has been identified in a broad range of wild hosts (black rhino, buffalo, bushbuck, cheetah, duiker, eland, giraffe, greater kudu, hartebeest, hippopotamus, impala, lechwe, leopard, lion, reedbuck, hyaena, topi, warthog, waterbuck, wildebeest and zebra). *T. b. rhodesiense* has also been identified in different wild species (Table 1). In general, *T. b. rhodesiense* has been identified in the same species as *T. b. sensu lato*, and identified more often in species with higher prevalence of *T. b. sensu lato*.

<sup>12</sup> Brunner JL, LoGiudice K, Ostfeld RS. Estimating reservoir competence of *Borrelia burgdorferi* hosts: prevalence and infectivity, sensitivity, and specificity. J Med Entomol. 2008;45:139–47.

**Table 1** Review of identifications of *Trypanosoma brucei rhodesiense* in wildlife<sup>a</sup>

Species	Location	Technique	Reference
Bushbuck	Nyanza Province Kenya Luangwa Valley, Zambia	HV BIIT	Heisch et al. 1958 Rickman et al. 1991
Duiker	Luangwa Valley, Zambia	BIIT	Rickman et al. 1991
Giraffe	Luangwa Valley, Zambia	BIIT	Rickman et al. 1991
Hartebeest	Serengeti, Tanzania	BIIT, HV	Geigy et al. 1971, Geigy et al. 1973
Hyaena	Nyanza Province Kenya Serengeti, Tanzania	ISO BIIT, HV	Gibson and Wellde 1985 Geigy et al. 1971, Geigy and Kauffmann 1973, Onyango et al. 1972
Impala	Luangwa Valley, Zambia	BIIT	Mulla and Rickman 1988, Rickman et al. 1991
Lechwe	Northern Botswana	BIIT	Drager and Mehlitz 1978
Lion	Luangwa Valley, Zambia Serengeti, Tanzania	BIIT BIIT, HV	Rickman et al. 1991 Geigy et al. 1971, Geigy and Kauffmann 1973, Onyango et al. 1972
Oribi	Nyanza Province, Kenya	ISO	Gibson and Wellde 1985
Reedbuck	Nyanza Province, Kenya Lambwe, Kenya	BIIT	Allsopp 1972, Robson et al. 1972 Njiru et al. 2004
Warthog	Luangwa Valley, Zambia Serengeti, Tanzania	BIIT SRA PCR	Awan 1979, Dillmann and Townsend 1979, Rickman et al. 1991 Kaare et al. 2003
Waterbuck	Luangwa Valley, Zambia Serengeti, Tanzania	BIIT BIIT	Dillmann and Townsend 1979, Rickman et al. 1991 Geigy et al. 1971
Zebra	Luangwa Valley, Zambia	BIIT	Mulla and Rickman 1988

<sup>a</sup> Source: H. Auty

○ **On which animals do tsetse flies feed?**

An analysis of blood-meal provides information on which animals the tsetse mainly feed. For example, *Glossina morsitans* have been found to feed mainly on warthogs, ruminants and hippopotamus, *G. pallidipes* predominantly on ruminants. Feeding patterns play an important role in the importance of different wildlife species in maintaining *T. b. rhodesiense* in circulation.

### ***4.1.3. Gaps in knowledge***

Where livestock are the principal reservoir, there are still questions to be answered:

- Formal quantification of the role of different livestock species in all at-risk areas, including their role in transmission ( $R_0$ ); a detailed understanding of the livestock trading systems is essential to control with respect to the livestock reservoir.
- Implementation of multi-partner programmes is desirable.
- Epidemiological patterns will be determined by distributions of reservoirs, of people and other components of the transmission systems (environment, tsetse).

Relatively little is known about trypanosomes in wildlife. The following gaps in knowledge therefore need to be addressed:

- Basic parameters describing epidemiology of trypanosome infections in wildlife to enable modelling
  - parasitaemia, duration of infection
  - mortality
  - host factors that influence epidemiology such as age and coinfection
- What are the most important risk factors for human infection?
- What happens in interface zones where livestock are also involved?

#### **4.1.4. Controlling r-HAT by controlling animal infection**

##### **a. Where domestic animals are the main reservoir**

Two main interventions have been tested as mechanisms for controlling r-HAT:

1. Mass treatment of cattle with drugs combined with spraying of insecticides
  - treatment with trypanocidal drugs affecting the human infective parasite *T. b. rhodesiense*.
  - to reduce the prevalence of the parasite in cattle to low enough levels to prevent transmission to humans.
2. Regular spraying of cattle with insecticide to reduce the number of infected tsetse flies
  - to ensure the prevalence of the human infective parasite in cattle remains at a low level, through general reductions in transmission.

Policy is already in place to treat cattle at markets in some countries, such as Uganda, but it needs to be properly implemented. The main problems identified are inadequate market infrastructure, poor awareness of farmers and veterinarians, drug costs seen as an additional market tax and poor enforcement in what is essentially a free market trade system.

While a significant reduction in parasite prevalence can be achieved quickly through the mass treatment intervention alone, sustained improvement will likely require the ongoing spraying of cattle.

##### **b. Where wild animals are the main reservoir**

r-HAT in wildlife is a huge challenge for control. There are no clear recommendations on the strategy for *T. b. rhodesiense* control in wildlife. An analysis of the roles of different host species could identify hosts for targeted control and the threshold number of individuals needed to maintain the infection but, as there are many species involved, the interventions in free living wildlife are very difficult. In areas where cattle and wildlife are in contact, it is crucial to understand the relative role of each.

Vector control is therefore likely to be the most cost-efficient strategy in those areas where wildlife is abundant.

Detection of human cases should be improved, notably in the interface with game reserves, as little is known about the risks of epidemics from these wilderness-associated foci.

Undoubtedly a multisectoral approach is called for when wildlife is involved as a potential reservoir, as HAT impacts both human and livestock health, as well as wildlife conservation issues. The wildlife sector could moreover provide a highly valuable input for a more holistic ecological approach (since disease risk may be influenced by wildlife distribution, habitat, land use, etc.).

Two countries having wildlife acting as a reservoir presented their situation, control measures and challenges (see also [Annex 3](#)).

#### **Main challenges**

- Extensive areas infested by tsetse but a small area covered with current control methods
- Limited spraying or vector control in game management areas and insufficient funds
- Limited surveillance and monitoring
- Lack of consolidated data on infection in both people and domesticated animals
- Lack of defined policy on how the Zambia Wildlife Authority (ZAWA) collaborates with the departments such as Veterinary and of Tsetse Control Unit both at national and local levels
- Threat to tourism industry

#### ***4.1.5. The Ugandan experience***

After the 1950 and 1980 epidemics, the Government of Uganda established a body known as the Uganda Trypanosomiasis Control Council (UTCC) with COCTU (the Co-ordinating Office for Control of Trypanosomiasis in Uganda) as its secretariat. The UTCC has representation from the Ministry of Health (MoH), the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), the Ministry of Finance and those ministries responsible for Wildlife and Tourism, Lands, Water and Environment, and Foreign Affairs.

Uganda is the only country with a recognized extensive problem of both forms of HAT. From 1997 to 2004, the number of HAT cases increased dramatically and r-HAT spread northwards, leading to a risk of geographical overlapping of the two forms of the disease in that country. This overlap may have significant therapeutic and diagnostic implications. To tackle the northwards spread of r-HAT, the UTCC launched the SOS (Stamping Out Sleeping sickness) campaign in 2006.

## ***SOS, Stamping Out Sleeping sickness***

Different actions made up this emergency intervention to stop the overlap of diseases:

1. Treat the 250 000 cattle in high-risk zones with drugs for animal trypanosomiasis (diminazine and isometamidium).
2. Prevent reinfection by application of insecticides in cattle using the restricted application protocol (RAP).
3. Stop market introductions by reinforcing government policy for point of sale treatment
4. Advocate community One Health messaging

The partners of this programme were investment partners IKARE, CEVA sante animale, the RIU (Research into Use programme) of the UK Department for International Development (DFID), WHO, COCTU and the University of Makerere/University of Edinburgh.

The programme was implemented in two phases:

- SOS Phase 1 (2006–2007): The first phase aimed to treat the 250 000 cattle in the high-risk zones in Kaberemaido and prevent reinfection by applying insecticides on cattle following the RAP method. RAP involves using cattle as live baits by applying insecticide to selected sites, i.e. the legs and belly of cattle on which the tsetse flies mainly feed (see section 7.2).

The intervention achieved:

- a significant decrease (67%) in the prevalence of trypanosomes in cattle, including *T. b. rhodesiense* (86%)
- a 63% reduction in human cases across seven districts between 2005 and 2006
- limited spread of the disease, with expansion of focus halted northwards
- demonstration of the possibility of treating hundreds of thousands of cattle in a short time
- demonstration of the need for public investment in treating cattle for the purposes of controlling r-HAT
- successful integrated intervention of community, MoH, Ministry of Livestock, the academic community and private–public partners
- stimulation of the community to invest in tsetse and trypanosomiasis control as some farmers are able to pay for the continued spray services.
- SOS Phase 2 (2008): The second phase aimed at building sustainability by using RAP, creating awareness and supplying veterinary services. The activities were also rolled-out to neighbouring Soroti and Serere districts (additional 175 000 cattle targeted).

- **Challenges**

The main challenges were both physical and technological.

Indeed, it was physically challenging to deliver 250 000 injectable treatments across five districts. This was made possible thanks to the participation of different partners:

- The private sector (CEVA sante animale) provided the drugs free of charge
- Industrial Kapital (a venture capital firm) provided finance for animal treatments
- Makerere Veterinary School: final year cohort to provide assistance to the district veterinary officers (DVO) system at community level as part of training at a cost of US\$ 1 per animal treated.

A technological challenge was to prevent reinfection. It was shown that a monthly RAP insecticide application maintained prevalence of all trypanosomes under 1% and that no reinfection with *T. b. brucei* occurred over the 6 months of the trial. This is therefore an affordable, quick and effective tool for *T. b. brucei* control and, as an added bonus for farmers, it also kills ticks.

- **Outcomes**

- A significant decrease in the prevalence of trypanosomes.

At 3 months post intervention, there was a significant decrease (67.1%) in the prevalence of *T.b sensu lato* from the baseline prevalence of 14.5% [13.0–16.2%] to 4.7% [3.8–5.8%]. The prevalence of zoonotic Tbr within the treatment area decreased by 85.7% from the initial 0.75% [0.41–1.2%] prevalence to 0.11% [0.0001–0.038].

In the absence of spraying at 9 months, the *T. b. sensu lato* had recovered to baseline levels and *T. b. rhodesiense* had increased to 0.48% [0.26–0.88%]. However, the geographical extent of the cattle detected to be infected with *T. b. rhodesiense* had reduced significantly compared with the baseline. All *T. b. rhodesiense*-infected cattle were found post-treatment in a limited cluster of three villages at the 9 months' sampling.

- 63% reduction in human cases across seven districts between 2005 and 2006
- Northwards expansion of focus halted
- Limited disease spread since 2005
- Post-treatment cases clustered near markets
- Undergraduate vets exposed to in-field experience and community service
- Joined up integrated primary health community, MoH, MAAIF

- **Achievements**

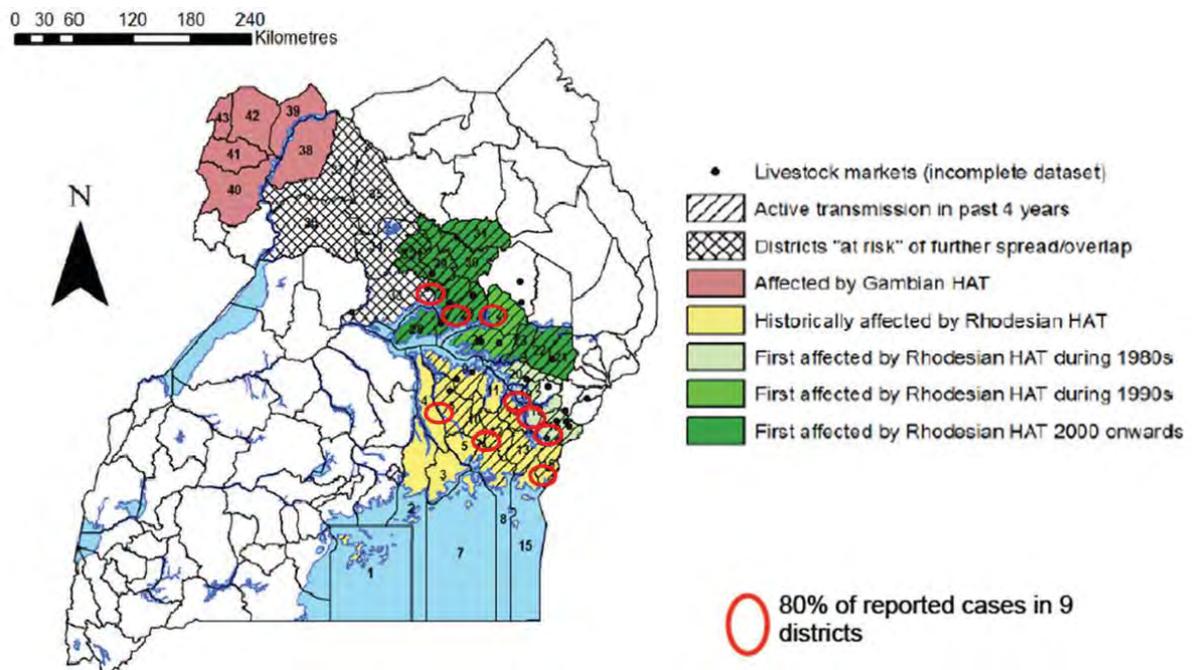
Beyond the great contribution to control animal African trypanosomiasis (AAT or nagana) and *T. b. rhodesiense* in cattle, the first phase of the SOS campaign also contributed to:

- Prevent the merger of *T. b. rhodesiense* and *T. b. gambiense*
- Demonstrate the need for public investment in treating cattle for the purposes of controlling HAT
- Explore utilization of the academic community—private—public partnerships during phase I and II interventions
- Demonstrate a model capable of treating hundreds of thousands of cattle in a short time
- Focus on sustainability from the start of the programme
- Stimulate the community to invest in tsetse and trypanosomiasis control as some farmers are able to pay for the continued spray services.

### ***SOS: a new funding model***

Despite the success of the SOS campaign, a risk of convergence of the two strains within the next 10 years still remains in Uganda (Figure 5), with potentially large public health consequences. Indeed, there is a lack of resources and current efforts are insufficient to effectively control the transmission of r-HAT and to halt overlap of the two strains of disease.

**Figure 5.** Risk of overlapping of the two forms of HAT in Uganda<sup>a</sup>



<sup>a</sup> Source: Social Finance.

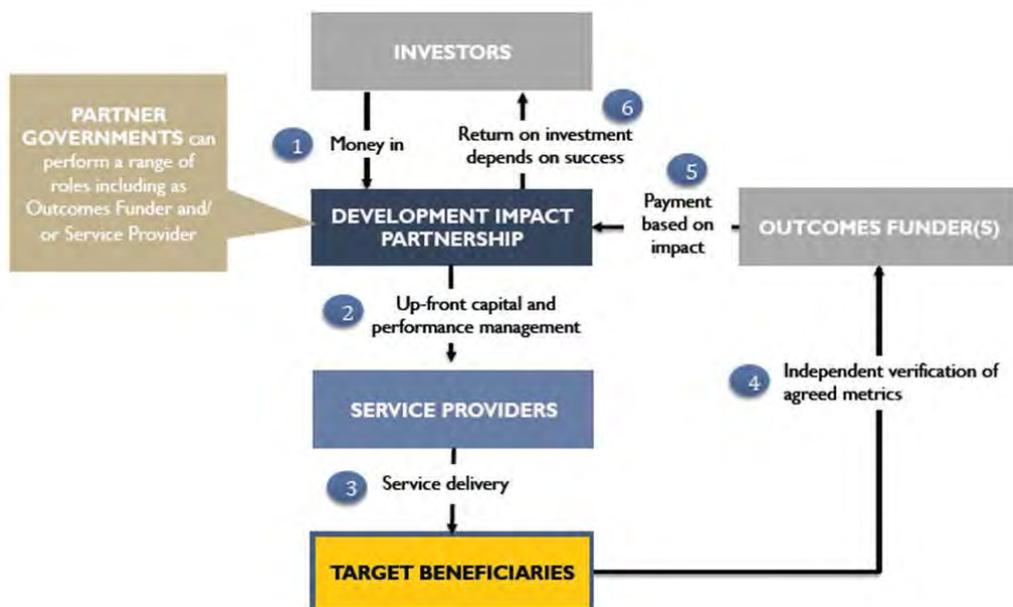
Traditional aid is increasingly under pressure, and donors are looking to novel financing mechanisms to get value for money, including better sustainability.

- **Development impact bonds**

Development impact bonds (DIBs) are a new way of public–private financing of development assistance, structured around the achievement of outcomes. Key stakeholders, including recipient governments, “outcomes funders” (typically donors but also potentially recipient country governments) and investors contract jointly to create a new legal entity, a Development Impact Partnership (Figure 6), and agree upon a desired development outcome and method of measuring success. Often, an intermediary will structure the contract, identify further investors, and identify and contract service providers to develop and implement intervention programmes aimed at reaching the desired outcome.

The private investors provide up-front capital to enable delivery of interventions focused on achieving pre-agreed outcomes. After the service delivery to target beneficiaries, outcomes are independently verified. Outcome funders, e.g. donors, repay investors their capital, including interest, if and only if outcomes specified at the outset are achieved. Investor money is therefore at risk if the outcomes are not achieved.

**Figure 6.** Development impact bond structure<sup>a</sup>



<sup>a</sup> Source: Social Finance.

A DIB has been proposed as a new model for tackling r-HAT in Uganda. DFID funded the inception phase study, which took place between May 2014 and January 2015.

An 8-year project objective would be to decrease parasite prevalence in cattle using a two-pronged intervention approach (Figure 7):

1. Mass treatment of cattle during the 3 first years, to quickly reduce parasite prevalence in cattle; and
2. A community vector control programme during the 8 years, to increase farmer demand for tsetse-effective insecticide products via a mass media campaign and more informative product packaging promoting the benefits of spraying animals, as well as targeted awareness-raising activities in areas of high risk of sleeping sickness.

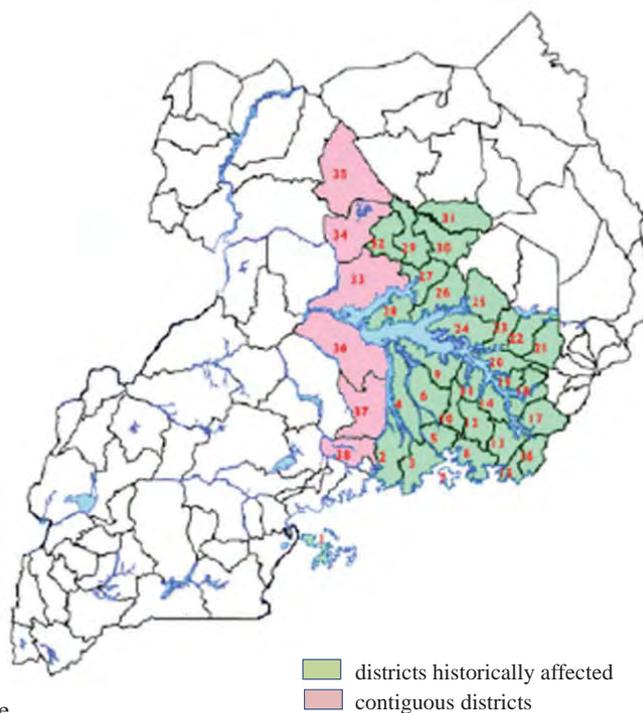
**Figure 7.** Intervention model and objectives for the project of r-HAT control in Uganda



An illustrative model of a DIB (Figure 8) would include a designated intervention zone, for example:

- 32 districts that have historically been affected by r-HAT and where humans are currently at risk of infection, and
- 6 contiguous districts in which there have not been any reported r-HAT cases but reinfection and/or overlap of the two strains of disease is a potential risk.

**Figure 8.** Illustrative model of an intervention zone for an r-HAT DIB in Uganda<sup>a</sup>



<sup>a</sup> Source: Social Finance.

In this model, potential payment triggers could include outcomes related to the delivery of the cattle mass treatment as well as sustained reduction in parasite prevalence in cattle.

While human health indicators are not being proposed for payment triggers due to the unreliability of data and underreporting of human cases of sleeping sickness, human case data will be analysed as part of the programme and human outbreaks would trigger rapid responses of mass treatment.

## 4.2. Geographical distribution and trends of disease distribution

### 4.2.1. Geographical distribution

As presented above, both wildlife and livestock are reservoir hosts for r-HAT. This has very important epidemiological implications as it leads to two different transmission patterns of the disease.

Most of the reported cases of r-HAT are linked to a **livestock reservoir**. Cattle can be highly mobile, and their movements along trade routes and through livestock markets pose a serious challenge not only for the control but also for the spread of the disease.

- In **Uganda**, which accounts for 60% of r-HAT cases reported from Africa during the past decade, cattle movements and trade have been directly linked to the transmission, expansion and spread of the disease. Tackling this threat therefore depends on close

collaboration with veterinary services, and r-HAT control calls for multisectoral coordination. The pattern of r-HAT distribution linked to the livestock reservoir is especially important in south-eastern Uganda. Cases are mainly reported from the districts of Iganga, Soroti, Dokolo, Kaberamaido and Lira.

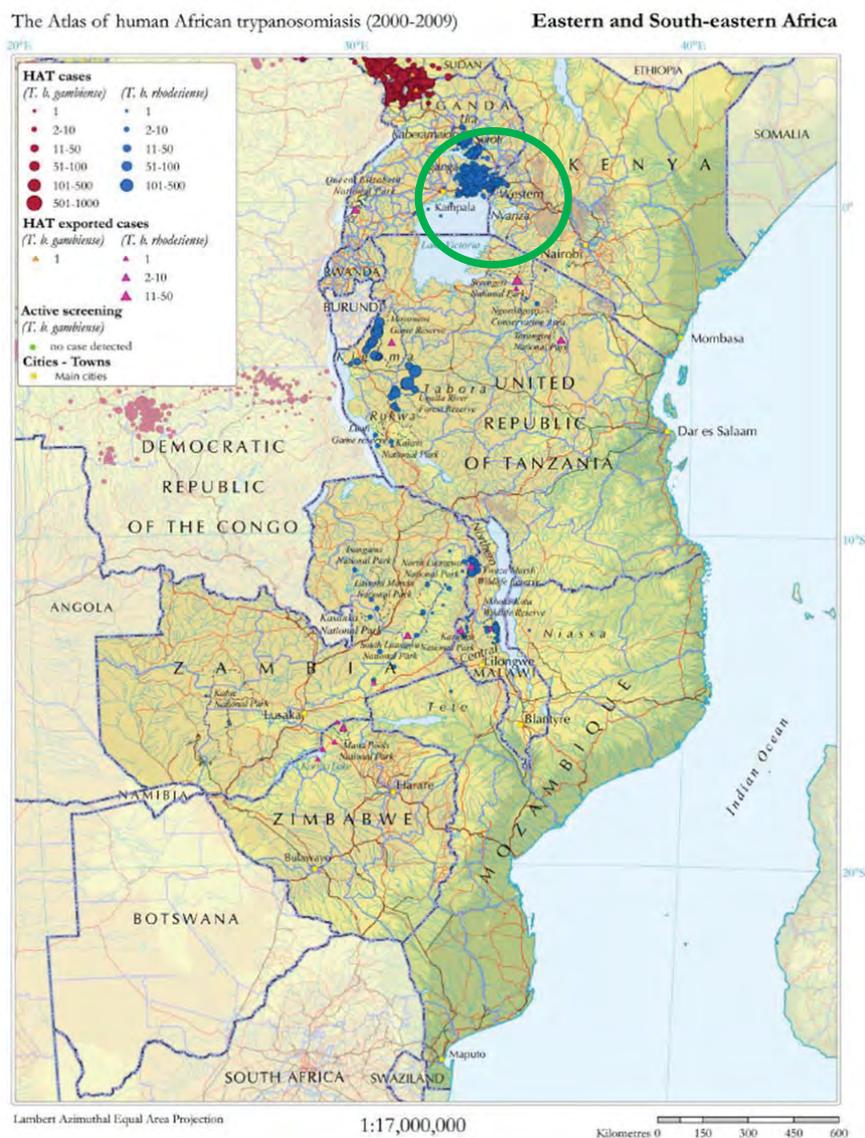
- This northwards shift poses, as several times alerted, a risk of convergence with the g-HAT that affects the north-west of the country.
- Domestic animals were also the source of r-HAT infection in **western Kenya**, where cases have been reported from the Western Province (districts of Bungoma, Teso and Busia). Sporadic cases were also reported from the Nyanza Province (mainly in Migori district). The last case from Teso was reported in 2009. Since then, two cases have been reported in tourists visiting the Masai Mara National Reserve (only in 2012), where the suspected reservoir was wildlife.
- **Mozambique** reported two cases in 2002 and 2004 in Tete and Niassa provinces. These cases were probably linked to a cattle reservoir, although the data available for this country are limited.

The **wildlife reservoir** is the central actor in the epidemiology of r-HAT in most of the other r-HAT endemic countries, except in some parts in the western United Republic of Tanzania where cattle may also play a role. There, the spatial relationship between r-HAT infections and protected areas is marked. In these settings, disease control depends on close collaboration with the authorities responsible for managing protected areas, and r-HAT control calls again for multisectoral coordination.

- **The United Republic of Tanzania** reports cases in the northern part of the country, notably from Ngorongoro, the Serengeti and Tarangire. In the west, cases are reported in the Kigoma Region related to the Moyowosi Game Reserve. Cases are also reported from Tabora Region linked to the Ugalla River Game Reserve but also to the so-called interphase cattle and game. Cases from Rukwa Region are linked to the Luafi Game Reserve and the Katavi National Park. Interestingly, only the waters of Lake Tanganyika seem to separate the cases of *T. b. gambiense* in the Democratic Republic of the Congo from those of r-HAT in the United Republic of Tanzania (Figure 9), thus posing also here a risk of convergence between the two forms of the disease such as that already described in Uganda.
- In **Malawi**, cases are clustered around Vwaza Wildlife Reserve (Northern Region), Nkhotakota Wildlife Reserve and Kasungu National Park (Central Region).
- **Zambia** has been reporting cases linked to national parks in the eastern and northern parts of the country (mainly to north and south Luangwa, Isangano, Kasanka and Lavushi Manda natural protected areas). r-HAT cases linked to Kafue National Park in the south-west of the country have also been reported and, most recently, in Rufunsa related to Lower Zambezi Natural Park. This is related to the cases detected in neighbouring Mana Pools National Park and Kariba Lake in northern Zimbabwe.

- Sporadic cases of r-HAT related to wildlife reservoirs have also been reported from the south-western part of **Uganda** in travellers visiting the Queen Elizabeth Park in 2006 and 2009, as well as an autochthonous case possibly related to this pattern of transmission described as interphase cattle and game. A suspected case of r-HAT was reported from Murchinson falls National Park in 2008.

**Figure 9.** Cases of human African trypanosomiasis reported from eastern and south-eastern Africa, 2000–2009<sup>a</sup>. The green circle indicates foci where livestock is the main reservoir.



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

The real situation in Burundi and Rwanda is unclear. Burundi does not transmit any data to WHO. In Rwanda, cases were reported in French soldiers in the 1990s but, according to an

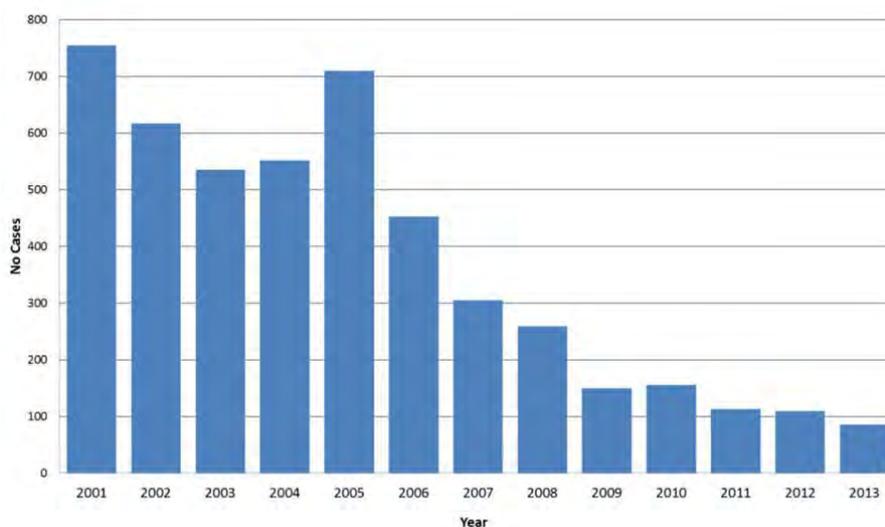
assessment mission targeting health facilities around the park (consultation of registers, interviews with medical staff), there is no evidence of the disease.

Infections in tourists who had visited protected areas but returned to countries where the health system is capable of detecting this infection are of interest. Indeed, they serve as an alert for WHO to inform countries of the need for reinforced surveillance in these areas. Such exported cases can also question the completeness of reported data and may shed some light on the extent of misdiagnosis and underreporting.

#### 4.2.2. General trends

The trend in the number of cases reported during the past decade reflects a global reduction of 65%, with stagnation around 100 cases reported annually for the past 3 years (Figure 10).

**Figure 10.** Number of r-HAT cases reported to WHO, 2001–2013

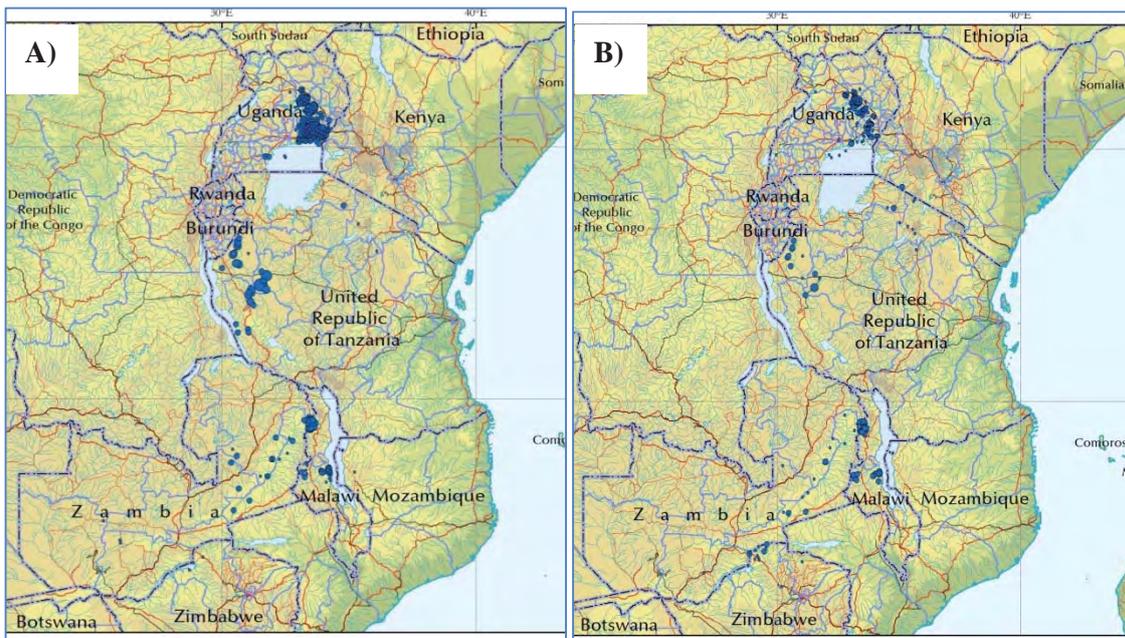


To look at the geographical distribution of this trend, two 5-year periods (2003–2007 and 2008–2012) have been mapped and compared (Figure 11). The **decrease is most clearly manifested** in south-eastern Uganda **where cattle are the major reservoir** of the parasite, but also in the western United Republic of Tanzania where cattle also have been involved as a reservoir. By contrast, in the remaining transmission areas where wildlife is the main reservoir, the situation is stable or even increasing in some places such as the Masai Mara. In the United Republic of Tanzania, the northern natural protected areas have also reported a slight increase in the number of cases during the 2008–2012 period.

This general trend reflects the opportunities for and availability of means for controlling transmission of *T. b. rhodesiense* from livestock to humans with effective veterinary actions against the domestic animal reservoir. By contrast, interrupting transmission from wildlife to

humans is much more complicated. However, the risk of epidemics may be related more to areas where cattle are suggested as a main reservoir – probably because the livestock live closer to the community – but also because relocating “naive” cattle in endemic areas creates new infections with all the animals reaching high levels of parasitaemia at the same time, 3 or 4 months after the introduction.

**Figure 11.** Distribution of r-HAT cases, A) 2003–2007 and B) 2008–2012<sup>a</sup>



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

### **4.2.3. Country reports**

Representatives of Kenya, Malawi, Uganda, the United Republic of Tanzania and Zambia presented the disease situation in their countries. The main topics are presented in Annex 4, country by country, including the geographical distribution of the disease, capacities for and challenges to r-HAT control and surveillance, and scores on progress towards r-HAT elimination.

The epidemic curves for the decade 2004–2013 had an overall downward trend in all countries, but increased slightly in 2013 (for Malawi) and in 2014 (for Uganda).

**The main challenges** cited differed by country, but converged on:

- The attrition of HAT-trained staff due to retirement and high turnover
- Decreasing community awareness
- The high cost and low efficacy of active case-detection activities
- Loss of government commitment and partners' interest as the number of cases falls
- Insufficient funding
- Lack of cross-border joint interventions
- Difficulties in intervening in remote places
- The need for multisectoral and multidisciplinary work
- The need for effective, sustainable and safer tools for r-HAT control

### 4.3. Population at risk

The risk of r-HAT arises from activities that provide exposure to the bite of tsetse flies and that bring humans into areas where livestock or wildlife interact with the tsetse vector.

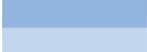
WHO and FAO have estimated the number and distribution of people at different levels of risk of r-HAT by combining the annual average number of cases reported (disease intensity) and the average annual population according to Landsat (population intensity).<sup>13</sup> Both averaged layers were subjected to spatial smoothing using the same quadratic kernel function. Both intensity surfaces were generated using the same search radius (30 km), thus resulting in two surfaces: D (average annual estimates of disease intensity) and P (average population intensity). The ratio between the two surfaces is the disease risk, or R.

Subsequently, risk has been categorized from very high (at least one case per 100 inhabitants was detected annually during the period studied) to marginal (less than one case per one million inhabitants) (Table 2). Of note is that, according to the agreed definition in the Roadmap for “elimination as a public health problem” (i.e. < 1 case per 10 000 inhabitants per annum), **the areas at low and very low risk of r-HAT have already reached the target of elimination as a public health problem.**

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<sup>13</sup> Simarro PP, Cecchi G, Franco JR, Paone M, Diarra A, Ruiz-Postigo JA et al. Estimating and mapping the population at risk of sleeping sickness. PLoS Neg Trop Dis. 2012; 6: e1859.

**Table 1** Thresholds for defining categories of risk of human African trypanosomiasis<sup>a</sup>

Category	R = D / P	HAT cases per annum	Colour
Very high	$R > 10^{-2}$	$\geq 1$ per $10^2$ people	
High	$10^{-3} < R < 10^{-2}$	$\geq 1$ per $10^3$ people AND $< 1$ per $10^2$ people	
Moderate	$10^{-4} < R < 10^{-3}$	$\geq 1$ per $10^4$ people AND $< 1$ per $10^3$ people	
Low	$10^{-5} < R < 10^{-4}$	$\geq 1$ per $10^5$ people AND $< 1$ per $10^4$ people	
Very low	$10^{-6} < R < 10^{-5}$	$\geq 1$ per $10^6$ people AND $< 1$ per $10^5$ people	
Marginal	$R < 10^{-6}$	$< 1$ per $10^6$ people	

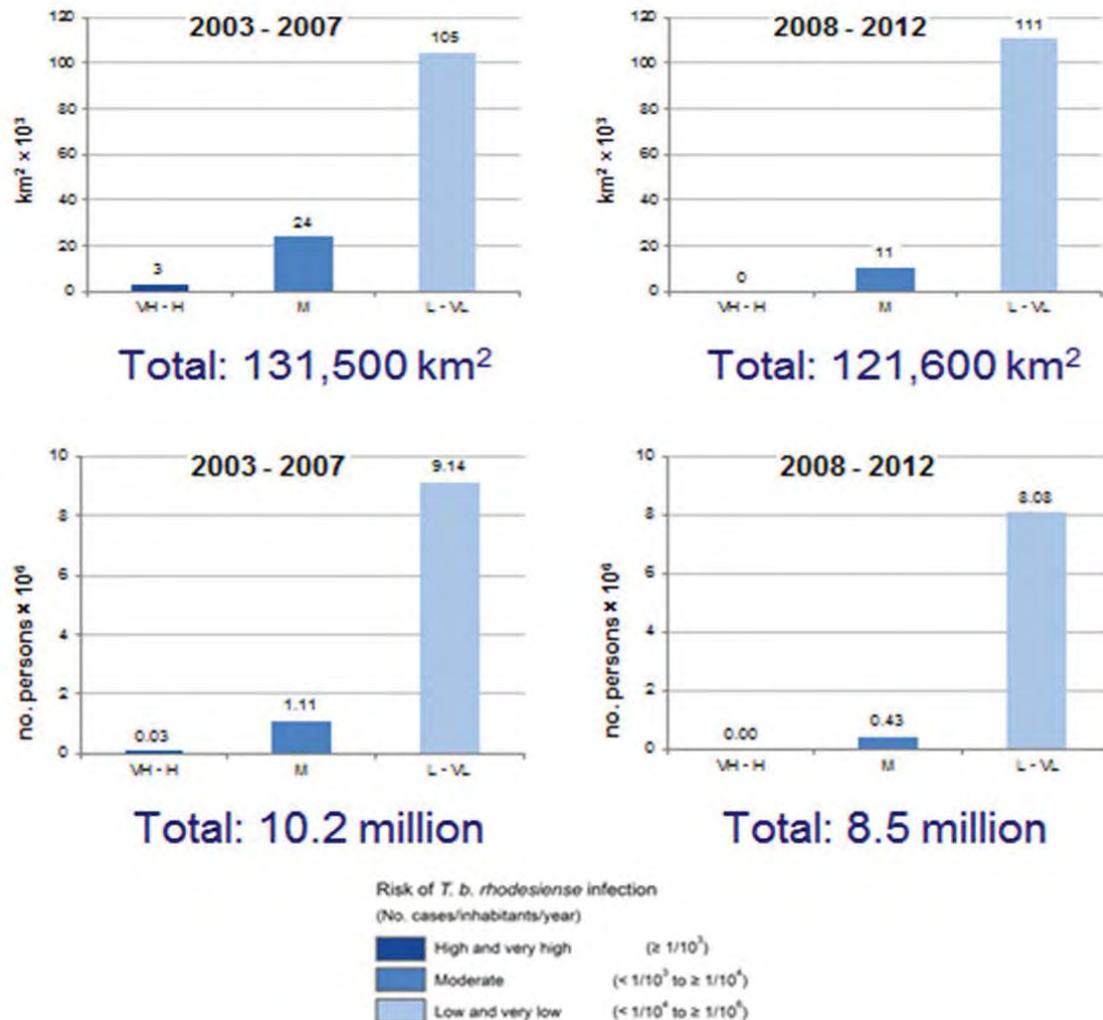
<sup>a</sup> Source: Simarro P et al., 2012.<sup>13</sup>

A comparison of the population at different levels of risk for the two 5-year periods (2003–2007 and 2008–2012) revealed that, in addition to a decrease in the total number of people at risk during 2008–2012, 95% (8.08 million) of the 8.5 million people at risk have already achieved the goal of living under the epidemiological threshold of elimination as a public health problem (Figure 12).<sup>13</sup>

The decreased risk is a direct consequence of the decrease in the number of cases reported; the maps of risk for the two 5-year periods follow the maps of disease distribution, which show a **marked reduction in risk in settings with an important cattle reservoir** for *T. b. rhodesiense*. By contrast, risk is stable in areas where wildlife is the main reservoir of the parasite.

Nevertheless, the characteristics of r-HAT transmission as well as the possible role of misdiagnosis and underreporting signal not only that these figures could be different at the field level, but also that the risk of epidemics and of backtracking into more people at high risk levels is an ever present threat.

**Figure 12.** Areas (above) and population (below) at different levels of risk of r-HAT, 2003–2007 (left) and 2008–2012 (right)<sup>a</sup>



<sup>a</sup> Source: P. Simarro et al., 2012.<sup>13</sup>

#### 4.4. Clinical features of r-HAT

Two different clinical presentations of r-HAT have been described in Kenya, Malawi and Zambia<sup>14</sup>:

- **“typical acute disease”**, the main form, is severe (malaria-like progressing to central nervous system involvement), of short duration and causes death in the absence of treatment or delayed treatment.

<sup>14</sup> Mwanakasale V, Songolo P, Olusegun B, Simarro P. Clinical presentation of human African trypanosomiasis in Zambia is linked to the existence of strains of *Trypanosoma brucei rhodesiense* with varied virulence: two case reports. J Med Case Rep. 2014;8:53.

- the “**atypical chronic form**” presents as a mild (malaria-like) syndrome of long duration, with mild central nervous system involvement and death is more easily evitable.

The presence of “**asymptomatic cases**” is controversial and might arise from an unspecific reaction (use of new techniques as SRA could help to confirm the existence of asymptomatic forms).

In Zambia, the two clinical presentations seem to have a different geographical distribution:

- “**typical acute disease**” is present in the northern province and in Lusaka and Eastern provinces;
- the “**atypical chronic form**” is present in some areas in Eastern province and in Malawi, with possible “asymptomatic cases” having been described in Luangwa valley in the 1980s.

Different explanations are proposed for the existence of these two different forms:

1. The existence of two strains of *T. b. rhodesiense* with varying degrees of virulence: one highly virulent (causing the acute form); the other less virulent (causing the chronic form).
2. The existence of *T. b. gambiense*-like trypanosomes infecting humans and causing the chronic infection.
3. Individual variation in host immune response to *T. b. rhodesiense*.

The existence of two different clinical forms can have **implications on control strategies**. Indeed, whereas only passive case detection and treatment can be implemented where typical acute disease is present, additional reactive active case detection and treatment could be implemented where atypical chronic disease or asymptomatic cases are present, as human hosts can serve as a reservoir of infection. Patients presenting with atypical chronic forms and transient or very low parasitaemia are a challenge for case management. Future research is needed to address this issue, notably molecular studies to differentiate the strains of *T.b. rhodesiense* and immunological studies on individuals with chronic or asymptomatic r-HAT.

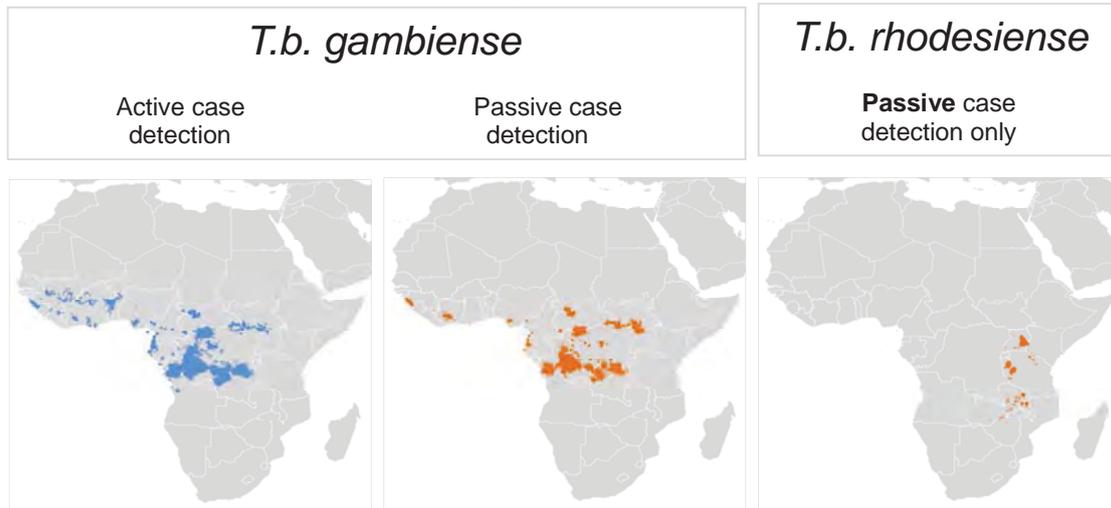
## 5. Modelling the epidemiology of r-HAT

### 5.1 Underreporting

Disease atlas projects have been set up for different diseases (e.g. malaria, dengue and HAT). These projects collate historical and contemporary data on the distributions of diseases to inform policy-makers, and signal changes in distribution over time and where interventions are likely to have the greatest impact. Using these data to inform statistical models, it is then possible to estimate and map the populations at risk of the disease and burden of the disease on human health.

The WHO Atlas of human African trypanosomiasis<sup>15</sup> provides such a resource. It contains data on disease prevalence and incidence from both active and passive surveillance and control activities for g-HAT, but r-HAT data consist only of reported cases from passive surveillance (Figure 13).

**Figure 13.** Distribution of HAT cases, by parasite and mode of detection<sup>a</sup>



<sup>a</sup> Source: Golding N; data from WHO Atlas of human African trypanosomiasis.

Whilst active case-detection data enable accurate modelling of HAT prevalence, passive case-detection alone does not since it is subject to several forms of bias. One form of bias is spatial variation in the probability of reporting of cases, as not all the health facilities in the affected area will have diagnosis and treatment skills and equipment, and because access to these health facilities may be restricted for populations living in more remote areas.

Mapping access to health facilities with diagnostic capacity for HAT has been carried out for g-HAT<sup>16</sup> but not for r-HAT. Access to health facilities with capabilities for diagnosis of r-HAT might be even more restricted in East Africa given the loss of diagnostic skills for r-HAT due to the decrease in the number of cases.

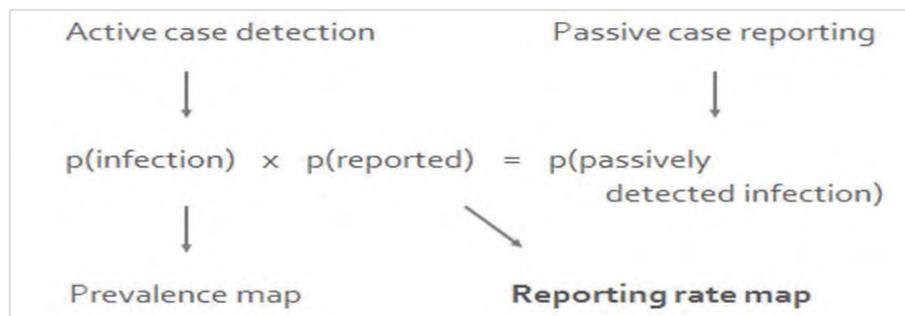
A geostatistical model with a joint likelihood has been designed to simultaneously estimate and map both the reporting rate and the prevalence of g-HAT, based on both active and passive case detection (Figure 14). However, this model cannot be directly applied to r-HAT due to the lack of active case-detection data. In order to map the true prevalence of r-HAT

<sup>15</sup> Simarro PP, Cecchi G, Paone M, Franco JR, Diarra A, Ruiz JA et al. The Atlas of human African trypanosomiasis: a contribution to global mapping of neglected tropical diseases. *Int J Health Geogr.* 2010 ;9:57.

<sup>16</sup> Simarro PP, Cecchi G, Franco JR, Paone M, Diarra A, Ruiz-Postigo JA et al. Mapping the capacities of fixed health facilities to cover people at risk of gambiense human African trypanosomiasis. *Int J Health Geogr.* 2014 ;13:4.

cases rather than just those that are reported, some other estimate of reporting rates must be obtained; however, these are unfortunately rare.

**Figure 14.** Structure of a joint model to estimate and map reporting rate for g-HAT<sup>a</sup>



<sup>a</sup> Source: N. Golding.

**Main challenges** to correctly estimating the reporting rate for r-HAT

- To collect more epidemiological data specific to r-HAT
  - active case-detection data for r-HAT
  - location and capacities of health facilities
  - other estimates of reporting rates for r-HAT (although these are subject to a great deal of uncertainty)
- To include other data such as treatment-seeking behaviour in the model
- To improve the calibration process with point estimates of r-HAT reporting rates
- To conduct a sensitivity analysis with different performances of diagnostic tools
- Tourists and sentinel sites can also represent a good source of good-quality data.

## 5.2 Suitability for r-HAT presence

Tsetse populations are constrained by climatic factors and the availability of suitable habitats, thus resulting in a focal distribution. r-HAT distributions are constrained by the distributions of tsetse populations and also by human–animal–environmental interactions.

Quantifying the relationships between disease (or vector) and covariates such as rainfall or land cover from locally observed data can improve epidemiological understanding. These relationships can then be extrapolated to areas where there are no data to predict spatial suitability.

The potential outcomes that can be measured for spatial r-HAT modelling are:

- Presence/absence of the disease, or disease distribution
- Prevalence/incidence
- Vector presence/absence, or vector distribution
- Vector abundance

### ***5.2.1 Introduction and spread of r-HAT***

Little is known about the impact of environmental factors on the spatial spread of r-HAT after its introduction to a new area. In Uganda, r-HAT has been spreading northwards since 1998 due to the movement of infected livestock. The disease was initially detected in Serere district (in 1998) and subsequently spread to Kaberamaido and Dokolo districts (from 2003). Both of these introductions are thought to have occurred via the movement of untreated livestock.

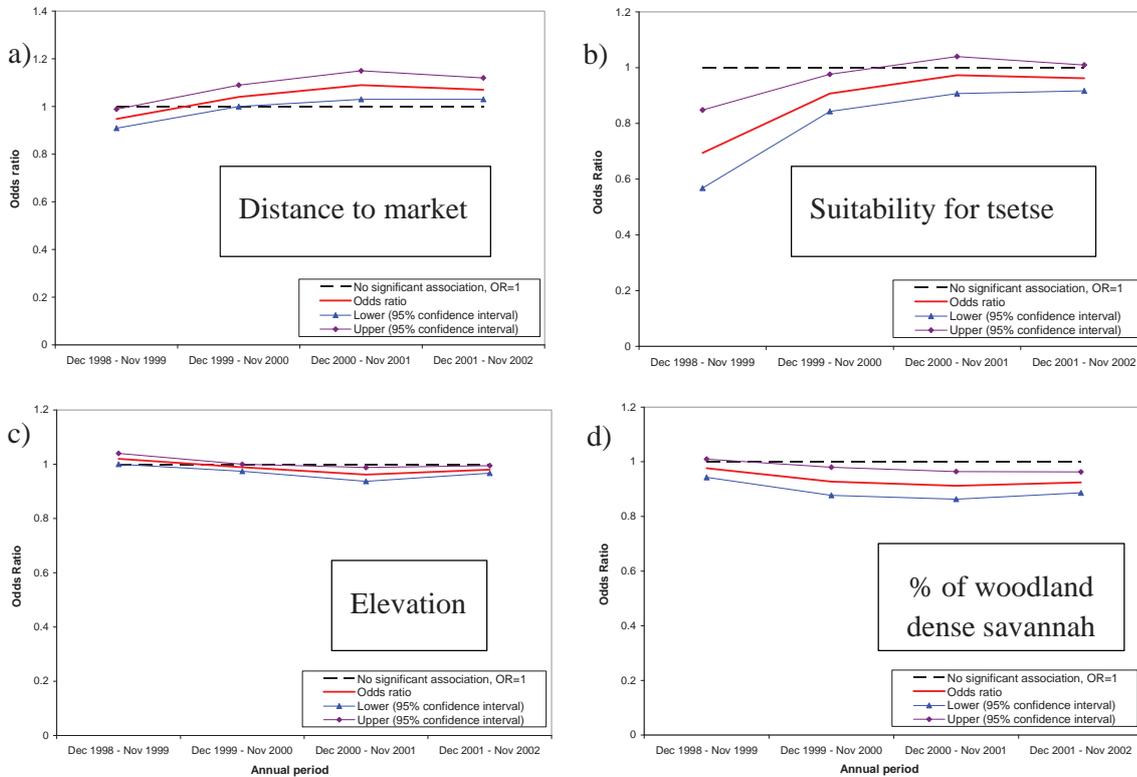
An annually stratified matched case–control study has been used to allow the temporal assessment of correlations between the spatial distribution of r-HAT and landscape factors.<sup>17</sup> Passively detected cases recorded from Serere hospital were geo-referenced at village-level and matched to a suitable control from the hospital’s inpatient records. There was no disease control activity at that time in the district.

Significant associations were detected between r-HAT and distance to the livestock market, elevation, land cover features and predicted tsetse suitability, with clear temporal changes in relationships. The association with the site of introduction (market) vanished after 2 years while the temporal changes in relationships with other factors indicated that the disease dispersed into more suitable habitats (lower elevation, higher predicted suitability for tsetse, more seasonally flooded grassland and less woodland/dense savannah (Figure 15)).

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<sup>17</sup> Wardrop NA, Fèvre EM, Atkinson PM, Welburn SC. The dispersal ecology of Rhodesian sleeping sickness following its introduction to a new area. *PLoS Negl Trop Dis*. 2013;7:e2485.

**Figure 15.** Temporal trends in the association between the risk of r-HAT cases occurring and a) distance to market; b) suitability for tsetse; c) elevation; and d) percentage of woodland dense savannah<sup>a</sup>



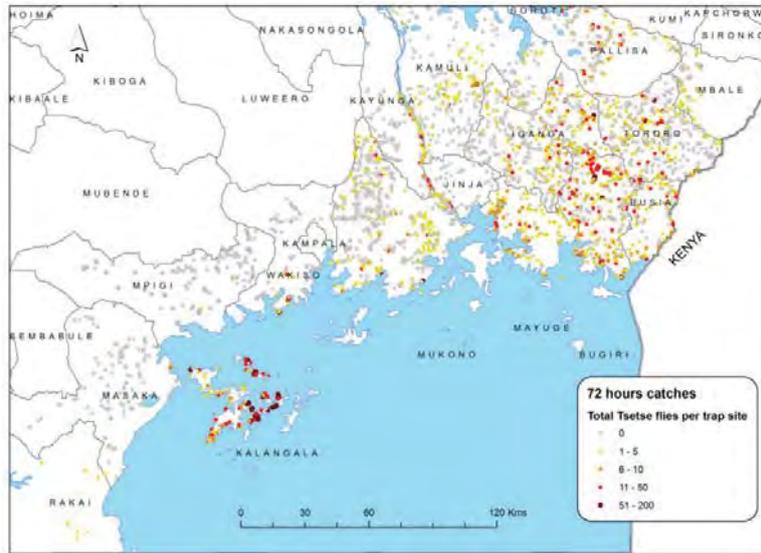
<sup>a</sup> Source: N. Wardrop, 2013.<sup>17</sup>

The distribution of r-HAT in Uganda has been strongly influenced by introductions (markets), but environmental factors also play an important role. While the disease can be introduced in a “less suitable” environment, spatial dispersal is observed over time into “more suitable” environments. In real conditions, matters are more complicated as multiple introductions across time can occur and only some of them will be maintained.

### 5.2.2 Tsetse distribution

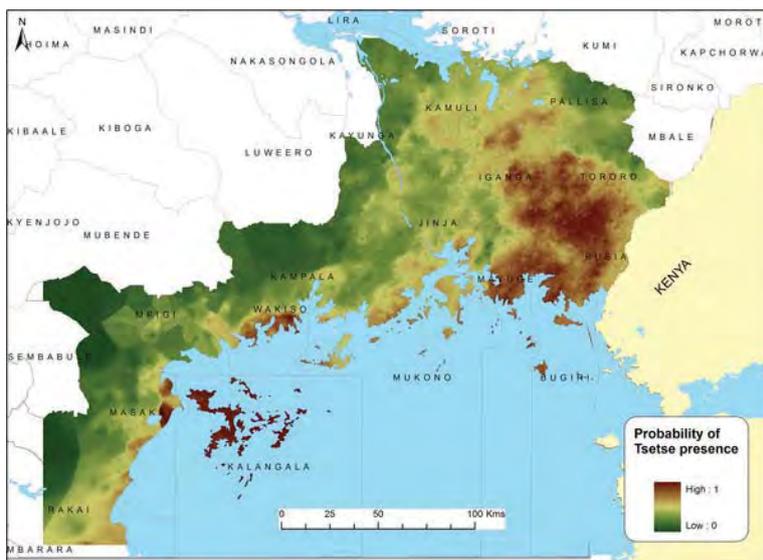
It is potentially easier to model tsetse distributions than HAT distributions. However, there is a lack of up-to-date data. Current tsetse distribution maps are mainly based on expert opinion rather than empirical observations. Spatial modelling methods can be used to correlate entomological sources data with environmental data such as land cover or climatic factors. These relationships can then be extrapolated to provide spatially continuous predictions of tsetse distributions (Figure 16 and Figure 17).

**Figure 16.** Tsetse distribution around Lake Victoria in Uganda after 72-h catches<sup>a</sup>



<sup>a</sup> Source: Survey carried out by COCTU; map provided by Mr Albert Mugenyi.

**Figure 17.** Predicted tsetse distribution based on catch data and environmental data<sup>a</sup>



<sup>a</sup> Source: Survey carried out by COCTU, analysed by A. Mugenyi.<sup>18</sup>

To maintain an active foci of r-HAT, the existence of tsetse, livestock and human populations is necessary but not sufficient. Environmental and socioeconomic factors also play a role in moderating the contact between these populations and thus the transmission of *T. b. rhodesiense* between vector and host species. The spatial relationships between vector,

<sup>18</sup> Albert M, Wardrop NA, Atkinson PM, Torr SJ, Welburn SC (2015) Tsetse Fly (*G.f. fuscipes*) Distribution in the Lake Victoria Basin of Uganda. PLoS Negl Trop Dis 9(4): e0003705.

livestock disease and spill-over to human hosts under different environmental conditions will be addressed in future work through the spatial modelling of HAT Atlas data, tsetse survey data and livestock prevalence data.

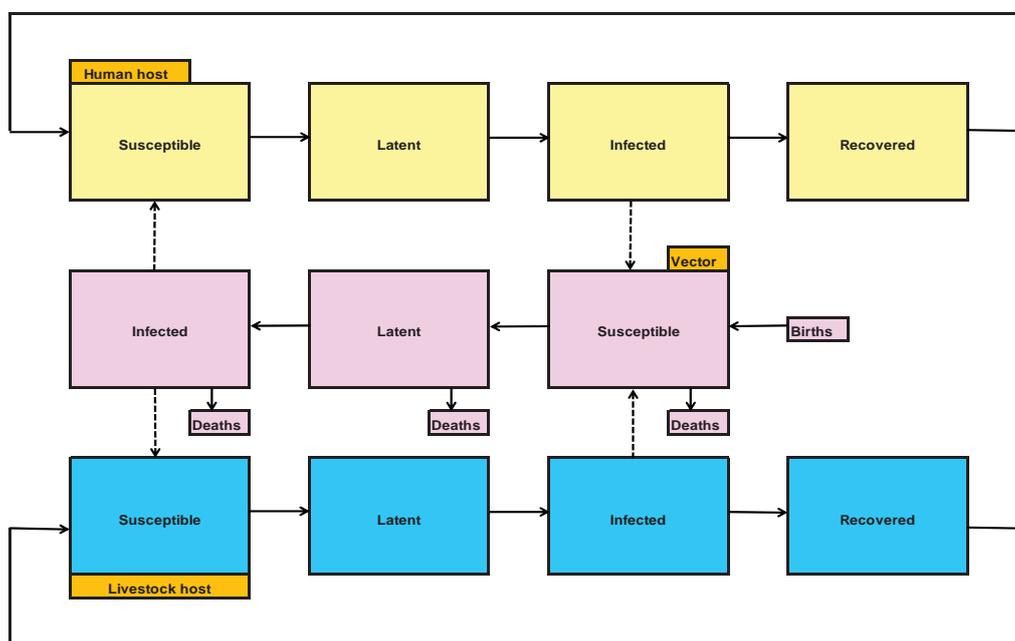
### 5.3 Weaknesses and strengths of modelling

Rogers' model provided the first quantitative analysis of trypanosomiasis dynamics (Figure 18) This model has been used to analyse the impact in different species of trypanosome of using insecticide-treated cattle or animal trypanocides, according to the number of cattle existing. The model can become more complex when considering flies feeding also on humans and wild animals. Other elements, such as vector control, can be included in it.

It was useful in showing the importance of the biting rate and of tsetse mortality in determining  $R_0$ . It was similar in this regard to the conclusions from models of malaria; the vector dynamics are, however, quite different.<sup>19</sup>

This model has been used to analyse the impact in different species of trypanosome of using insecticide-treated cattle or animal trypanocides, according to the number of cattle existing. The model can become more complex when considering flies feeding also on humans and wild animals. Other elements, such as vector control, can be included in it.

**Figure 18.** Model framework for trypanosomiasis dynamics<sup>a</sup>



<sup>a</sup> Source: DJ Rogers, 1988.

<sup>19</sup> Rogers DJ. A general model for the African trypanosomiases. *Parasitology*. 1988;97:193–212.

These models present several **weaknesses**:

- Births and deaths in human/non-human hosts are ignored
- All host and vector populations are assumed to be constant over time
- The tsetse birth rate is assumed to be constant
- Tsetse mortality was implicitly assumed independent of fly age
- Little account is taken of seasonality/dynamics
- No consideration is given to explicit effects of temperature/rainfall
- Feeding choice is independent of age

Climatic factors, such as variation in temperature, influence dynamics of the tsetse population and need to be incorporated.

Models are therefore needed that incorporate the following aspects of the vector population:

- Mortality changing with age
- Mortality increasing with temperature
- Interaction between these two factors
- Non-equilibrium populations
- Modest changes in the rates of larval production with temperature
- Marked changes in the rates of larval development with temperature
- Density-dependent mortality in pupae and perhaps also in adults.

Models need also to address changes in human pressure, host availability and which hosts tsetse are biting – and how this might change with tsetse age.

## 6. Research on control tools

### 6.1 Diagnosis

#### 6.1.1. Existing tools and challenges

Diagnosis of r-HAT is a multi-step procedure. The **suspicion** of infection is based on clinical, serological and molecular evidence. Then the **confirmation** of infection is based on microscopic detection of the parasite in chancre, lymph node, blood or cerebrospinal fluid. Finally, **determination of disease stage** is based on examination of cerebrospinal fluid.

#### *a. Clinical suspicion*

Clinical signs and symptoms are not pathognomonic (fever, joint pains, headache, chancre, pruritus, neurological disorders). They provide a first suspicion of HAT but are shared by other diseases such as malaria, AIDS or typhoid fever. Confirmation by microscopy remains necessary as long as drugs are toxic, expensive and difficult to administer.

The **main challenge** is the rapidly disappearing clinical expertise as the number of cases decreases.

## ***b. Serological suspicion***

The available serological tests are not very performant. Successes in g-HAT are not replicable in r-HAT serological diagnosis.

- **Antigen detection** (ELISA and latex agglutination prototypes) has proven unreliable.
- **Antibody detection**
  - ELISA, direct agglutination and IFAT are based on non-purified antigens and have limited specificity
  - The lateral flow test with VSG117 and rISG65 has poor sensitivity

### **Main challenges** and opportunities

- The **serum resistance-associated gene** (SRA) is the only well characterized T.b. rhodesiense-specific antigen.
- r-HAT patients mount an immune response to native and recombinant SRA that can be detected by Western Blot and ELISA.
- It might be possible to develop a rapid diagnostic test (RDT) for r-HAT but the delay in the appearance of anti-SRA antibodies is unknown.

## ***c. Parasitological confirmation***

Different techniques are available to confirm cases by microscopy, with different lower detection limits and sensitivity (Table 3). The most commonly used techniques are still wet blood-film, thin smear and thick drop, whereas more performant tests exist, that should be promoted in the countries to be used more in routine diagnosis. The mini-anion exchange centrifugation technique (mAECT), the most sensitive technique (80%), takes “only” 30 minutes to be performed and the material can also be used for detecting trypanosomes in cerebrospinal fluid (CSF).

**Table 3** Characteristics of the different techniques for confirming r-HAT cases by microscopy<sup>a</sup>

Test	Max. volume	Lower detection limit per ml	Sensitivity
chancre aspirate	10 µl		
lymph aspirate	10 µl		
wet blood film	10 µl	10000	
thin smear	10 µl	10000	
thick drop	20 µl	5000	
mHCT	2 x 60 µl	500	48 % (field)
QBC	2 x 60 µl	500	
mAECT	500 µl	<30	80 % (field)
mAECT BC	5000 µl	<10	90 - 97 % (field)
RBC lysis – AO	3000 µl	< 50	50 % (50 tryps/ml)
MSC	4000 µl	1	

<sup>a</sup> Source: P. Büscher, taking data from D. Mumba Ngoyi<sup>20</sup>, P. Truc<sup>21</sup>, S. Bieler<sup>22</sup>, M. Camara<sup>23</sup> and P. Büscher.<sup>24</sup> mHCT: microhaematocrit centrifugation technique; QBC: Quantitative Buffy Coat; mAECT: mini anion exchange centrifugation technique; mAECT BC: mini-anion exchange centrifugation technique on buffy coat; RBC lysis-AO: red blood cell lysis - acridine orange; MSC: modified single centrifugation.

<sup>20</sup> Mumba Ngoyi D, Ali Ekangu R, Mumvenma Kodi MF, Pyana PP, Balharbi F, Decq M et al. Performance of parasitological and molecular techniques for the diagnosis and surveillance of gambiense sleeping sickness. *PLoS Negl Trop Dis.* 2014;8:e2954.

<sup>21</sup> Truc P. et al. Parasitological diagnosis of human African trypanosomiasis: a comparison of the OBC and miniature anion-exchange centrifugation techniques. *Trans R Soc Trop Med Hyg.* 1998;92:288–9.

<sup>22</sup> Biéler S, Matovu E, Mitashi P, Swewannyana E, Bi Shamamba SK, Bessell PR et al. Improved detection of *Trypanosoma brucei* by lysis of red blood cells, concentration and LED fluorescence microscopy. *Acta Trop.* 2012;121:135–40.

<sup>23</sup> Camara M, Camara O, Ilboudo H, Sakande H, Kaboré J, N’Dri L et al. Sleeping sickness diagnosis: use of buffy coats improves the sensitivity of the mini anion exchange centrifugation test. *Trop Med Int Health.* 2010;15:796–9.

<sup>24</sup> Büscher P, Ngoyi D, Mumba D, Kaboré J, Lejon V, Robays J et al. Improved models of mini anion exchange centrifugation technique (mAECT) and modified single centrifugation (MSC) for sleeping sickness diagnosis and staging. *PLoS Negl Trop Dis.* 2009;3:e471.

#### **Main challenges and opportunities**

- Need for equipment and power supply at point-of-care (microscope, centrifuge, 12-v source)
- Microscopy must be applied on all fluids that contain trypanosomes, such as chancre juice, lymph aspirate or CSF and not only on blood.
- False–negatives may occur
- Some of the procedures, in particular the most sensitive ones, involve multiple steps and are relatively complex to perform
- Personnel need continuous training
- mAECT and modified single centrifugation tubes are available for adoption by NSSCPs

#### **d. *Molecular methods***

Molecular methods are based on DNA and RNA detection.

- **DNA detection**
  - PCR (polymerase chain reaction), PCR-oligochromatography and real-time PCR
  - LAMP (loop-mediated isothermal amplification): isothermal, thermostable, little sample preparation (the most simple)
- **RNA detection**, which is a better surrogate for parasite detection
  - NASBA (nucleic acid sequence-based amplification)
  - spliced leader real-time PCR

### **Main challenges and opportunities**

- Need for sophisticated equipment (controlled reaction temperatures, centrifugation, micropipettes)
- Need for specialized training
- Cost (expensive)
- Further clinical evidence is required to demonstrate that sensitivity is superior to microscopy.
- In humans, not proven to be more sensitive than microscopy. Further clinical evidence would be required to demonstrate that sensitivity is superior to microscopy
- Transformation into “point-of-care” format?
- Choice of target sequence:
  - ITS: *T. b. rhodesiense*
  - 18S: problem in bovines because of cross reactions with non-pathogenic trypanosomes
  - SRA: can be used for detection in cattle, but not very sensitive (particularly if low parasitaemia)
  - RIME: can be used to detect any species in the sub-genus Trypanozoon and is present in multiple copies (about 500 copies per parasite)
- Animal reservoir: SRA-based molecular tests are useful but increased analytical sensitivity (single copy gene) is needed
- Xenomonitoring: Molecular tests could be used to detect trypanosomes in the vector.

### ***e. Disease stage determination***

A lumbar puncture is still required to determine the stage of disease after parasitological diagnosis of trypanosome infection. In practice, staging of r-HAT is often performed only after a dose of suramin has been administered, as it is considered that blood parasitaemia should be cleared before a lumbar puncture in order to avoid the risk of introducing the parasite into CSF in cases of traumatic lumbar puncture.

The disease stage is defined from the number of white blood cells (WBC) in CSF and the presence of trypanosomes (Table 4).

**Table 4** Criteria for staging in human African trypanosomiasis from cerebrospinal fluid

	WBC count	
	0-5 / $\mu$ l	$\geq$ 6 / $\mu$ l
trypanosome negative	Hemo-lymphatic 1 <sup>st</sup> stage	Meningo-encephalitic 2 <sup>nd</sup> stage
trypanosome positive	Meningo-encephalitic 2 <sup>nd</sup> stage	Meningo-encephalitic 2 <sup>nd</sup> stage

**Main challenges** and opportunities

- New neuroinvasion biomarkers in CSF are under study
- Biomarkers for staging in blood are under study and rapid diagnostic tests (RDT) for detecting new CSF biomarkers are under development
- New drugs that are safe and effective for both stages of the disease may render stage determination redundant

**f. General challenges**

**General challenges** of diagnostic tools

- The difficulty of evaluating new tools given the low and rapidly declining number of cases.
- Adapting the format of new tools to “point-of-care” use
- Use of antibodies against tsetse saliva as a tool for detecting exposure of humans and animals to tsetse flies.
- The possibility of doing active screening in humans in the DIB project or in view of elimination has been discussed. If active screening is conducted, the molecular tests could be chosen as a diagnostic tool. However, for individual diagnosis, mini column is the most recommended tool.

**6.1.2. New developments**

**a. Light-emitting diode (LED) fluorescence microscopy**

LED fluorescence microscopy can be used to detect trypanosomes that are stained with acridine. It is faster (only 3 minutes to stain) and less tiring (dark background) than standard bright field microscopy. Sensitivity is further improved when trypanosomes are concentrated in a procedure that includes lysis of red blood cells and centrifugation.<sup>25</sup> Some of the LED fluorescence microscopes that are available can be solar or battery powered and can be easily

<sup>25</sup> Bieler S, Matovu E, Mitashi P, Swewannyana E, Bi Shamamba SK, Bessell PR et al. Improved detection of *Trypanosoma brucei* by lysis of red blood cells, concentration and LED fluorescence microscopy. Acta Trop. 2012;121:135–40.

switched between bright field and fluorescence. These methods could also be used to diagnose several other diseases (such as tuberculosis or malaria).

### ***b. HAT LAMP kit***

The LAMP test is a simplified PCR that can be used to detect parasite DNA. It presents several advantages: it is isothermal, rapid (40 min), performed in a closed system and has a visible readout. Moreover, the preparation of the specimen is easier and less expensive than for a classical PCR. The kit that is currently available is based on the RIME target and detects any species of the Trypanozoon sub-genus, but cannot differentiate subspecies of *T. brucei*. This test has not shown more sensitivity than microscopy.<sup>26</sup>

Like for other molecular tests, filter papers can be used for blood collection, but with the disadvantage that sensitivity decreases. To improve sensitivity, buffy coat samples can be spotted on filter papers. Data on the performance of these methods in field conditions are still to be collected.

For the moment, the price of the reagents for a single LAMP test is approximately US\$ 3, but the block (incubator) for the test is expensive.

## **6.2 Treatment**

### ***6.2.1 Existing tools***

The drugs used in r-HAT are the same ones that have been employed for many decades, and the evidence base for their use is limited.

**Suramin** is the **first-line drug in stage I treatment**. It is administered following a test dose (1–2 mg/kg) using various empirical regimens consisting of five intravenous injections (20 mg/kg) with a maximum of 1 g per injection. These doses are usually given over a period of 3 weeks.

**Pentamidine** (4 mg/kg x 10 days) is rarely used and data on its efficacy against stage I r-HAT consists of just a few case series.

**Melarsoprol** is the **first-line drug in stage II treatment** but adverse drug reactions are frequent. Empirical schedules were replaced by a simplified 10-day regimen (2.2 mg/kg x 10 days) in 2009, following a study of 107 patients that used historical data (300 patients treated within the 2-years prior to the study) for comparison (Table 5). This new regimen does not improve treatment safety but is efficient and halves the duration of hospitalization. Country policies have not changed yet and still use the former empirical schedules.

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<sup>26</sup> Mitashi P, Hasker E, Mumba Ngoyi D, Patient Pyana P, Lejon V, van der Veken W et al. Diagnostic accuracy of loopamp *Trypanosoma brucei* detection kit for diagnosis of human African trypanosomiasis in clinical samples. PLoS Negl Trop Dis. 2013;7: e2504.

**Table 5** Safety and efficacy of a 10-day schedule of melarsoprol (trial data) against historical data<sup>a</sup>

	<b>Trial data (n=107)</b>	<b>Historic data (n=300)</b>
<b>Safety</b>		
Mortality	8.4% (7) [CI 4.0-15.0]	9.3% (28) [CI 6.3-13.2]
Encephalopathic syndrome	11.2% (12) [CI 6.6-19.9]	13.0% (39) [CI 9.4-17.3]
<b>Efficacy</b>		
End of treatment	100% (98) [CI 96.3-100]	No information available
Follow-up 12 months	95.9% (94)	
Relapses	1% (1)	
<b>Treatment Adherence</b>	100% (107) [CI 96.6-100]	91% (273) [CI 87.1-93.9]
<b>Hospitalization time</b>	13 days [CI 12-14]	29 days [CI 28-30]

<sup>a</sup> Source: C. Burri.

The evidence base for **patient management** is also limited.

- **Suramin dose prior to staging**
  - Rationale: reduces the risk of mechanical central nervous system contamination, reduces parasite antigen release with melarsoprol, clearer interpretation in cases of traumatic lumbar puncture.
  - Unclear impact on patient outcome.
- **Use of steroids during melarsoprol administration**
  - r-HAT: one small study, no benefit shown.

### **6.2.2 Future tools**

The classic needs for new HAT medicines include efficacy, safety, simple administration, central nervous system penetration (efficacy in both disease stages) and affordability.

The **key challenge for the evaluation of new drugs is the enrolment of cases in clinical trials**. Indeed, it is difficult to enrol a sufficient number of patients to power a trial. Trials may need to use historical data for comparison rather than a randomized, controlled design. But these studies will not be optimally clean and decisions are needed on how the treatment group is managed and analysed in relation to heterogeneous historical data.

A **standard approach** to conducting future trials should be adopted. Guidance developed for g-HAT clinical trials could be used as a starting point. Consensus is needed on

inclusion/exclusion criteria, the approach to analysis of the treatment group relative to the historical data, and a standardized protocol for the conduction of follow-up (e.g. intervals for lumbar puncture and total duration).

The **drug candidate** at the most advanced stage of development is **fexinidazole**, given orally for 10 days, once a day with food. Fexinidazole and its metabolites are active against *T. b. gambiense* and *T. b. rhodesiense* in vitro and in vivo.

In **phase I clinical trials**, the number and frequency of adverse effects were not very high, and were mainly gastrointestinal problems and headaches. One inconvenience is that the drug should be given after food intake, which is not easy to guarantee in certain settings. A **phase II/III clinical trial** is ongoing in **g-HAT** patients.

The general approach for r-HAT is to extrapolate from the results collected with g-HAT and to use historical controls, including both first- and second-stage cases. However, the sample size still needs to be defined.

Beyond the sample size issue, several points need to be resolved:

- Criteria for selection are the highest opportunity to recruit cases
- Increase patient recruitment:
  - widespread information using existing channels and a communication plan
  - referral to adequately equipped centres (ECG and biochemistry) → need for a referral system?
  - active case searches: not a priority in terms of public health
- Follow-up for efficacy assessment:
  - Follow-up must be conducted but there is a lack of evidence about its duration for assessment of new treatments. As r-HAT is acute, a follow-up at 3 months must be included.
  - To explore mechanisms for achieving good follow-up of patients.
- Guarantee of food supply and food intake by the patient before drug intake.

## 7 Vector control

### 7.1 Historical operations

Between the 1950 and 1980s, **ground spraying** with persistent insecticides such as DDT and dieldrin were the mainstay of tsetse control. From the 1970s, the **sequential aerosol technique** became increasingly important. However, from the 1980s, **targets** and, later, **insecticide-treated cattle** became the most widely used tools for vector control.

### Lessons learnt from historical operations

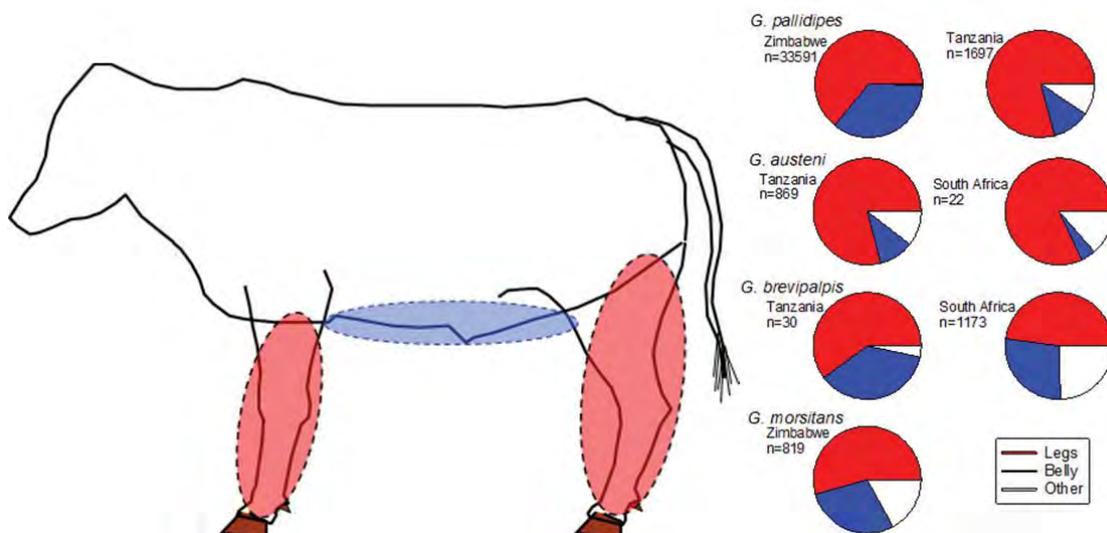
- Vector control has successfully contributed to control of r-HAT foci
- Several methods have been used
- Successes were achieved through large-scale operations
- External contractors played important roles
- Control was expensive and required strong vector control departments

## 7.2 Improving vector control

### Restrictive application protocol

The most affordable technique for farmers is to treat their cattle with insecticides. Some 75–99% of tsetse feed on the legs or belly of cattle (Figure 19). Restricting insecticide to the legs and/or belly reduces insecticide costs by 80–90%, with only a slight reduction in efficacy. The restrictive application protocol (RAP) reduces costs to below US\$ 1 per animal per year, requires less insecticide, and is safe, simple and clean. Spraying cattle with insecticides is also effective against tick-borne diseases of livestock such as East Coast fever (ECF), anaplasmosis and babesiosis, and could provide an incentive for farmers to spray. In Uganda, farmers incidentally also spray the ears to be more effective against brown ear tick, the vector of ECF.

Figure 19. Tsetse feeding pattern on cattle<sup>a</sup>



Source: S. Torr et al., 2007<sup>27</sup>; J. Esterhuizen (unpublished data); V. Kovacic (unpublished data).

<sup>27</sup> Torr SJ, Maudlin I, Vale GA. Less is more: restricted application of insecticide to cattle to improve the cost and efficacy of tsetse control. Med Vet Entomol. 2007;21:53–64.

However, cattle are not always present in sufficient numbers. Many national parks and wilderness areas in East and Southern Africa are also important HAT foci, with low numbers of livestock. The method is not therefore a panacea.

### **Tiny targets**

Field-based analyses of the responses of riverine tsetse to visual and olfactory cues resulted in the development of “**tiny targets**”. Compared to traditional traps, they are twice as effective, around 10 times cheaper, relatively long-lasting (6 months) and easy to deploy. Trials in Kenya and Uganda have shown that tiny targets can provide > 90% control of *G. fuscipes* and can even eliminate isolated populations of tsetse when deployed at densities of 20/km<sup>2</sup> along lake shores and rivers. The density of non-isolated populations of tsetse was reduced by ~90% to mean catches of < 0.5 tsetse/trap/day. Tiny targets cost US\$ 1 per target; annual costs of deploying and maintaining tiny targets are US\$ 46/km<sup>2</sup>. After allowing for the costs of community sensitization, monitoring and administration, the total annual cost is US\$ 85/km<sup>2</sup>. Nevertheless, tiny targets are not as cost-effective against savannah tsetse flies and hence only in areas where *T. b. rhodesiense* is transmitted by *G. f. fuscipes* is this method appropriate. It is not advised for foci where the pathogen is transmitted by savannah tsetse. Artificial baits are efficient tools for control of savannah tsetse.

#### **More lessons learnt:**

- Insecticide-treated cattle offer the prospect of cost-effective tsetse control where cattle are present. So if there are cattle, they need to be preferably RAP.
- Tiny targets are cost-effective for riverine but not savannah tsetse.
- Quality-assured tsetse control products are needed (insecticide performance, colour, durability).
- Sensitization is key as local communities are crucial partners.
- Coordination with medical teams is crucial for monitoring the impact of vector control on r-HAT transmission.

### **7.3 Protecting people living in or near wildlife areas**

To better protect people living in or near wildlife areas, it is important to understand why, where and when tsetse flies bite humans. Being mobile, especially in the absence of livestock, appears to be a very high risk factor for being bitten by *G. morsitans*. Hunters and tourists are therefore potentially at risk. However, many tsetse species also bite humans near and within buildings. Tsetse behaviour seems to change inside buildings: outdoors, the tsetse biting humans are young flies that cannot have developed a mature infection; indoors, older flies, with higher probability of being infected, tend to bite humans.

Some phenols and wood smoke reduce the number of tsetse attracted to cattle, but the protective effects of **repellents** seem to be lost in domestic settings. For people living in or near wildlife areas, methods used against malaria mosquitoes might be effective. For example, indoor residual spraying, insect screens and insecticidal netting will kill tsetse indoors and prevent them from entering.

Beyond communities living in or near wildlife areas, at-risk people include foreign tourists visiting game reserves and moving through the park in vehicles. **Vehicle-mounted traps** for tsetse could also contribute to reducing tsetse populations over an extensive area. Eradication of tsetse flies from inside parks does not seem to be feasible, but targeted interventions focussed at the interface of wildlife and settled areas, and foci within wilderness areas, offer the prospect of cost-effective control. Research to develop cost-effective methods in wilderness areas is being carried out.

#### **Other lessons for the future**

- Interventions focussed on transmission hotspots may offer more cost-effective control of r-HAT.
- Within wilderness areas, simple interventions may offer protection to people in offices, hotels and their homes.
- Highly focal deployment of targets in the vicinity of buildings is not effective.
- Mobile baits might offer a new cost-effective means of controlling tsetse.

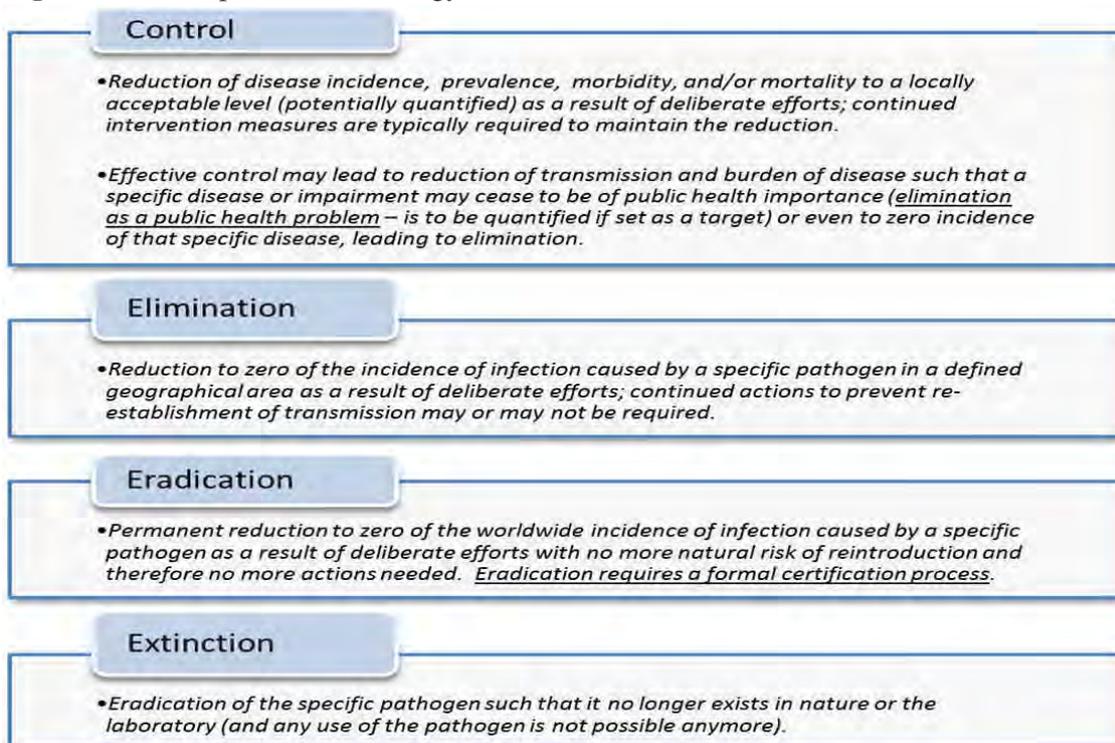
The respective roles of FAO, PAAT (Programme Against African Trypanosomiasis), IAEA (International Agency for Atomic Energy) and PATTEC on tsetse and trypanosomiasis control have been presented (see Annex 5).

## 8. Elimination of r-HAT

### 8.1. Concepts and terminology

Clarifications of concepts and terminology for control, elimination, eradication and extinction are detailed in Figure 20.

Figure 20. Concepts and terminology<sup>a</sup>



<sup>a</sup> Source: WHO NTD-STAG, 2014.

Elimination of r-HAT as a public health problem has been quantified as **less than 1 case/10 000 people at risk.**

### 8.2. Assessment of feasibility of disease r-HAT elimination

The International Task Force for Disease Eradication issued in 1988 a list of basic principles to guide the assessment and feasibility of infections for eradication and elimination (Table 6).

**Table 6** Determinants of disease elimination feasibility, as defined by the International Task Force for Disease Eradication/Elimination, 1988<sup>a</sup>

Determinants of Elimination Feasibility	Status, <i>T. b. gambiense</i>	Status, <i>T. b. rhodesiense</i>
Biological plausibility (absence non-human reservoirs, naturally induced immunity, etc)	Likely, but more data needed	No
Understanding of disease epidemiology	Yes,	Yes, but incomplete
Effective tools	Yes, better tools needed	Yes, better tools needed
Effective surveillance and M & E methods	Yes, but incomplete	Incomplete
Proof of principle	Yes	No
Political will	Yes	Yes

<sup>a</sup> Source: P. Holmes.

### **8.2.1. Biological plausibility**

While the elimination of g-HAT seems biologically plausible (even if more data are needed on the existence of an animal reservoir), it is highly unlikely for r-HAT because it is a zoonosis. Moreover, part of the non-human reservoir resides in wildlife, where control activities appear to be very complicated. Theoretically, by lowering the intensity of infection in livestock and/or by eliminating tsetse flies, the transmission could be interrupted.

### **8.2.2. Understanding of disease epidemiology**

While the epidemiology of g-HAT is now well understood as the distribution of the disease is limited to well-described foci, that of r-HAT remains incomplete; for example, understanding of the relative contribution of each host species to the total community reservoir potential, or the role of the so-called interface zones between cattle and game reserves. Moreover, the epidemiological situation is still unclear in certain countries (Burundi, for example).

### **8.2.3. Effective tools**

As discussed above, better tools are needed, both for easier diagnosis and for safer and easier treatment. Fortunately, substantial efforts have been made during the past years, and new tools are in the pipeline.

### **8.2.4. Effective surveillance and monitoring and evaluation methods**

Even if areas at risk of sleeping sickness are not fully covered by control and surveillance

programmes, most foci of the disease are well known. Ministries of Health carry out interventions through NSSPCs and health systems. Moreover, WHO assists NSSCPs to implement control activities and capacity-building through in-service training and thematic workshops at national, regional and international levels.

Nonetheless, the challenges for surveillance, notably for r-HAT, include diminishing community awareness, loss of expertise for clinical suspicion and laboratory confirmation among health workers, the need for new tools such as individual serological tests for diagnosis and screening, and loss of government commitment for diseases for which reporting is not mandatory.

### ***8.2.5. Proof of principle***

As proof of principle, g-HAT has been eliminated in several foci, for example in the focus of Luba (Equatorial Guinea). After intensive control activities initiated in 1985, the number of cases reduced drastically. The last case was reported in 1995 despite regular active and passive surveillance.

The incidence of r-HAT has decreased markedly in many countries during the past decade, making clear the possibility of elimination of the disease as a public health problem.

### ***8.2.6. Political will***

Multiple meetings, declarations and resolutions show that there is marked interest among political decision-makers to support HAT control and elimination.

- In 2000, during the summit in Lomé of the African Union Organization, the Heads of State and Governments of African countries declared their willingness to free Africa from the scourge of tsetse and trypanosomiasis and promoted PATTEC.
- In 2003, the 56th World Health Assembly adopted resolution WHA56.7, calling on Member States to intensify HAT control efforts to “implement a programme for the elimination of human African trypanosomiasis as a public health problem”.
- In 2005, elimination of HAT was endorsed during the 55th WHO Regional Committee for Africa in Maputo by AFR/RC/55/R3 and included in the conclusions of the International Scientific Council for Trypanosomiasis Research and Control (ISCTRC) in Addis Ababa, Ethiopia.
- In 2007, endemic countries endorsed the elimination goal during a WHO meeting on elimination of g-HAT held in Geneva.
- In 2011, the STAG-NTD assessed and deemed elimination of HAT to be feasible.
- In 2012, elimination of HAT “as a public health problem” was included in Roadmap.
- In 2013, the 66th World Health Assembly adopted resolution WHA66.12 on NTDs to ensure continued country ownership to expand and implement interventions to reach

the targets agreed in the Global Plan to Combat Neglected Tropical Diseases and set out in the Roadmap, where elimination of HAT is included.

- In 2014, two WHO stakeholders meetings took place in Geneva to accelerate the process of defining objectives for the control and elimination of each of the HAT forms, and to reinforce coordination for their control and surveillance.

Nonetheless, the decrease in governmental commitment and partners' interest for r-HAT control as the number of cases falls has been pointed out by several countries.

## **8.3. Elimination of r-HAT as a public health problem**

### ***8.3.1 Roadmap goal***

The goal for r-HAT as stated in the Roadmap is “to eliminate HAT as a public health problem” by 2020, defined as < 1 new case per 10 000 inhabitants in at least 90% of foci, with < 2000 cases reported annually at continental level.

### ***8.3.2 Rationale***

During the past decade, the total number of reported r-HAT cases has decreased by 65%. In addition to a decrease in the total number of people at risk, in the period 2008–2012, 95% (8.08 million) of the 8.5 million of people at risk have already reached the goal of living below the epidemiological threshold of a public health problem.

Although the elimination defined as zero cases or the interruption of transmission is very challenging for r-HAT, its elimination as a public health problem by 2020 is achievable.

### ***8.3.3 Strategy***

A control and elimination strategy must be adapted according to the different epidemiological situations. Since HAT is a focal disease, the strategy must be dynamic and adapted for each focus as the different foci have different, changing patterns.

Two different transmission scenarios are considered in foci of *T. b. rhodesiense*:

1. Transmission areas where wild animals, mainly kept in natural protected areas, are the main parasite reservoir.
2. Transmission areas where the main parasite reservoir is cattle.

A One Health approach, which combines the different methods available in a multisectoral collaboration, is required.

### ***a. Control of the animal reservoir***

Some other approaches are useful for the control of *T. b. rhodesiense* in the **domestic animal** reservoir:

- Curative (treating animals affected by animal trypanosomosis or nagana)
- Prophylactic chemotherapy prophylactic
- Avoidance of tsetse-infested areas
- Control of livestock trade markets
- Animal protection: restricted grazing, impregnated net fencing, and repellents, for which use in cattle is still controversial as tsetse flies might then feed on humans.

Conversely, there is no consensus on how to control *T. b. rhodesiense* in the **wild animal** reservoir.

### ***b. Tsetse control***

Different methods can be adapted to the different situations and focused in hotspots:

- Insecticide-treated targets and traps
- Insecticide-treated cattle (animal baits): pour-on, restricted applications
- Aerial spraying (i.e. sequential aerosol technique, or SAT)
- Sterile insect technique, or SIT
- Vehicle spraying and vehicle baits
- Clearing vegetation and ground spraying
- There is a need to define which method should be used, where it should be applied and at what level of community involvement.

### ***c. Control of disease in humans***

As r-HAT is an acute vector-borne zoonosis, control of the disease in humans will not help substantially to control *T. b. rhodesiense*. Nonetheless, the detection of affected individuals is crucial to offering the best treatment possible and ensuring accurate surveillance.

Active screening of populations for r-HAT is not cost-effective. Nonetheless, **reactive active screening**, targeting specific villages or groups of people or families where cases have been recently detected, can be effective in some areas. It is currently based on parasitology screening of selected populations.

Most of the reported cases are captured **passively**. Passive case-detection should be a continuous activity performed in selected fixed health facilities strategically located in at-risk areas. Health posts and community health workers that do not have the equipment to diagnose and treat HAT cases should be instructed to identify and refer clinical suspects to an adequate fixed health facility. The diagnosis is currently based on parasitology; the most appropriate and sensitive method should be used.

- There is a clear **need to improve access to HAT diagnosis by strengthening and expanding the existing network of fixed health facilities with this capacity**, particularly because of the high turnover of medical staff in the affected areas.

The detection of affected individuals must be followed by **proper case management**. After staging, medical staff should ensure the best treatment available, with the most adequate and safest drugs.

- **There is a need to improve access to and quality of treatment by strengthening and expanding the existing network of fixed health facilities offering HAT treatment.**

The system requires continuous training, equipment and supervision, especially when the number of cases detected annually is low.

#### ***d. Prevention of human–tsetse fly contact***

Contact between humans and tsetse flies should be prevented through appropriate vector control.

#### ***e. Epidemiological surveillance***

Continuous monitoring of the epidemiological situation (occurrence and distribution) and the proper response to detected changes in trends should be in place to achieve and sustain the control of r-HAT. This implies that the following important elements must be ensured:

- Data collection and analysis
- Response
- Network of facilities capable of diagnosing, managing and reporting cases
- Identification of sites (inventory and needs for extension)
- Training and equipment with regular refreshment

Cases diagnosed in non-endemic countries are useful in highlighting the transmission of r-HAT in the probable places of infection.

### ***8.3.4 Needs for a multidisciplinary (One Health) approach***

#### ***a. Generalities of the One Health concept***

Recently, FAO, OIE and WHO have engaged in a coordinated effort to address health risks at the animal–human–ecosystems interfaces.<sup>28</sup> In April 2010, they issued a tripartite concept

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<sup>28</sup> The FAO–OIE–WHO collaboration: sharing responsibilities and coordinating global activities to address health risks at the animal–human–ecosystems interfaces – a tripartite concept note. April 2010 ([http://www.who.int/entity/foodsafety/zoonoses/final\\_concept\\_note\\_Hanoi.pdf?ua=1](http://www.who.int/entity/foodsafety/zoonoses/final_concept_note_Hanoi.pdf?ua=1)).

note on their strategic alignment, current collaboration and joint actions for future collaboration. The vision of this collaboration is to prevent, detect, contain, eliminate and respond to animal and public health risks attributable to zoonoses and animal diseases that impact food security through multisectoral cooperation and strong partnership.

Collaboration among the human health, animal health and wildlife sectors should yield benefits that are more than merely additive. These are related to direct positive outcomes not only in reduced risks and improved health and well-being of animals and humans, but also in financial savings, reduced time to detect disease outbreaks and subsequent public health actions as well as improved environmental services.

The concept of One Health comprises:

- Initiating more preventive action by addressing the root causes and drivers of infectious diseases, particularly at the animal–human–ecosystems interfaces.
- Building more robust public and animal health systems that are based on good governance and are compliant with the WHO International Health Regulations and OIE international standards, with a shift from short-term to long-term interventions.
- Strengthening national and international emergency response capabilities to prevent and control disease outbreaks before they develop into regional and international crises.
- Better addressing the concerns of poor people by shifting focus from developed to developing economies, from potential to actual disease problems, and to the drivers of a broader range of locally important diseases.
- Promoting wide-ranging institutional collaboration across sectors and disciplines.
- Conducting strategic research to enable targeted disease control programmes.

The main questions to be answered through the “One health approach” are:

- Stakeholders – who are the key actors and what are their roles?
- Poverty and livelihoods – what are the consequences for people’s livelihoods, incomes and well-being?
- Holism – how integrated is the approach across diseases, sectors and disciplines?
- Uncertainty – how is uncertainty and ignorance being addressed?
- Accountability – what accountability mechanisms exist, particularly for those who are affected?
- Sustainability
- Strategic research

Good governance of human and animal health services requires<sup>29</sup>:

- **Coordination** within the responsible government authorities for the detection of and response to zoonotic events.
- **National policy**, strategy or plan for surveillance and response to zoonotic events.
- **Focal points** responsible for animal health (including wildlife) designated for coordination with the Ministry of Health and/or International Health Regulations national focal points.
- **Functional mechanisms** for intersectoral collaborations that include animal and human health surveillance units and laboratories.
- Priority zoonotic diseases with **case definitions** and with systematic and timely collection and collation of data.
- Timely and systematic **data and information exchange** among animal surveillance units, laboratories, human health surveillance units and other relevant sectors regarding potential zoonotic risks and urgent zoonotic events.
- Access to **laboratory capacity**, nationally or internationally (through established procedures), to confirm priority zoonotic events.
- Zoonotic disease surveillance that includes a **community component**.
- Regularly updated **roster (list) of experts**.
- **Mechanism for response to outbreaks** of zoonotic diseases by human and animal health sectors.

### ***b. Applying the One Health concept to HAT***

#### **Surveillance**

Maintaining surveillance for human cases becomes more difficult as the number of r-HAT cases continues to decrease and will need to become integrated into the wider healthcare provision. Linking animal, wildlife and human health systems to better understand the epidemiological situation and risk zones is therefore crucial.

Surveillance of animal trypanosomiasis is in itself challenging as animals often carry **mixed infections** of *T. brucei*, *T. congolense* and *T. vivax* – the latter two species being more pathogenic to animals but non-infective to humans – and not all livestock infected with *T. brucei* spp show clinical signs. However, trypanosomiasis in cattle is among the diseases that are notifiable to the OIE.<sup>30</sup>

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<sup>29</sup> WHO–OIE Operational framework for good governance at the human–animal interface: bridging WHO and OIE tools for the assessment of national capacities ([http://www.oie.int/fileadmin/Home/fr/Media\\_Center/docs/pdf/WHO-OIE\\_Operational\\_Framework\\_final.pdf](http://www.oie.int/fileadmin/Home/fr/Media_Center/docs/pdf/WHO-OIE_Operational_Framework_final.pdf)).

<sup>30</sup> OIE Terrestrial animal health code. Chapter 1.2: Criteria for the inclusion of diseases, infections and

## **Control**

In areas where there is a livestock reservoir, **control must be targeted at livestock**, with substantial support from human health services for funding and logistics, as it should be done specifically to improve human health. Control of *T. b. rhodesiense* infection in livestock requires mass treatment with trypanocides and tsetse control through insecticide pour-ons. Cattle can also be protected by restricting grazing areas and using impregnated netting fences.

In areas with a significant wildlife population, it is more difficult to control trypanosomiasis transmission. Particular attention should therefore be focused towards the interface of wildlife and livestock that then transmit to humans. In those areas, the surveillance of human populations should be strengthened with sentinel surveillance sites, guided by the distribution of infection in wild animals.

## **Integrated response**

Integration of human and livestock services is crucial and human resources available from both sectors could be synergized. National bridging workshops can play an important role by answering the following questions:

- How should data from humans, livestock and wildlife be triangulated for more effective control?
- How could responsibilities, funding, data sharing, control activity implementation, surveillance and diagnostic capacities be shared realistically?
- Which drivers are blocking current attempts to integrate approaches?

### **8.3.5 Indicators**

Progress towards elimination will be measured by two **quantitative indicators** updated annually:

- ✓ Number of cases reported
- ✓ Number of foci reporting less than 1 case per 10 000 inhabitants

**Qualitative indicators** will also be needed to assess the quality and extent of the elimination activities:

- ✓ Geographical extent of the disease
- ✓ coverage of population at risk by control and surveillance activities
- ✓ Progress of population across different levels of risk

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infestations in the OIE list

([http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre\\_criteria\\_diseases.htm#chapitre\\_criteria\\_diseases](http://www.oie.int/index.php?id=169&L=0&htmfile=chapitre_criteria_diseases.htm#chapitre_criteria_diseases))

### 8.3.6 Requirements

Intensified and sustainable control of r-HAT requires the following inputs:

- **Commitment and political support in endemic countries to the objectives and process of r-HAT elimination** under the One Health approach.
- **Appropriate funding from the international community and r-HAT endemic countries** to implement control strategies and support operational research and tool development. The funding gap should be reconciled through effective commitment from partners coupled with strong advocacy at national and international levels.
- **Efforts to scale up health system capacities for diagnosis and treatment in rural areas where r-HAT transmission occurs.** The overall performance of the health system in these areas is often weak, characterized by unskilled staff, low attendance and low coverage. WHO has a crucial role in supporting r-HAT endemic countries with training and equipment to reinforce diagnosis and treatment and to monitor (surveillance) progression of the disease.
- **Larger multisectoral approach under the One Health strategy**, whereby WHO has only a minor role in controlling r-HAT. Consideration must also be given to the zoonotic component of the disease as well as its negative impact on various sectors of the economy such as food production and tourism.
- **A national coordination body in each disease-endemic country, including all sectors involved** in interrupting r-HAT transmission and its impacts (human and animal health, wildlife management and tourism).
- **Coordination of different r-HAT actors in a network for r-HAT elimination** to advance the fight against the disease, accelerate research discoveries, expand scientific knowledge, improve medical care and enhance public health measures for control and monitoring of the disease.

## 8.4. Summary

1. The Roadmap provides clear terminology and targets for elimination of NTDs, including HAT.
2. The zoonotic component of r-HAT is a barrier to achieving the elimination of the disease
3. Nevertheless, r-HAT is already at a very low level of endemicity in most affected countries.
4. Through the One Health approach, and using the existing or improved tools, r-HAT can be eliminated as a public health problem.

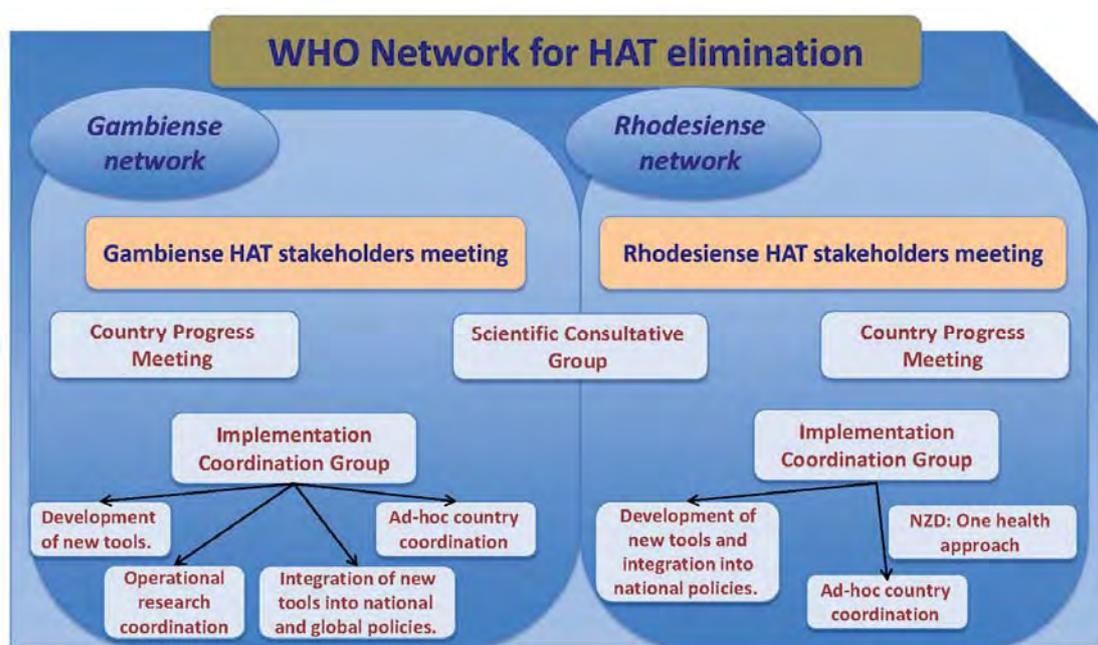
## 9. WHO network for intensified r-HAT control

Collaboration is a key element in the progress towards HAT elimination and the coordination of activities required to synergize efforts, avoid overlap and harmonize activities. A WHO Expert Committee on the control and surveillance of human African trypanosomiasis recommended in 2013 that coordination be strengthened among people involved in control and research in order to facilitate the development and validation of new control tools.

The first WHO stakeholders meeting on g-HAT elimination (March 2014) proposed a framework for a WHO network for g-HAT elimination. WHO proposed that inspiration be drawn from this framework to develop a network for intensified r-HAT control.

The “WHO network for HAT elimination” is so called because WHO provides governance to strengthen efforts towards the 2020 target for HAT elimination, i.e. elimination of the disease as a public human health problem.

**Figure 21.** The WHO network for the elimination of human African trypanosomiasis<sup>a</sup>



<sup>a</sup> Source: Adapted from the Report of the first WHO stakeholders meeting on g-HAT elimination, 2014.<sup>31</sup>

The network for intensified r-HAT control plans to hold a general forum: the stakeholders meeting. Three groups (Figure 21) will provide effective support for driving activities during the interval between meetings, with more groups added according to identified needs.

<sup>31</sup> Report of the first WHO stakeholders meeting on gambiense human African trypanosomiasis elimination. Geneva, 25–27 March 2014. Geneva: World Health Organization; 2014 (WHO/HTM/NTD/IDM/2014.4).

- Scientific and Technical Consultative Group
- Country Progress Meeting
- Implementation Coordination Group

### **9.1. WHO rhodesiense HAT elimination stakeholders meeting**

This meeting convenes all the stakeholders involved in the control/elimination of r-HAT in its different aspects, including:

- National sleeping sickness control programmes;
- Other national actors involved in the control of r-HAT, including livestock, agriculture, wildlife and natural resources and tourism organisms.
- Scientific institutions and platforms developing new tools to control r-HAT;
- International organizations involved in r-HAT control; and
- Public and private donors.

It is an open forum where progress in intensified r-HAT control is reported and important advances, difficulties and gaps are discussed. The different groups included in the network report to the stakeholders meeting.

Meetings provide a tool for advocacy of intensified r-HAT control. Donors participate also in the meetings in order to acquire information on progress and discuss financial gaps in the road to elimination.

WHO convokes meetings every 24 months at its headquarters in Geneva and ensures the Secretariat.

### **9.2. Rhodesiense HAT Scientific and Technical Consultative Group**

The Scientific and Technical Consultative Group could be shared between g-HAT and r-HAT networks.

This group of individuals has vast experience on different aspects of HAT. It advises on strategies, tools and evaluation of outputs of activities; answers specific scientific and strategic questions and issues; identifies possible barriers to elimination; and proposes technical and strategic solutions.

Members are selected from WHO's panel of experts and, according to the agenda, they may also include other specialists in specific areas.

The Group meets on request at WHO's headquarters in Geneva and WHO provides the Secretariat. It reports to the WHO g-HAT elimination stakeholders meeting and r-HAT elimination stakeholders meeting.

### **9.3. Country Coordination Meeting**

This is a general meeting of WHO and all the r-HAT focal points of endemic countries. Occasionally, other implementers (NGOs, international agencies), other national organisms (livestock, agriculture, wildlife conservation, tourism), WHO collaborating centres or other experts may be invited.

The meeting updates the r-HAT country situation and the results of control and surveillance in the framework of the control/elimination process. It reviews and advises on policies, strategies and implementation.

This meeting with all the r-HAT focal points is organized every year (or 2 years) by the WHO Regional Office for Africa in an African country.

### **9.4. Implementation Coordination Group**

Given the complexity and specificity of the topics to be treated, this working group is split into several specific thematic subgroups that identify areas of work. These subgroups are closely interconnected and coordinated. The first stakeholders meeting identified the following themes requiring subgroups:

- Development of new tools and integration of new tools into national policies
- Ad-hoc country coordination

The subgroups include representatives of r-HAT focal points from selected disease-endemic countries, research institutions and institutions developing new tools or implementing activities in the field. Each subgroup reports the outcomes to the WHO r-HAT elimination stakeholders meeting.

Meetings are held according to needs, either face-to-face or virtually via the Internet. One annual face-to-face meeting is recommended of each subgroup, with the date and venue decided according to needs and participants. Donors are also invited to participate in any subgroup as observers. WHO ensures the secretariat of each subgroup. The outcomes of these meetings should be drafted and circulated to all the members of the other subgroups, and may also be disseminated to a broader tsetse and trypanosomiasis community depending on the outcomes. A webpage on the WHO website should be dedicated to communications from the r-HAT network. Main outcomes could also be published in the tsetse and trypanosomiasis magazine by the FAO.

As the number of staff at WHO in charge of HAT is limited, all the stakeholders must be proactive and contribute to these activities. Moreover, meetings are important to ensure coordination and regular updates, but there is a lot of work that needs to be done in the interval between meetings.

Rather than a standalone subgroup of the Implementation Coordination Group, it has been agreed that the One Health approach should be used in each of the subgroups or thematic working groups.

Coordination should be shown at central, regional and national levels. Successful experiences at country level could be used to address these challenges upwards. Ethiopia and Kenya are moving forward with this approach.

## **10. Conclusions and outcomes**

The participants of the first stakeholders meeting issued a final declaration and agreed that in order to achieve the Roadmap target of elimination of r-HAT as a public health problem by 2020, the following should be addressed:

1. Build on recent progress in reducing the incidence of r-HAT, whilst recognizing that the epidemic potential remains of an acute disease with high lethality.
2. Need for multisectoral (One Health) cooperation and coordination at international, regional, transboundary and national levels.
3. Coordination at the national level and intersectoral collaboration is essential. COCTU provides an excellent example.
4. Faster adoption and better utilization of existing and new tools, e.g. new drugs in the pipeline, improved diagnostics, more cost-effective vector control, and their quality assurance.
5. Strengthen the capacity of human resources and infrastructure.
6. Greater attention to the animal reservoir is required as well as to the respective roles of livestock and wildlife in different countries and in different ecological situations.
7. Improved and sustained surveillance of *T. b. rhodesiense* infection in humans and animals.

## 11. Declaration on the elimination of rhodesiense human African trypanosomiasis

Participants attending the meeting stated their interest in joining the network and agreed the following declaration<sup>32</sup>:

22 October 2014 | Geneva

Human African trypanosomiasis (HAT), also known as sleeping sickness, has been one of the major diseases of mankind. After it was brought close to elimination in the 1960s, the disease surged significantly by the end of the 20th century. Over the past decade and through joint efforts by countries, WHO and partners, HAT's incidence has been reduced by over 90%.

Success in controlling the disease, coupled with unprecedented political will, led WHO to publish its Roadmap on Neglected Tropical Diseases in 2012 to control / eliminate / eradicate 17 diseases including the elimination of HAT as a public-health problem by 2020. The Sixty-sixth World Health Assembly in 2013 endorsed the objectives of the Roadmap (WHA66.12), providing an international mandate to work towards elimination.

Rhodesiense HAT (r-HAT) is a zoonotic disease in which wildlife and domestic animals are the main reservoirs and play a central role in maintaining transmission to humans by the bite of infected tsetse flies. The zoonotic nature of this disease makes its elimination especially challenging. However, the elimination of r-HAT as public-health problem (defined as less than 1 case/10 000 people at risk) is achievable. The first WHO stakeholders' meeting on r-HAT (Geneva, 20–22 October 2014) supported the Roadmap's goal of achieving and sustaining the elimination of r-HAT as a public-health problem by 2020.

The stakeholders urged the scaling up and maintenance of health system capacities for diagnosis and treatment in r-HAT transmission areas, quantification of infection risk in humans and animals, and vector control. Especially important is the establishment in endemic countries of national coordination bodies including all sectors involved in r-HAT transmission and its impact (i.e. human and animal health, wildlife and tourism) to bring together and synergize efforts.

The zoonotic component of r-HAT, as well as its negative impact on various sectors of the economy – mainly livestock, agriculture and tourism – calls for a larger multisectoral approach. In this context, WHO has a crucial role in supporting endemic countries in the diagnosis, treatment and development of policies to monitor the disease trends.

The WHO network for HAT elimination was launched in March 2014 by stakeholders involved in gambiense HAT. Participants in the r-HAT meeting declared their interest in joining the network to advance the fight against the disease by accelerating biomedical research, expanding the scientific knowledge base, implementing cost-effective vector control,

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<sup>32</sup> [http://www.who.int/trypanosomiasis\\_african/meeting\\_declaration\\_rhodesiense\\_2014/en/](http://www.who.int/trypanosomiasis_african/meeting_declaration_rhodesiense_2014/en/)

improving diagnosis and clinical care, and enhancing the efficacy of medical and veterinary public-health measures for the control and monitoring of the disease.

The stakeholders appealed to the international community and r-HAT endemic countries to give their full commitment, political support and essential resources to achieve and sustain this goal.

Institutions and organizations represented at the stakeholders meeting on r-HAT elimination having adopted this declaration:

- Institutions from r-HAT endemic countries:
  - Kenya Agricultural and Livestock Research Organization (KALRO)
  - Ministry of Health, Malawi
  - Ministry of Health and Social Welfare, United Republic of Tanzania
  - National Sleeping Sickness Control Program (NSSP), Uganda
  - Coordinating Office for Control of Trypanosomiasis in Uganda (COCTU)
  - Makerere University, Kampala, Uganda
  - Ministry of Health, Zambia
  - Copperbelt University, School of Medicine, Zambia
  - Zambia Wildlife Authority (ZAWA)
  
- International organizations:
  - African Union Commission (AU) / Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC)
  - Food and Agriculture Organization of the United Nations (FAO)
  - International Atomic Energy Agency (IAEA)
  - Programme Against African Trypanosomosis (PAAT)
  - World Health Organization Strategic and Technical Advisory Group on Neglected Tropical Diseases (WHO NTD STAG)
  - World Health Organization (WHO)
  
- Scientific institutions:
  - Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), Montpellier, France
  - International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya
  - Edinburgh Global Health Academy. University Edinburgh, U.K.

- Institut de Recherche pour le Développement (IRD), Montpellier, France
  - Institute of Infection and Global Health, University of Liverpool, U.K.
  - Interdepartmental Research Centre for Neglected Diseases, Institute of Tropical Medicine, Antwerp, Belgium
  - Liverpool School of Tropical Medicine (LSTM), Liverpool, U.K.
  - Scotland's Rural College (SRUC), U.K.
  - South African Centre for Epidemiological Modelling and Analysis (SACEMA), Stellenbosch, South Africa
  - Spatial Ecology & Epidemiology Group (SEEG), University of Oxford, U.K.
  - Swiss Tropical and Public Health Institute (STPHI), Basel, Switzerland
  - University of Glasgow, Glasgow Centre for International Development, U.K.
  - University of Southampton, U.K.
- Foundations and NGOs involved in HAT:
    - Drugs for Neglected Diseases Initiative (DNDi)
    - Foundation for Innovative New Diagnostics (FIND)
- Donors:
    - Bayer HealthCare
    - Sanofi
    - Ceva Santé Animale
    - Vestergaard Frandsen SA
    - Social Finance Ltd
    - Merial

## Annex 1. Agenda

Time	Topic	Detail	Objective / Contents	Presenter
<b>Monday 20 October 2014</b>				
09:30–10:00	<b>Welcome</b>	Addresses by WHO		Director NTD/HQ
10:00–10:30	<b>Coffee break</b>			
10:30–11:00	<b>Introduction</b>	Presentation of the meeting		Coordinator IDM/HQ
11:00–12:00	<b>Country report on r-HAT (I)</b>	- Kenya - Malawi - United Republic of Tanzania	To describe the distribution of r-HAT To get an overview of country's health system capacities to tackle r-HAT (diagnostic and treatment availability, including drug accessibility). To assess country disease awareness and response. To know plans to fight r-HAT	G. Murilla M. Lemerani G. Mchau
12:00–13:30	<b>Lunch</b>			
13:30–14:15	<b>Country report on r-HAT (II)</b>	- Uganda - Zambia	Continuation	C. Wamboga V. Mwanakasale
14:15–15:30	<b>Animal reservoir for r-HAT (I)</b>	- General considerations  - Distribution wildlife reservoir - Control of wild reservoirs: National Parks and tourism industry involvement	To review the role of animal reservoirs of r-HAT. The differing epidemiological scenarios (wild or domestic reservoir) that may require different control approaches. Describe the patterns of r-HAT transmission by domestic lead reservoir  To define capacities to establish the extent of the wild reservoir problem  To discuss wildlife reservoirs and how to get control	E. Fevre  H. Auty S. Siamundele / M. Kilewo
15:30–16:00	<b>Coffee break</b>			
16:00–17:00	<b>Animal reservoir for r-HAT (II)</b>	- Control of domestic animal reservoir	To describe the capacity to intervene in the animal reservoir  To describe control through the livestock reservoir To describe a new funding model to tackle r-HAT	S. Welburn  C. Waiswa N. Colaco
<b>Tuesday 21 October 2014</b>				
09:00–10:00	<b>Epidemiology of r-HAT (I)</b>	- Disease distribution - Geographical variation	To describe the distribution and risk of r-HAT To describe the clinical features	P.P. Simarro V. Mwanakasale
10:00–10:30	<b>Coffee Break</b>			
10:30–12:00	<b>Epidemiology of r-HAT (II): modelling</b>	- Estimating under-reporting - Estimating suitability of r-HAT presence - Models for r-HAT	To describe models to estimate under-reporting of r-HAT, addressing the scale of under-diagnosis To describe models to estimate suitability of r-HAT presence and subsequent threat of epidemics To describe strengths, weaknesses and the way forward	N. Golding N. Wardrop J. Hargrove
12:00–13:00	<b>Lunch</b>			
13:00–14:30	<b>Research on control tools</b>	- Diagnosis of r-HAT. Current status and challenges - Research and development for diagnosis of r-HAT - Treatment of r-HAT. Current status and challenges - Research and development for treatment of r-HAT	To review the state of the tools for r-HAT diagnosis.  To describe the current development of new diagnostic tools for r-HAT.  To review the state of the tools for r-HAT treatment  To describe the current development of new treatment tools for r-HAT .	P. Buscher S. Bieler A. Moore C. Burri
14:30–15:00	<b>Coffee break</b>			
15:00–15:30	<b>Vector control (I)</b>	- Vector control in r-HAT:	To review vector control tools and approaches in r-HAT control	S. Torr
15:30–17:00	<b>Vector control (II)</b>	- Role of FAO in tsetse and trypanosomosis control - Role of and PAAT in tsetse and trypanosomosis control - Role IAEA on tsetse control - Role of PATTEC on advocacy and coordination of tsetse	To describe the role of FAO in tsetse and trypanosomosis control  To describe the role of FAO in tsetse and trypanosomosis control  To describe the role of IAEA in tsetse control To describe the role of PATEC on advocacy and coordination of tsetse control	G. Cecchi G. Cecchi G. Cecchi H. Mahamat

		control		
<b>Wednesday 22 October 2014</b>				
9:00–10:00	<b>Elimination of r-HAT (I)</b>	- What is the expected end point for r-HAT control		P. Holmes
10:00–10:30	<b>Coffee break</b>			
10:30–11:00	<b>Elimination of r-HAT (II)</b>	- r-HAT as NZD Multisectoral approach.	To present r-HAT control under “One Health” approach.	B. Abela-Ridder
11:00–12:00	<b>Strategy for intensified control of r-HAT</b>	- Approaches to intensified r-HAT control	To describe the strategy for r-HAT control To discuss approaches to control / eliminate r-HAT	J.R. Franco
12:00–13:30	<b>Lunch</b>			
13:30–14:00	<b>WHO Network for intensified r-HAT control</b>	- Rationale and mechanism for coordination	To establish a coordination network for intensified r-HAT control within the frame of the WHO network for HAT elimination	J.R. Franco
15:30–16:30	<b>Conclusions and outcomes</b>	Meeting wrap-up		P. Holmes
16:30–17:00	<b>Farewell coffee</b>			

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## **Annex 3. Control of wildlife reservoirs: two examples**

### **1. Zambia**

#### ***Background***

Tsetse flies have been present in all wildlife estates in Zambia:

- Zambezi Valley – Lower Zambezi National Park, Chiawa and Rufunsa game management areas (GMAs)
- Luangwa Valley – South and North Luangwa National Parks; Chifunda, Musalangu, Munyamadzi GMAs
- Nyika Plateau
- Kafue National Park ecosystem

Trypanosomiasis has a huge **socioeconomic impact** as it affects both humans and domesticated animals such as livestock and local dogs.

In Zambia, the game management reserves are areas where people cohabit with wildlife (whereas in national parks there is no community living there). These communities are at risk of contracting rhodesiense human African trypanosomiasis (r-HAT). Tourists, visiting mainly for hunting, are also at risk; 15 tourists were reported as having contracted r-HAT by the Ministry of Tourism from 2000 to 2013.

#### **Control measures**

The Government has taken preventive measures by developing a general management plan (land use plan) for GMAs in order to minimize human contact with tsetse flies, implement fire management plans (early burning) and conduct sensitization and awareness campaigns through the volunteers from community resource boards.

#### **Challenges to prevention**

- Increased encroachment into the tsetse infested belts mainly in GMAs, for example in Mumbwa and Rufunsa.
- Limited spraying or vector control in GMAs.
- Limited surveillance and monitoring.
- Lack of consolidated data on infection in both humans and domesticated animals.
- Absence of defined policy on how the Zambia Wildlife Authority (ZAWA) collaborates with departments such as veterinary and tsetse control units at both national and local levels.
- Ad hoc coordination at the ground level.

### **The way forward**

There is a need for **improved coordination** among the concerned institutions such WHO, ZAWA, Veterinary Department, Tsetse control Unit, Ministry of Health, Ministry of Community Development, academia and affected communities through Community Resource Boards to ensure that each organization plays an active role. This coordination should be held in three areas: administration, funding, and technical/research.

## **2. United Republic of Tanzania**

### **Background**

Wildlife protected areas represent 28% of the total mainland area of the United Republic of Tanzania (Figure 1):

- 16 national parks, Ngorongoro Conservation Area (NCAA), 28 game reserves and 44 game control areas (25%)
- 815 forest reserves (3%)

Most of these areas have high tsetse densities. Moreover, the abundance of susceptible wild animals, acting as reservoirs for *T.b. rhodesiense*, pose a high risk of transmission of r-HAT to visitors, rangers and other staff. Reported cases of r-HAT are linked to these wildlife protected areas.

### **Control measures**

***In national parks and NCAs: vector control*** is the main tool and is done through:

- Insecticide-treated targets deployed in national parks to reassure tourists;
- Hand-spraying vehicles entering the parks (more than 68 000 cars sprayed between 2011 and 2014);
- Bush clearing in residential/business areas and roads);
- Use of insect repellents;
- Dipping or hand-spraying of domestic animals in areas nearby national parks.

Prescribed (early or controlled) burning **is coupled with advocacy on tsetse and trypanosomiasis control.**

***For communities in wildlife interface areas:*** education and awareness to communities, initiation of **community-based tsetse control activities** in interface areas in collaboration with local government authorities, and use of **insecticide-treated targets** and regular dipping or spraying of livestock.

## **Role of the Tanzanian government**

### ***Regulations***

- Livestock policy (2006) statements on tsetse and trypanosomiasis and Acts No.17 of 2003 Animal disease control.
- Wildlife Conservation Act (1974): establish, organize and manage protected areas.
- Policies (Wildlife Policy; National Tourism Policy, 1999; etc.) and regulations.
- Awareness creation through seminars, information, education and communication (IEC) materials and public media (radio and TV spots).

### ***Coordination***

- Multisectoral collaboration and Technical committee through PATTEC coordinator.
- Proposed tsetse and trypanosomiasis desk at the East Africa Community.
- Multisectoral collaboration includes: research, surveillance and capacity building (MoHSW, MoLFD, NIMR, TAWIRI, TPRI, TTRI, SUA, UDSM, TANAPA, NCAA, Mweka, etc.).

### **Challenges**

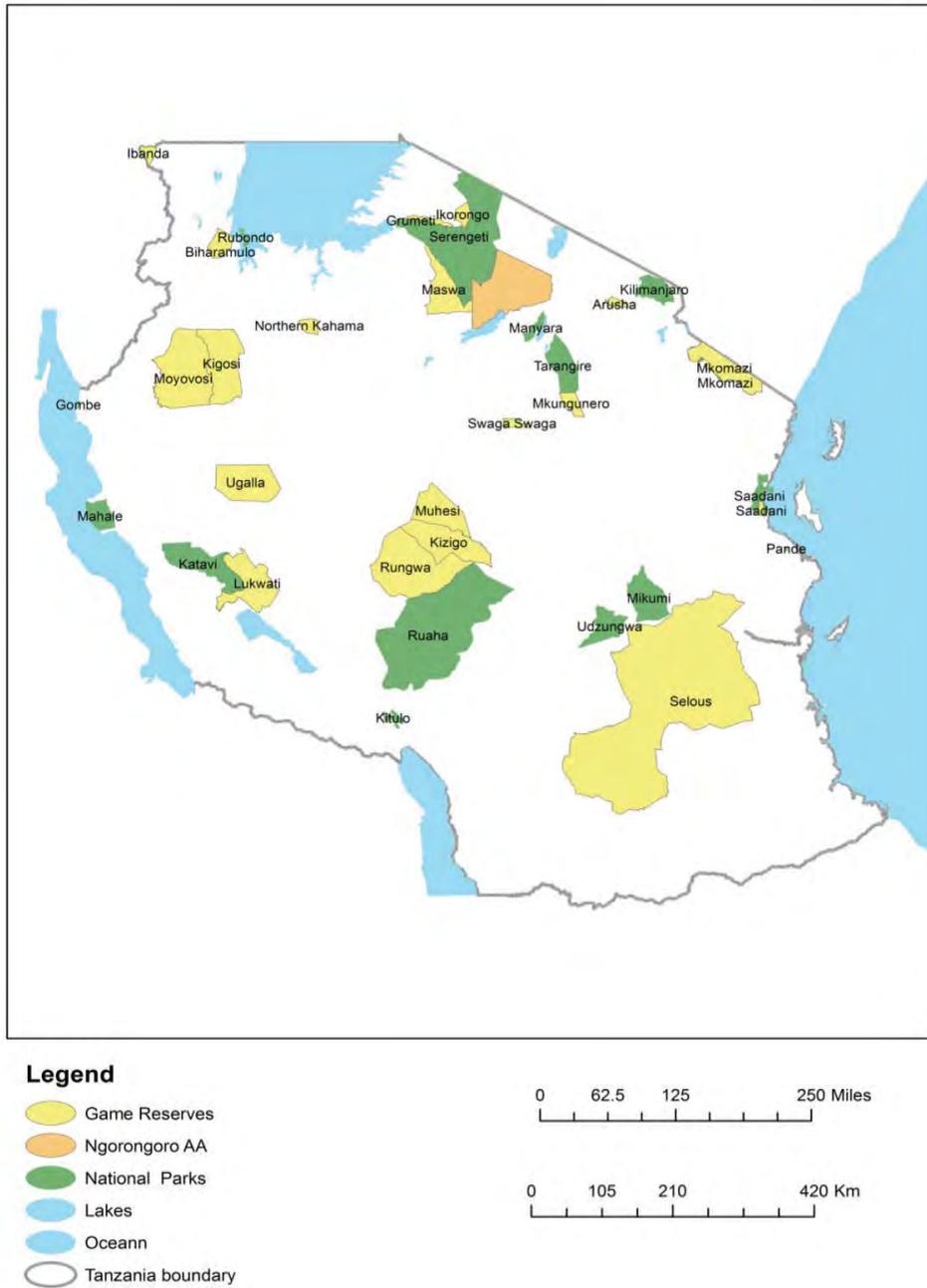
- Lack of or insufficient funds for control.
- Extensive areas infested by tsetse but small area covered with current control methods.
- Threat to tourism industry.

### **The way forward**

The Government, in collaboration with other stakeholders, will strengthen:

- capacity-building for tsetse and trypanosomiasis management;
- advocacy and awareness raising on HAT and animal African trypanosomiasis;
- the ongoing control and research activities on tsetse and trypanosomiasis survey and mapping, control, diagnosis and treatment;
- implementation of the 2013–2017 strategic plan;
- collaboration with development partners such as BADEA (Arab Bank for Economic Development in Africa) for project funding for Serengeti ecosystem in the northern and HAT western blocks.

**Figure 1.** Wildlife protected areas, United Republic of Tanzania



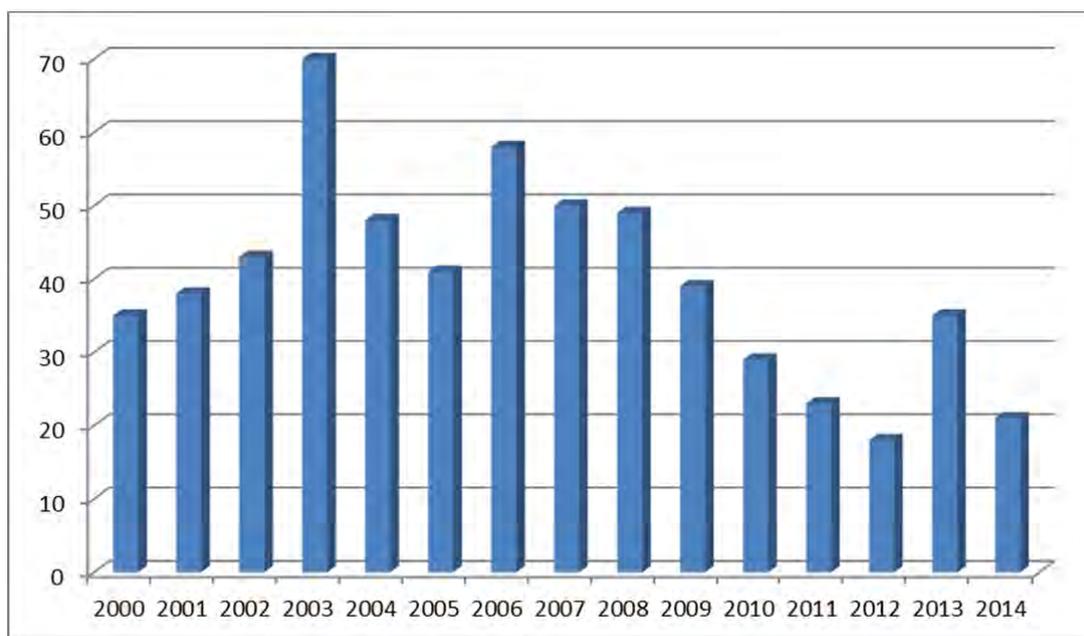
## Annex 4. Country update

### Malawi

#### Current situation

The number of r-HAT cases decreased from 2006 to 2012 but slightly increased in 2013 (data for 2014 are incomplete) (Figure 1).

**Figure 1.** Number of r-HAT cases reported in Malawi, 2000–2014<sup>a</sup>

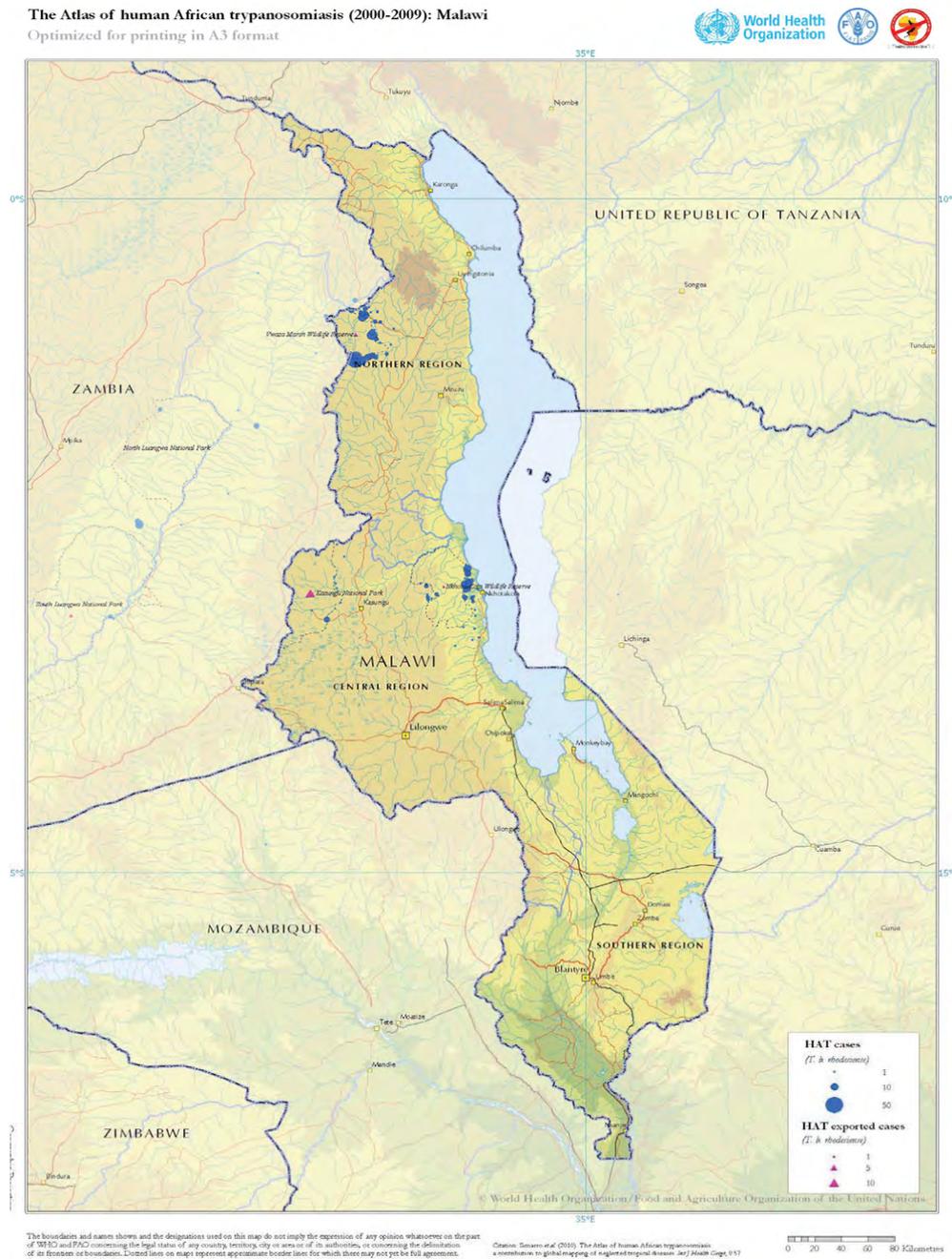


<sup>a</sup> Data for 2014 are incomplete.

In Malawi, cases are clustered around the Vwaza Wildlife Reserve (Northern Region), Nkhotakota Wildlife Reserve and Kasungu National Park (Central Region) (Figure 2).

The r-HAT cases reported during the past 5 years were mainly detected passively (94.3%). They were mainly males (83%), aged 1.5 to 70 years. They presented late to the health facility (94.3% late-stage case detection), leading to high case-fatality rates (23% on average, but 38% in 2014). Indeed, among the 21 cases reported in 2014, 4 died because of late presentation and 4 because of drug toxicity.

**Figure 2.** Distribution of r-HAT cases in Malawi, 2000–2009<sup>a</sup>



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

## **Response**

The response to r-HAT has different components:

- formation of a National Trypanosomiasis Secretariat;
- inclusion of HAT activities in the MoH Sector Strategic Plan (NTDs) 2011–2016;

- strong collaboration among all stakeholders;
- passive and active case detection in all endemic districts;
- strong community participation in HAT activities in all endemic areas;
- continual maintenance of surveillance in old focus sites;
- development of IEC materials, including stamps;
- broadcast of radio messages to improve public awareness;
- monthly screening of game reserve staff:
  - screening serves as awareness
  - tests used: dry blood films, and haemagglutination if strong suspicion.
- joint setting of traps with the wildlife department – Nkhotakota;

An HAT awareness plan includes production of stamps; lobbying campaign with Members of Parliament for increased government funding; football and netball trophies; setting up district trypanosomiasis emergency teams; HAT briefings for traditional leaders, healers, Area Development Committees, teachers, veterinary officers and health surveillance assistants on referral of HAT cases; and awareness campaigns through electronic and media houses.

### **Main challenges**

- Failure to detect cases in early stages and increased case-fatality rate. Case-detection services must be brought closer to people and surveillance improved.
- Lack of cross-border joint interventions
- Attrition of HAT-trained staff
- Less partners interested in HAT
- Inadequate funding and transport (8-year-old vehicle)

### **Ministry of Health needs**

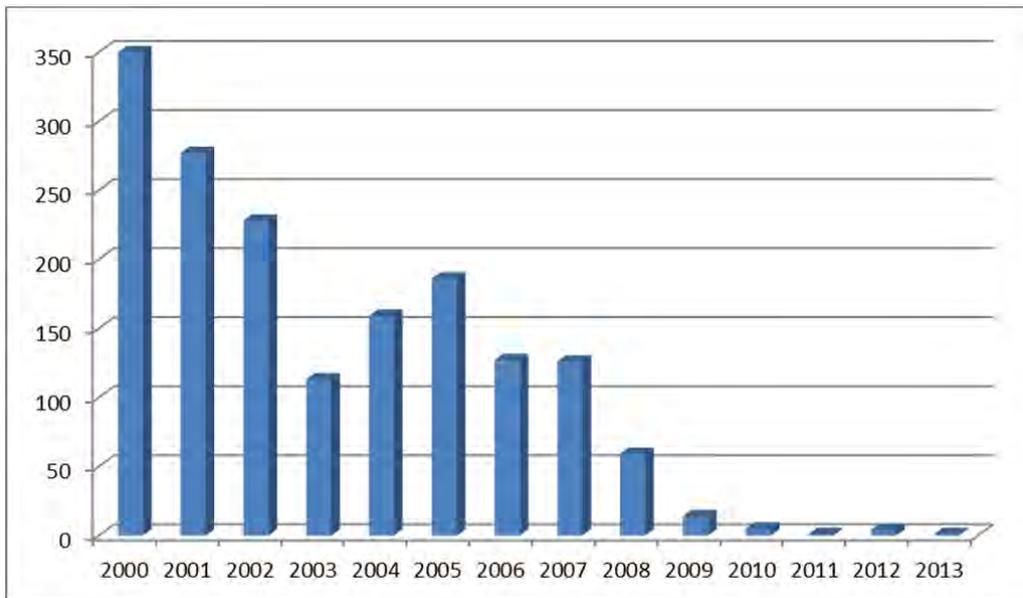
- Conduct community sensitization and empowerment on HAT
- Strengthen active case detection at community level
- Introduce cross-border interventions
- Conduct HAT health worker trainings
- Introduce laboratory case-finding in HAT-endemic health facilities in rural areas
- Collaborate with the wildlife sector to contain tsetse flies through traps and mass spraying with chemicals
- Lobby for a safer drug
- Introduce football and netball trophies for school competitions in HAT endemic areas
- Secure a new utility vehicle
- Advocate increased funding (government and WHO)

## United Republic of Tanzania

### Current situation

r-HAT was first recorded in 1922 in the districts of Maswa (Simiyu Region) and Shinyanga (Shinyanga Region) in the northern part of the country. The number of reported cases has been decreasing since 1995, dropping to fewer than 5 cases since 2009 (Figure 3).

**Figure 3.** Number of r-HAT cases reported in the United Republic of Tanzania, 2000–2013



The Ministry of Health and Social Welfare (MoHSW) has strengthened surveillance in two sentinel sites in the most affected regions: Kigoma and Kaliua (Figure 4).

**Figure 4.** Distribution of r-HAT cases in the United Republic of Tanzania, 2000–2009<sup>a</sup>



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

## **Response**

### **Activities undertaken by the Ministry of Health and Social Welfare**

- IEC materials for African human and animal trypanosomiasis (HAT/AAT) awareness developed and disseminated (fact sheet, leaflets, calendars, posters, TV/radio spots).
- In collaboration with the Ministry of Livestock and Fisheries Development and the National Institute for Medical Research (Tabora Research Centre), a total of 127 health workers trained on proper diagnosis and management of HAT cases.
- Surveillance
  - passive and occasional active surveillance conducted (when funds available)
  - two sentinel surveillance sites established for monitoring HAT trends (Kaliua in Urambo and Nguruka in Kigoma rural)
- HAT included in NTD National Master Plan 2011–2015
- Human cases treated in district hospital and a few selected health centres
- Vector control measures implemented in hotspot areas

### **Activities undertaken by the Ministry of Livestock and Fisheries Development**

- National livestock policy (2006): aims to control and eradicate tsetse and trypanosomes for increased livestock production and productivity
- Mapping of AAT/HAT in collaboration with the Ministry of Health and Social Welfare and update on tsetse distribution map
- Training of extension field officers (60)
- Community-based tsetse control (impregnated targets and animal dipping)

### **Activities undertaken by the Tanzania National Parks Authority**

- Tsetse control (car spraying and targets)
- Community awareness (outreach programme)
- Tourist awareness about tsetse bites in affected areas
- Active surveillance (outbreak response)

### **Awareness plan**

- Higher level advocacy for resource allocation
- Community awareness (mass media, TV, local radio, IEC material)
- Integration with other activities, Integrated Disease Surveillance and Response training, NTDs.

## **Main challenges**

- Advocacy and community awareness
- Timely reporting, diagnosis and proper treatment

- Inclusion of HAT/AAT in NTD umbrella
- Involvement of key stakeholders

**Ministry of Health and Social Welfare needs**

- Conduct a nationwide situation analysis of HAT
- Foster HAT/AAT awareness and advocacy
- Implement a multisectoral approach towards elimination/control
- Provide support for drugs
- Train health workers, in view of the high turnover of staff
- Secure more resources for vector control

## Zambia

### Current situation

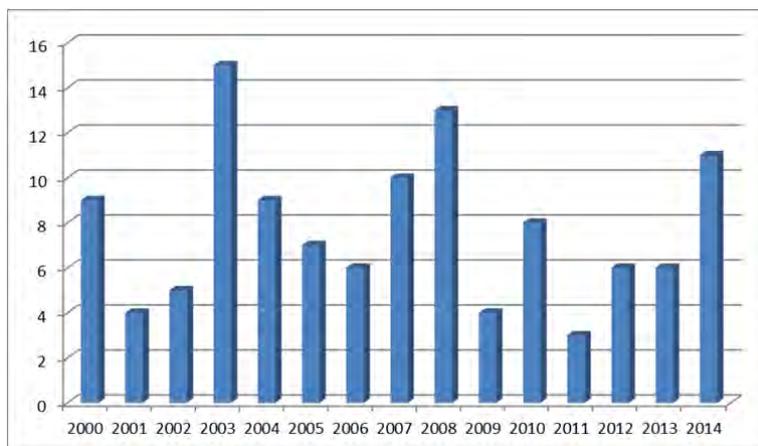
Zambia has been reporting r-HAT cases linked to national parks in the eastern and northern part of the country (mainly North and South Luangwa, Isangano, Kasanka and Lavushi Manda natural protected areas). r-HAT cases linked to Kafue National Park in the south-west of the country have also been reported and, most recently, in Rufunsa related to Lower Zambezi National Park (Figure 5). This is related to the cases detected in neighbouring Mana Pools National Park and Kariba Lake in northern Zimbabwe.

**Figure 5.** Distribution of r-HAT in districts (red stars) and national parks (green areas), Zambia



Zambia reports less than 15 cases per year since 2004 (Figure 6). Chama district has not reported cases since 2009, but patients from this area could seek treatment in Malawi.

**Figure 6.** Number of r-HAT cases reported in Zambia, 2000–2014<sup>a</sup>



<sup>a</sup> Date for 2014 are incomplete.

**Figure 7.** Distribution of r-HAT cases in Zambia, 2000–2009<sup>a</sup>



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

## **Response**

At least nine hospitals have laboratory capacities for diagnosis of r-HAT, seven of which are also able to treat r-HAT patients (Table 1). Moreover, mobile hospitals, consisting of 5–6 trucks equipped for laboratory diagnosis and treatment, are available. They visit remote areas following a planned programme to screen hard-to-reach populations.

**Table 1** Health facilities providing r-HAT laboratory diagnosis and treatment

District	Facility	Service
Mpika	Chilonga Mission H	Lab D & Treat
	Mpika District H	Lab D
Chama	Chama District H	Lab D & Treat
Nyimba	Nyimba District H	Lab D* & Treat
Lundazi	Lundazi District H	Lab D & Treat
Rufunsa	Mpanshya Mission H	Lab D & Treat
	Katondwe Mission H	Lab D & Treat
	Chongwe District H	Lab D & Treat
Mambwe		Lab D
National level	Mobile Hospitals	Lab D

#### **Current control programmes for r-HAT under the Ministry of Health**

- Active case detection and treatment (Chama District Hospital)
- Passive case detection/routine screening and treatment in the remaining nine health facilities involved
- Drugs provided by WHO, Geneva, through the Country Office.
- Notification of HAT cases based on goodwill, making it difficult to have accurate figures
- Vector control. A project started in April 2014 with spraying cattle initially along the border with Namibia.

#### **Challenges**

- Few trained human resources (laboratory diagnosis and administration of r-HAT drugs) with high staff turnover.
- Lack of transport for referrals.
- Remoteness of transmission sites.
- Bad state of roads making them impassable at certain times of year.
- Few screening centres
- Few treatment centres
- Laboratory methods generally used are less sensitive (Giemsa-stained thick blood-smear microscopy mostly), with only Chilunga hospital performing the Woo method.
- Problems with availability of antitrypanosomal drugs, relying on WHO supplies).

- Insufficient knowledge on HAT by local communities.
- No specific interest in r-HAT at the NTD unit in the Ministry of Health.

### **Way forward**

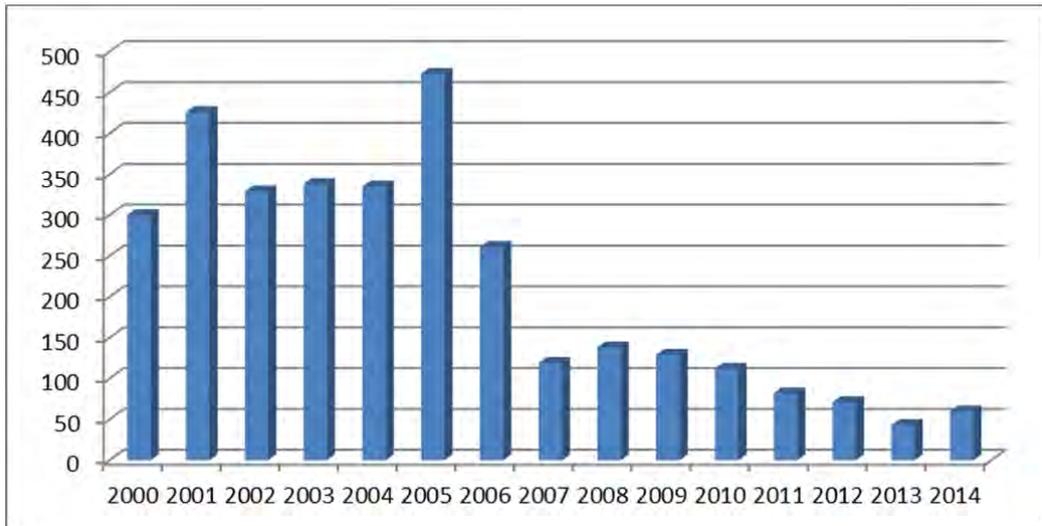
- Establish more screening and treatment centres in endemic areas.
- Introduce more sensitive methods for laboratory diagnosis of r-HAT (e.g. **mAECT**).
- Introduce health education (IEC) programmes.
- Make notification of r-HAT cases at screening point mandatory.
- Conduct regular in-service training of laboratory and clinical staff in laboratory diagnosis and management of r-HAT cases.
- Improve referral system (**ambulance at Nabwalya cRHC**).
- Improve stocking of r-HAT drugs at national, provincial and district hospital levels.
- Improve access to remote transmission sites (**tarring of Nabwalya road**).
- Use mobile hospital services for r-HAT active surveillance.

## Uganda

### Current situation

The number of r-HAT cases reported in Uganda decreased from 317 in 2004 to 43 in 2013, but increased in 2014 (Figure 8).

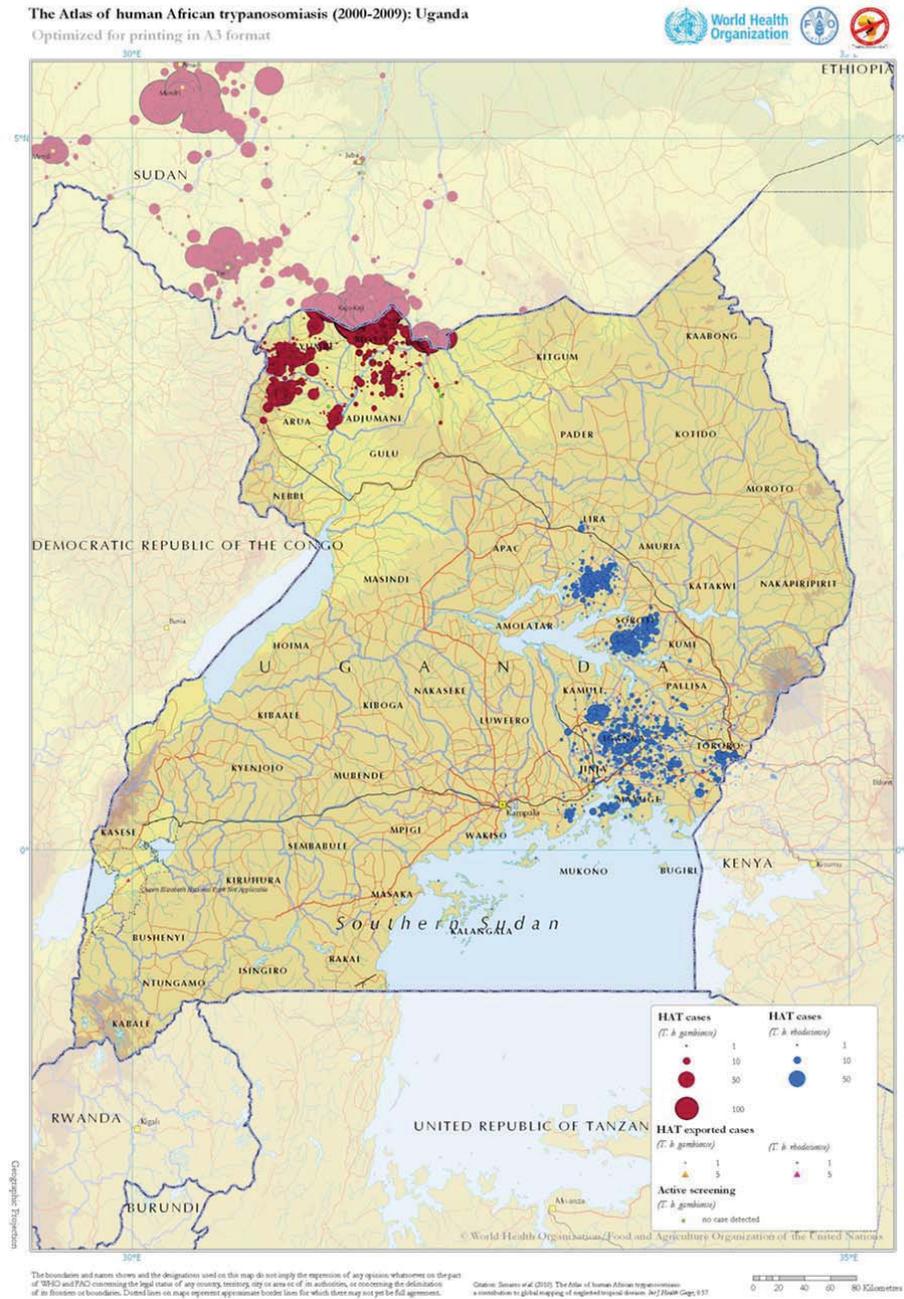
**Figure 8.** Number of r-HAT cases reported in Uganda, 2000–2014<sup>a</sup>



<sup>a</sup> Data for 2014 are incomplete.

The area affected by r-HAT has also shrunk since 2000, and cases are now clustered in Dokolo district in the Northern Region (Figure 9). This phenomenon results not from underreporting as there are health facilities in the ancient foci, but from a change in the dynamics of r-HAT in Uganda.

**Figure 9.** Distribution of r-HAT cases in Uganda, 2000–2009<sup>a</sup>



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

## **Response**

### **Response by the Ministry of Health**

- Passive case detection, treatment of confirmed cases and follow up of post-treated cases (passively)
- Support to supervision and delivery of drugs to treatment centres
- Data retrieval from treatment centres
- Response to epidemics with mainly support of WHO

### **Response by the Ministry of Agriculture, Animal Industry and Fisheries**

- Tsetse vector suppression and monitoring
- Community sensitization
- Capacity-building
- Control of livestock movements
- Supporting AAT surveillance activities in districts, epidemiological mapping and reporting of AAT in high-risk areas

### **Coordination**

- Technical Committee meetings to receive updates on the HAT, nagana and tsetse situation
- Policy guidance through the Uganda Trypanosomiasis Control Council (UTCC)
- Extraordinary Meetings of Technical Committee or UTCC to discuss emerging issues on tsetse and trypanosomiasis from time to time
- Regional meetings to discuss tsetse and trypanosomiasis issues in each of the affected sub-regions, developing and sharing quarterly coordination workplans and seeking facilitation from Uganda government and other partners.

### **Awareness plans to control r-HAT**

- Awareness and advocacy is one of the guiding principles in the draft tsetse and trypanosomiasis policy and all tsetse and trypanosomiasis intervention projects are encouraged to include this component.
- The Co-ordinating Office for Control of Trypanosomiasis in Uganda (COCTU) recently kick-started several approaches which include:
  - briefs of any critical issues to the Ministry of Agriculture, Animal Industry and Fisheries senior policy management at their different sittings
  - holding regional technical leaders' meetings in affected areas
  - sending teams to hold discussions with Local Governments at different levels

- undertaking “catalytic activities and interventions” in those areas thought to be at higher risk by COCTU
- deploying verification teams to capture issues of awareness in community or health facilities and suggest solutions
- Using mass media especially radio
- Setting up awareness centres in affected areas. The first opened on 14 October 2014 in the current epidemic focus of Dokolo.

### **Challenges**

#### **Challenges for the Ministry of Health**

- Low index of HAT suspicion among health workers
  - health workers’ interest in HAT is low and many experienced workers are due to retire or have retired
- Low community awareness
  - bad beliefs associating HAT with witchcraft in some communities
  - poor health-seeking behaviour of those at risk
- Lack of a surveillance system at community level for screening or referral of suspects (linking patients to facilities)
- Lack of an alternative drug to treat relapsed cases
- Unreliable availability of modified single centrifugation tubes for CSF
- Low prioritization of HAT at all levels due to competing priority needs
- Weak intersectoral collaboration especially for field activities
- Limited financial resources

#### **Challenges for the Ministry of Agriculture, Animal Industry and Fisheries**

- Limited funding
- Decentralization practice, which has led to low prioritization by local governments
- Poor enforcement of regulations, for example on livestock movements
- Livestock markets – tsetse and trypanosomiasis problem does not lead to their closure (business as usual)
- Livestock are classified as a business and there is limited public investment in their treatment

#### **Challenges to coordination**

- Actions still highly fragmented despite having COCTU in place: major actors still heavily locked up in their silos

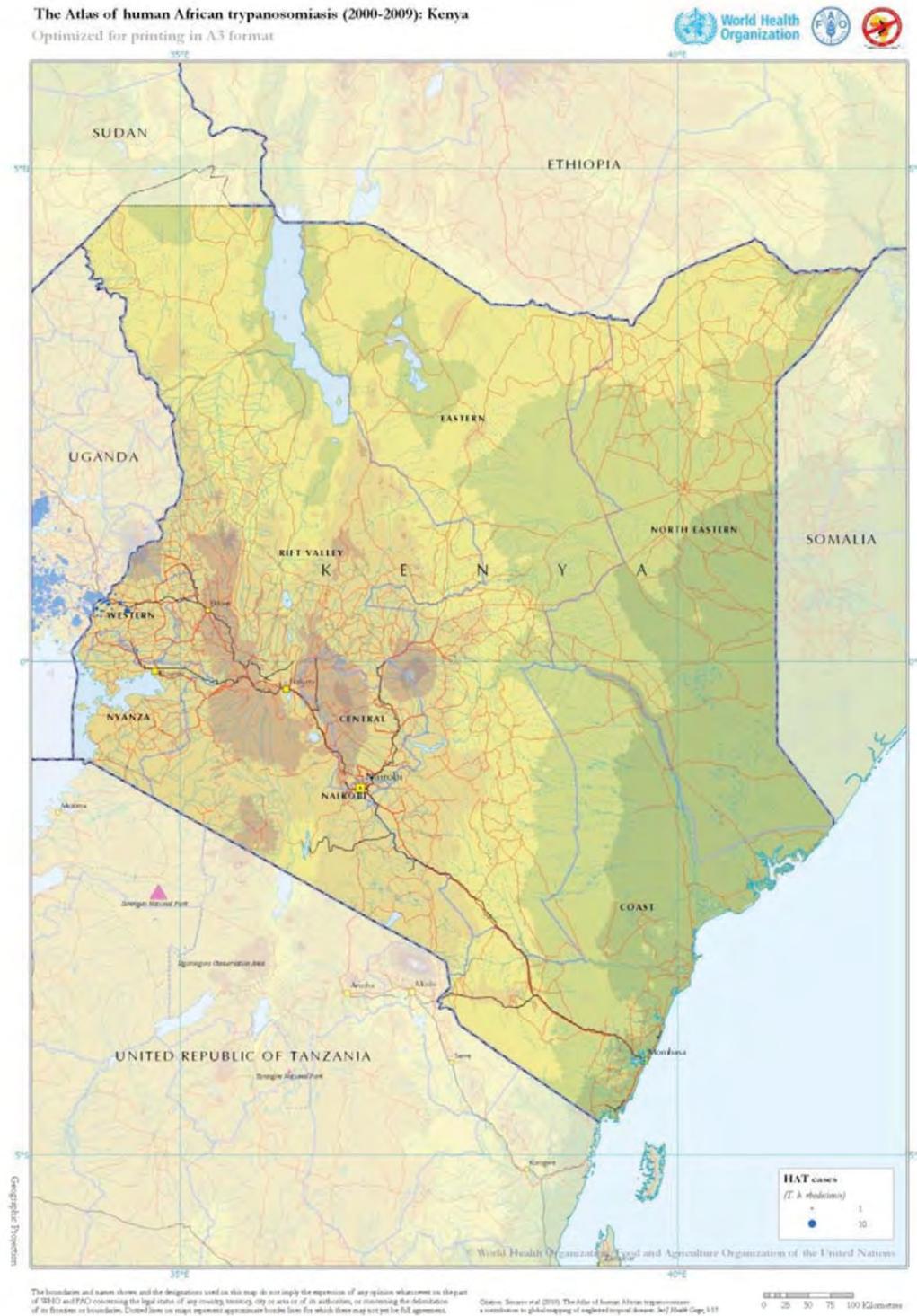
- Very few actors share data with COCTU without being heavily followed up, which is expensive
- The tsetse and trypanosomiasis policy to guide concrete actions still awaits cabinet approval
- Decentralization of decision-making and interventions
- Animal reservoir issues: cattle movement, pig reservoir, undefined role of wild animal reservoir

#### **Main needs**

- Strengthen passive case detection through training of health workers and availing sensitive diagnostic equipment
- Increase community awareness (develop a communication strategy to address gaps) through established regional centres
- Promote advocacy for HAT if it is to be prioritized at all levels
- Establish a reliable community surveillance system, preferably using village human and animal health teams
- Conduct supervision visits to guide implementation and address gaps
- Ensure and support timely reporting at all levels
- Implement a monitoring and evaluation framework
- Establish active response teams (mobile teams) to manage epidemics
- Strengthen intersectoral and action-oriented collaboration at all levels
- Build and support partnerships
- Consider deliberate efforts to avail drug(s) for treatment of relapses



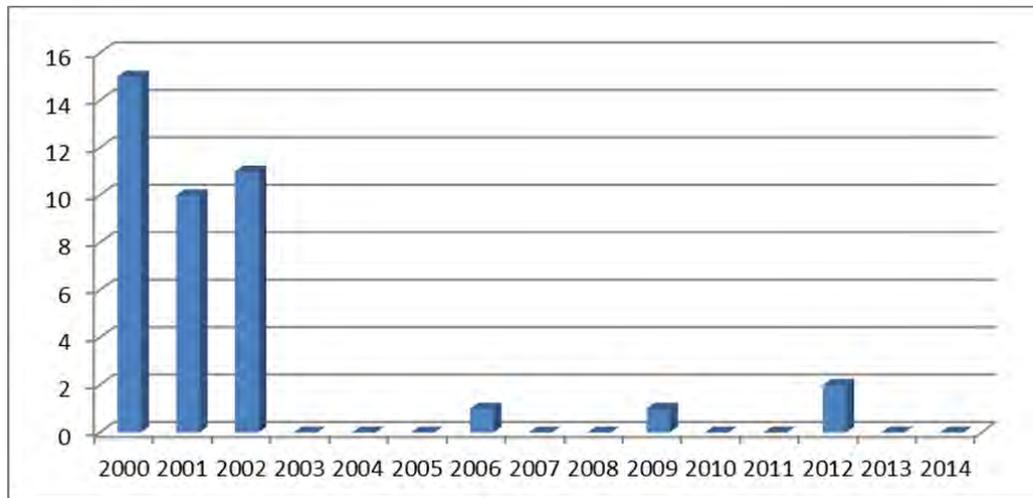
**Figure 11.** Distribution of r-HAT cases in Kenya, 2000–2009<sup>a</sup>



<sup>a</sup> Source: WHO Atlas of human African trypanosomiasis.

Since 2004, 2 cases of r-HAT cases have been reported in Kenya, from Teso district (2006, 2009) (Figure 12). Moreover, 2 tourists became infected in the Mara Game Reserve.

**Figure 12.** Number of r-HAT cases reported in Kenya, 2000–2014<sup>a</sup>



<sup>a</sup> Data for 2014 are incomplete.

### **Response**

Kenya has an integrated and multidisciplinary approach to effectively control r-HAT.

A directors' forum was established in the mid-1990s comprising the directors of the Kenya Trypanosomiasis Research Institute (KETRI), the Veterinary Services and the Wildlife Services. It provided leadership and enabled the efficient use of funds, with no duplication of effort and shared responsibility.

KETRI, a multidisciplinary institute of research and active surveillance of HAT, is composed of medics, veterinary epidemiologists, medical entomologists, social scientists, environment and land use scientists and a communications worker. A Rapid Response Technical Team (RRTT) was established in 1994 in KETRI to respond to emergencies.

The directors' forum and the RRTT have been very successful in controlling the disease, with a dramatic decrease in the number of cases since the 1990s; however, their activities have ended since the number of cases has fallen.

Each of the stakeholders is still involved in the control of HAT:

- Ministry of Health
  - trained by KETRI on case detection and treatment of HAT
  - concurrent infections treated during both active and passive surveillance
  - provided a medical doctor to the National Referral Sleeping Sickness Hospital (NRSSH), Alupe

- Ministry of Livestock
  - treatment of livestock for trypanosomiasis and other infections
  - tsetse control, continuous use of available tools
  - disease outbreaks prevented
- Kenya Wildlife Service
  - trained by KETRI on trap deployment, repair and maintenance
  - carried out vector control in the Ruma National Park
  - quarterly monitoring and evaluation carried out by KETRI
  - currently, tsetse are confined to national parks, game reserves and conservation areas
- Training of teachers and schoolchildren in Busia/Teso
  - training modules developed
  - passive surveillance enhanced, while active case-detection activities have been abandoned.
  - fewer turnovers among teachers than among medical staff.
- Involvement in regional networks on tsetse and trypanosomiasis: EANETT (Eastern African Network for Trypanosomiasis) and HAT Platform
  - harmonization of data collection tools and mentorship

### **Lessons learnt**

- Senior management involvement
  - regular Directors’ meetings for policy direction and decision-making
  - no duplication of effort
- Integrated and multidisciplinary –expertise combined
- Training of health-care personnel and community to enhance case detection
- Harmonization of protocols and standard operational procedures; information-sharing within regional networks
- Rapid response team very effective in emergencies, e.g. during the Bungoma HAT outbreak in 1995
- Research well integrated with field implementation
- Critical mass of well-trained personnel available for the HAT programme
- Persons presenting for screening at the NRSSH increased significantly after sensitization
  - school sensitization should be repeated as it has shown its efficacy.

### **Main challenges**

- Funding
- High cost and low case detection of active surveillance
- High rate of transfers of trained primary health-care personnel to non-endemic areas
- Government commitment decreases as the number of cases falls.

### **Ministry of Health needs**

- Maintain expertise through:
  - education, awareness and skills to detect and diagnose HAT
  - re-assessment of facilities to support HAT diagnosis
- Acquire evidence to inform policy on HAT elimination plans
- Integrate HAT diagnosis into primary health care
- Provide coordination, effective leadership and teamwork, with clearly defined roles of all key players, trust, transparency and effective communication
- A critical mass of researchers, health workers, extension staff (Ministry of Livestock), community with high HAT suspicion index in order to consolidate country capacity
- Work with key players in order to strengthen capacity to sustain passive surveillance
- Enhance the school sensitization and awareness programme to support case-finding
- Ensure effective and sustainable control tools and strategies for elimination of r-HAT
- Improve data collection, harmonization and quality.

## Annex 5. Respective roles of FAO, PAAT, IAEA and PATTEC on tsetse and trypanosomiasis control

### FAO

Achieving food security for all is at the heart of efforts by the Food and Agriculture Organization of the United Nations (FAO). Its main goals are eradication of hunger, elimination of poverty, and sustainable management and utilization of natural resources. The FAO is also teaming up with WHO and OIE to jointly pursue the One Health approach.

Animal trypanosomiasis has an impact on herd productivity (halving meat and milk production), crop production (impossible or reduced exploitation of draught power). It therefore leads to food insecurity and livelihood vulnerability; the total losses in terms of agriculture–livestock production being estimated at US\$ 4.5 billion per year.

#### *Recent and ongoing projects on tsetse and trypanosomiasis*

- Funded by FAO Regular Programme Budget
  - *Projet d'appui à la lutte contre les mouches tsé-tsé et les trypanosomoses animales dans la région de Sikasso au Mali* (Budget: US\$ 339 000)
  - *Projet pilote d'appui à la prévention et à la lutte contre les trypanosomoses animales en Angola* (Budget: US\$ 288 000)
  - *Opération pilote de prise en charge de la lutte contre la tsé-tsé et la trypanosomose animale par les bénéficiaires dans la Province du Kéné Dougou au Burkina Faso* (Budget: US\$ 341 500)
- Funded by the Government of Italy
  - *Improving food security in sub-Saharan Africa by supporting the progressive reduction of tsetse-transmitted trypanosomiasis in the framework of NEPAD* (Budget: US\$ 1 million)
    - Priority countries: Burkina Faso, Ghana and Mali (West Africa); Ethiopia, Kenya and Uganda (East Africa)
    - Focus: data management and Geographic Information Systems (GIS)
- Funded by the International Fund for Agricultural Development (IFAD)
  - *Development of innovative site-specific integrated animal health packages for the rural poor (West and East Africa)* (Budget: US\$ 1.6 million)
    - Priority countries: Kenya, Ghana and Burkina Faso
    - Other beneficiary countries (training): Eritrea, Ethiopia, Burundi, Rwanda, Sierra Leone, Nigeria, Mali, Côte d'Ivoire, Niger and Benin
      - Focus: Livestock Protective Net Fencing

### *Normative activities*

FAO, jointly with the International Fund for Animal Health (IFAH), the Global Alliance for Livestock Veterinary Medicines (GALVmed) and the International Atomic Energy Agency (IAEA), has initiated a project on quality control/quality assurance of trypanocides. Monographs have been prepared for two major trypanocides: isometamidium chloride and diminazene aceturate, and are due for publication by OIE in its Technical and Scientific Series.

### *Training activities*

- Courses on tsetse and animal trypanosomosis data management and geospatial analysis/GIS: 170 people trained over the past 18 months
  - *A one-week course took place in seven countries in 2013–2014 (Sudan, Mali, Zimbabwe, Gabon, Kenya, Ghana and Uganda)*
  - *A two-week course at regional level took place in Addis Ababa (Ethiopia) in 2014 for 11 English-speaking countries (Ethiopia, Ghana, Kenya, Nigeria, South Sudan, Sudan, Malawi, Zimbabwe, Mozambique, United Republic of Tanzania and Uganda)*

- Geographical Information System

The goal of this training is to improve the efficiency and cost-effectiveness of field interventions against African trypanosomoses and to promote evidence-based and rational planning, execution, monitoring and evaluation of field interventions. The sustainability of this training is based on the use of a freeware, Open Source Software (Quantum GIS) and public domain GIS datasets, the follow-up of training activities (e-mail, telephone, technical assistance missions, etc.) and cost-sharing with beneficiaries and partners.

- Support to training activities on HAT

FAO participated in the 6th International Course on African trypanosomoses, Kinshasa (Democratic Republic of the Congo, 9–27 June 2014) organized by the non-profit Association against Trypanosomiasis in Africa (ATA) with the support of WHO and other partners.

- Lectures on ‘GIS and African trypanosomoses’ (14 June 2014)

## **PAAT**

The Programme Against African Trypanosomosis (PAAT) is an interagency collaboration that since 1997 joins together the efforts of FAO (which hosts the Focal Point of the PAAT Secretariat), WHO, the IAEA and the AU-IBAR (African Union-Interafrican Bureau for Animal Resources).

PAAT aims at an African continent where trypanosomoses no longer constrain sustainable agriculture and rural development (SARD), nor do they threaten human health.

Its objectives are to assist countries affected by tsetse and trypanosomiasis (T&T) in promoting SARD and human health through partnerships and coordinated efforts.

### *Partners*

PAAT has several partners:

- African Union - Pan African Tsetse and Trypanosomiasis Eradication Campaign (AU-PATTEC)
- African Member States affected by the T&T problem (39 sub-Saharan countries)
- World Organisation for Animal Health (OIE)
- United Nations
  - International Fund for Agricultural Development (IFAD)
  - United Nations Industrial Development Organization (UNIDO)
- International cooperation for development: Italian cooperation, UK Department for International Development (DFID), Japan, US Department of Agriculture (USDA), GALVmed
- Research institutes
  - Africa-based: Centre International de Recherche Développement sur l'Élevage en zone Subhumide (CIRDES), International Centre of Insect Physiology and Ecology (ICIPE), International Livestock Research Institute (ILRI), National Agricultural Research Systems (NARS)
  - Europe-based: Agricultural Research for Development (CIRAD), Centre for Tropical Veterinary Medicine (CTVM), Institute of Tropical Medicine (ITM), Glasgow and Strathclyde universities, Free University of Berlin
- Private sector: International Animal Health Organisation (IFAH)

### *PAAT Information System (PAAT-IS)*

The PAAT uses geographic information systems (GIS) in several projects:

- The Atlas of human African trypanosomiasis (HAT)
  - WHO-led, jointly implemented with FAO in the framework of PAAT
  - Products:
    - HAT distribution maps: continental, national, focus level
    - HAT risk maps: continental, national, focus level
    - Estimates of coverage of active and passive screening activities
    - Accessibility to diagnostic and treatment centres
    - Input for modelling/estimating/mapping underreporting
- The Atlas of tsetse and African animal trypanosomosis (AAT)
  - FAO-led, jointly implemented with IAEA in the framework of PAAT
  - Preliminary results: AAT distribution in Ethiopia, Kenya and Uganda from the period 1990–2013
    - 131 scientific publications identified and processed

The national Atlases of tsetse and AAT are being developed with FAO/PAAT assistance in Sudan, Mali, Zimbabwe, (Ethiopia and Uganda).



**PAAT Web site**  
[www.fao.org/ag/paat.html](http://www.fao.org/ag/paat.html)  
*(also available on CD-Rom)*

- publications
  - PAAT Technical and Scientific Series
  - Tsetse and Trypanosomiasis Information bulletin
- reports of PAAT meetings and workshops
- training manuals
- maps and GIS datasets
- donors
- activities and events



**PAAT Technical and Scientific Series**  
*(monographic publications)*

- Drug management and parasite resistance
- Impacts of trypanosomiasis on agriculture
- Sterile Insect Technique
- Socio-economic and cultural factors
- Economic guidelines for strategic planning
- Long-term management options
- Trypanotolerant livestock
- Land cover mapping for decision making



**Tsetse and Trypanosomiasis Information (TTI) bulletin**  
*(half-yearly periodical in both English and French which deals with subjects related and pertinent to T&T research, control, policy issues and strategies for intervention)*

- paper abstracts
- meeting reports
- publications



**FAO GeoNetwork**  
[www.fao.org/geonetwork](http://www.fao.org/geonetwork)  
*(FAO corporate geospatial data repository)*

- GIS-data sharing and dissemination
- contains key PAAT-IS GIS datasets
- metadata search and editing
- web mapping



**Networking and harmonization**

- technical cooperation, assistance and support
- capacity building
- standardization of methodologies and decision making

### Trainings

- A regional GIS training course was jointly organized by IAEA and FAO in collaboration with, and in assistance to, AU-PATTEC for 11 English-speaking countries in Addis Ababa (Ethiopia) in March 2014.

- Another GIS training course for 16 French-speaking countries is planned for January 2015 in Vienna (Austria).

## IAEA

A FAO/IAEA joint division based in Vienna works on the use of nuclear techniques in food and agriculture. It is composed of five sections: Soil and Water, Plant Breeding, Livestock, Food and Environment, and Insect Pest Control (Sterile Insect Technique, or SIT).

### *Ongoing projects on tsetse and trypanosomiasis*

- Projects in which training, entomological data collection and feasibility studies are the core components
  - **Zimbabwe:** Improving crop and livestock production through the eradication of bovine trypanosomiasis in Matusadona National Park (ZIM5017), 2014–2015 (Budget: €208 400).
  - **Angola:** Supporting Feasibility Studies for Using Sterile Insect Technique as part of Area-Wide Integrated Pest Management for Control of Tsetse Flies (*G. morsitans centralis*) (ANG5012), 2014–2015 (Budget: €121 600).
  - **Chad:** Finalizing the feasibility study to assess whether the sterile insect technique (SIT) can be applied for the creation of sustainable tsetse-free zones (CHD5003), 2013–2014 (Budget: €60 655).
  - **Uganda:** Demonstrating the feasibility of a sterile insect technique component as part of an area-wide integrated pest management approach to increase livestock productivity (UGA5033), 2014–2015 (Budget: €142 800).
- Projects with an operational SIT component
  - **Ethiopia:** Contributing to the creation of sustainable tsetse-free areas (ETH5018), 2014–2015 (Budget: €319 900).
  - **Senegal:** Supporting the operational phase of eliminating *Glossina palpalis gambiensis* from the Niayes area by promoting the development of integrated stockbreeding (SEN5033), 2014–2015 (Budget: €144 713 (just 2014)).
- Regional projects with training as a major component
  - **Regional:** Supporting area-wide tsetse and trypanosomiasis management to improve livestock productivity and enable sustainable agriculture and rural development (Phase II) (RAF5070), 2014–2015 (Budget: €352 800).

### Research activities

- Ongoing Coordinated Research Programmes (CRP)
  - Enhancing vector refractoriness to trypanosome infection (2012–2015) with the participation of 18 countries
  - Applying population genetics and GIS for managing livestock insect pests (2008–2013) with the participation of 12 countries
- Laboratory in Seibersdorf
  - Six strains of five tsetse species: *Glossina pallidipes*, *G. swynnertoni*, *G.m. centralis*, *G.p. gambiensis*, *G. brevipalpis*
  - Validation of UV irradiation equipment for processing blood for tsetse diet
  - Validation of sex separation of pupae by NIR scanner
  - Applied research related to the CRPs
- Research contracts
  - Standardizing visual control devices for area-wide control of the savannah tsetse fly species *G.m. centralis* in Angola
    - Contracting institute: University of Neuchâtel
    - Period of contract: 2012–2014
  - Validation of techniques for large-scale rearing of *Glossina palpalis gambiensis* and long-distance transport of fly material
    - Contracting institute: Slovak Academy of Sciences
    - Period of Contract: 2011–2014

### Normative activities

IAEA has issued standard operating procedures for virus control; blood processing and dosimetry for SIT, and a tutorial DVD on the use of free open source GIS software applied to pest control programmes, with the collaboration of FAO.

### Training activities

- Regional training courses
  - Standardized collection and processing of tsetse flies for molecular tsetse population genetic and morphometric analyses (Kenya, 2012, 23 participants from 13 countries)

- Standardized entomological monitoring, data collection and GIS-aided data processing as needed for area-wide integrated pest management campaign (Burkina Faso, 2012, 23 participants from 15 countries)
- Free open source software for GIS and data management applied to tsetse and trypanosomiasis control programmes in collaboration with FAO and PATTEC (Ethiopia, 2014, 14 countries expected)
- Free open source software for GIS and data management applied to tsetse and trypanosomiasis control programmes (French edition) in collaboration with FAO and PATTEC (January 2015)
- Fellowships and scientific visits under technical cooperation projects to enhance the collaboration among projects and countries working on tsetse control (20 fellowships of an overall duration of 32 months during the last biennium)
- Training in Seibersdorf laboratory

#### *PAAT and PATTEC*

IAEA is member of the Secretariat of PAAT, alongside FAO, WHO and AU-IBAR.

- IAEA supports the PAAT Information System (PAAT-IS), in particular, the Atlas of tsetse and African animal trypanosomiasis, a FAO-led initiative jointly implemented with IAEA in the framework of PAAT.
- IAEA also organized and executed training courses (both national and regional) and technical assistance missions jointly with the PAAT.

IAEA also strongly supports PATTEC as coordinating body of the Member States. It is reflected in the Memorandum of Understanding with PATTEC and the yearly resolution during the General Conference in support of the PATTEC Initiative.

## **PATTEC**

### *Context of the initiative*

The Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) was created following the adoption in 2000 of Decision AHG/Dec. 156 (XXXVI) by the African Heads of State and Government within a specific context:

- The urgent need to eliminate severe animal health, public health and rural development problems resulting from tsetse and tsetse transmitted trypanosomiasis
- Increasing tsetse infestation and prevalence of trypanosomiasis

- Reduced effectiveness and availability of trypanocides
- Overall frustration caused by unsustainable approaches to eliminate the tsetse fly vector
- Inspired by success stories in Zanzibar and socioeconomic justification for tsetse eradication.

### *Overall strategy*

The PATTEC strategy is based on four pillars:

- Advocacy for vector eradication through a phased-conditional, area-wide and sustained approach underpins the PATTEC Initiative through
  - joint, concurrent and coordinated action
  - integration of appropriate technologies and approaches based on sound policy and strategy development and high-quality baseline data
- Advocacy for a results-oriented, dynamic programming approach
- Participatory approach
- Monitoring and evaluation

### *Policy guidance, strategic direction and guidelines*

PATTEC has issued several guidelines:

- First strategic plan (2001–2012)
- Revised strategic plan (2013–2017)
- National tsetse and trypanosomiasis strategies, programmes and workplans validated on the basis of a continental framework
- Linking tsetse and trypanosomiasis programmes to the Comprehensive Africa Agriculture Development Programme (CAADP) process and framework
- Collaboration with IAEA in the development of tsetse and trypanosomiasis guidelines for declaring areas free from tsetse and tsetse-transmitted trypanosomiasis
- Practical recommendations have emerged from a workshop on strategies and technical advances in tsetse and trypanosomiasis management (Livingstone, Zambia, 8–12 September 2014)
- A draft policy framework for integrating tsetse and trypanosomiasis programmes in rural development strategies is undergoing a consultative process

### *Capacity-building and training*

More than 150 personnel drawn from tsetse and trypanosomiasis affected countries have been trained over the past 3 years. Topics covered include principles of area-wide integrated pest management (AW-IPM), Project Cycle Management (PCM), GIS application to tsetse, and trypanosomiasis programme planning and management, tsetse biology and ecology, etc.

A new complementary training course on informed decision-making in the management of tsetse and trypanosomiasis has been designed and will be rolled out from next workplan.

### *Partnership-building*

- AW-IPM approaches are complex undertakings, hence the need to:
  - draw upon external capacities through strategic partnerships and alliances (programming, planning, funding, implementation, etc.)
- Effective coordination of very diverse and competent partners calls for a multi-stakeholder partnership framework
  - consensus on concept reached during the workshop on strategies (Livingstone, Zambia, 8–12 September 2014)
  - inventory of partners and their profiles under development for effective coordination
- A partnership with the Vector Group based at the Liverpool School of Tropical Medicine (LSTM) is crucial (policy, strategy development).

### *Advocacy and awareness-creation*

The PATTEC Strategic Plan on African Trypanosomiasis (2008–2011) was supported by the Foundation for Innovative New Diagnostics (FIND).

The Kinshasa Declaration on cooperation in implementation of PATTEC (30 October 2009), signed by 10 ministers responsible for agriculture and public health of Angola, the Central Africa Republic, the Democratic Republic of the Congo, Sudan, Uganda and Zambia, enhanced prospects for operationalizing the One Health paradigm in management of tsetse and trypanosomiasis.

The challenge of HAT is now more visible at all levels of society in the affected countries, and there is evidence of sustained advocacy activities in r-HAT and g-HAT affected countries after closure of the project.

### *Resource mobilization*

- Identifying and initiating dialogue with resource partners
  - New resource partners have been identified (e.g. BADEA) to support the creation of a tsetse-free area of up to a total of one million km<sup>2</sup> (upon receipt of proposals from tsetse and trypanosomiasis affected countries)
- The key message in resource mobilization is the contribution of tsetse and trypanosomiasis elimination to global food security, public health and rural development agenda
- Past resource mobilization efforts are being consolidated into a record management system.

### *Facilitation of technology transfer*

The GIS application is considered a very powerful tool to be applied to AW-IPM. Regular training programmes in GIS application were therefore conducted, strongly supported by FAO through an ongoing project “*Improving food security in sub-Saharan Africa by supporting the progressive reduction of tsetse-transmitted trypanosomiasis in the framework of the NEPAD*”.

