Summary sheet of the *in itinere* case "Eradication of tsetse flies"

Eradication of tsetse flies using the sterile insect technique

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I-The innovation story : The innovation is "the eradication of tsetse flies through the sterile insect technique" carried out in an "adaptive manner" by a coordination cell including veterinary services and research institutes, which is completely specific to the Senegal case (see below), and which uses the results of operational research in real time. The "novelty" of the tsetse fly eradication project conducted jointly by CIRAD, national and regional research institutes, IAEA, and the support services for livestock farmers (*Direction des Services Vétérinaires* (DSV) and regional veterinary services) is the adaptation of an existing technique based on an innovative institutional partnership and the daily monitoring of results with a systematic readjustment process.

The tsetse fly eradication project in Niayes began with informal discussions in 2005 between the DSV and IAEA, but it is part of a much longer history of innovation (area-wide integrated pest management (AW-IPM) and the sterile insect technique (SIT) to control tsetse flies) which began in the 1970s (Fig. 1). The first level impacts only concern the Niayes area in Senegal, while the second level impacts extend to Africa and even the planet through the resulting development of a new mosquito control method.

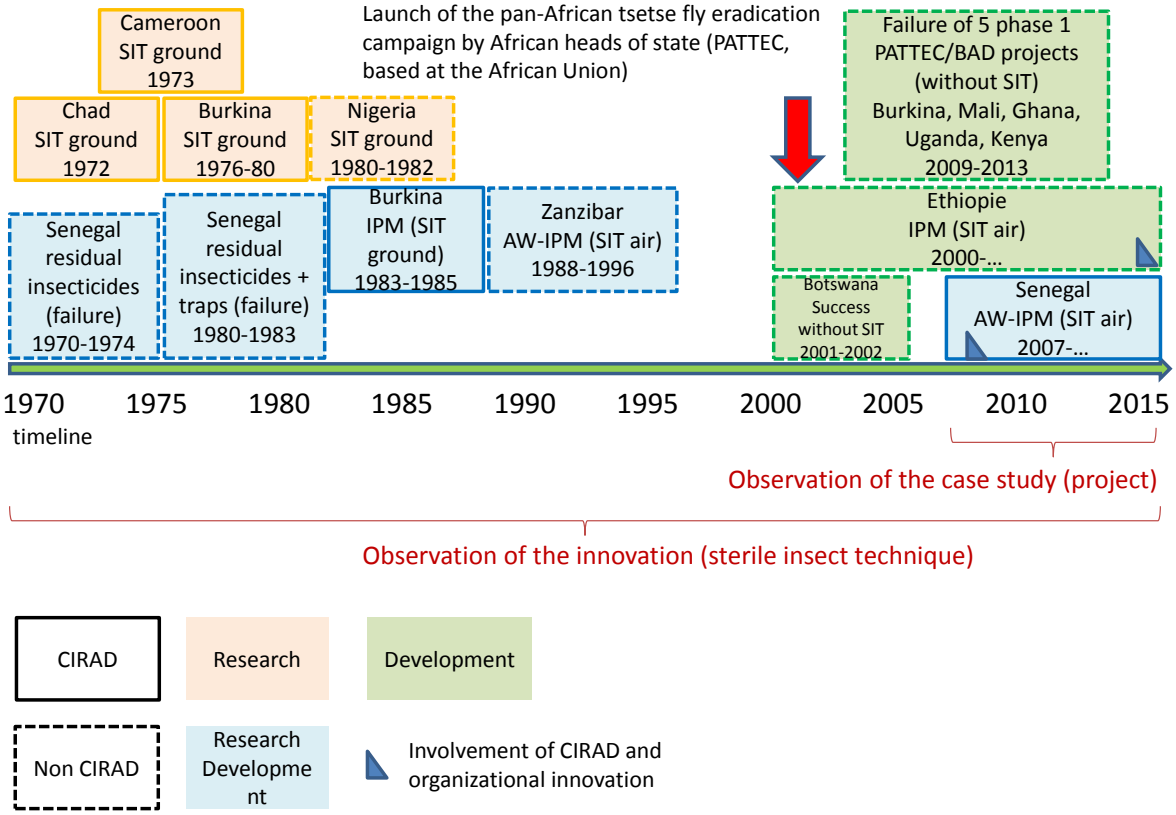

Figure 1- Timeline

The milestones of the innovation can be summarized as follows:

- the research projects preceding the case (1970-1985) where all of the scientific and methodological basics were developed by different research teams dominated by CIRAD and IAEA;
- two research-development projects (the Sidéradougou agro-pastoral area in Burkina Faso for CIRAD and Zanzibar for IAEA) which demonstrated the feasibility of eradication using an integrated control method with a SIT component;
- in the 2000s, the launch of the pan-African campaign for the eradication of tsetse flies and trypanosomoses (PATTEC) with 6 key projects, of which 5 were unsuccessful and the last (Ethiopia) is currently supported by IAEA and CIRAD;
- launch of the eradication project in Niayes in 2007 following discussions between DSV and IAEA (2005-2007), with the feasibility (2007-2010), pre-operational (2011) and operational (starting from 2012 and still underway) phases.

The feasibility phase of the eradication project in Niayes rendered it possible to demonstrate the importance of trypanosomoses in the target area, define a 1000 km^2 target population and demonstrate the isolation of this

population by population genetics, allowing an eradication strategy to be chosen. The importance of the methods developed by the project's research component (ISRA-CIRAD) was vital for this phase, reducing for example sampling costs by over 90% when identifying the target population.
The pre-operational phase enabled methodologies to be established for the transport of irradiated males, and the study of the quality, competitiveness, survival and dispersion of the sterile males. It also allowed the strategy to reduce densities of tsetse flies (insecticide traps and insecticides applications on livestock) to be tested, and thus to build the sequential eradication strategy deployed from 2012.
In the operational phase, all of the tools and methodologies developed through research were used in a quasi-military manner by the regional veterinary services staff and ISRA technicians employed by the project. The sterile males were released by an automatic machine loaded on a gyrocopter. The first aerial automatic tsetse fly release machine was developed and tested in collaboration with the Mubarqui team (Mexico) and a second machine developed by CIRAD and its partners is currently being patented. In addition, the distribution models were used to target where to set traps and to determine the density of the sterile males to be released.
The figure below presents the landscape of players in the operational phase.

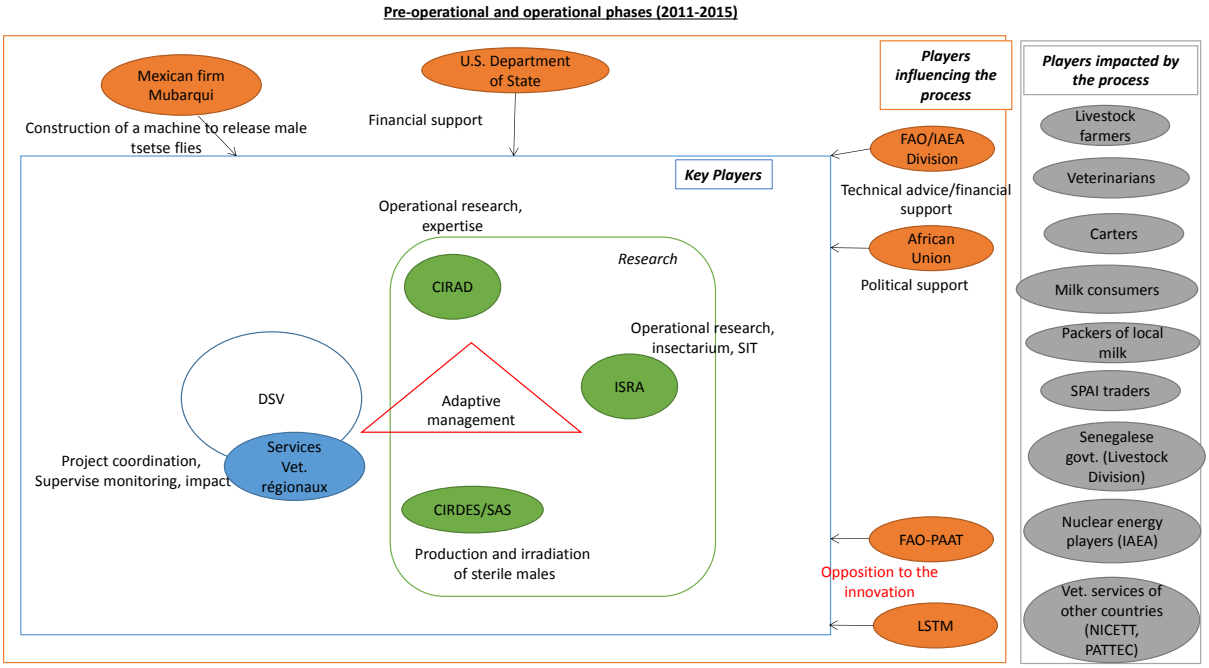

Figure 2- Landscape of players (operational phase)

It should be noted that funding was obtained iteratively (depending on the success of each phase). IAEA funded the feasibility study (2007-2010) and the pre-operational phase (2011) as the sole international financial partner, then listed the project as a priority in its Peaceful Uses Initiative (PUI), which led the U.S. Department of State to fund the project starting from 2012. About 30% of the budget is dedicated to operational research.
Lastly, one should note that the civilian actors impacted by the process have only very limited influence over its implementation, but they are at the heart of the valorization of the project for livestock farming.

II- The lessons from the impact pathway analysis

The analysis of causal relations conducted in a participatory fashion largely confirmed the scenarios developed by the researchers and diverse stakeholders. These scenarios were established by taking into account the impacts observed in Zanzibar following a tsetse fly eradication project in the 1990s and through comprehensive interviews with a dozen livestock farmers in the Niayes area. The participatory workshop, and particularly a focus group with the livestock farmers, enabled the researchers' hypotheses to be validated as well as clarified by quantifying the speed of the expected development of zootechnical and genetic innovations (changes in livestock farming systems and breeds). Lastly, the participatory approach enabled us to put in perspective the relative impact of the eradication project on the innovation compared to other factors (land pressure, theft, plastic-related mortality). These factors also are contributing to reduced herd sizes and intensification, and it will be difficult to quantify the relative importance of the research on the developments observed. In contrast, it appears clear that the project will enable livestock farmers to better adapt to other constraints.

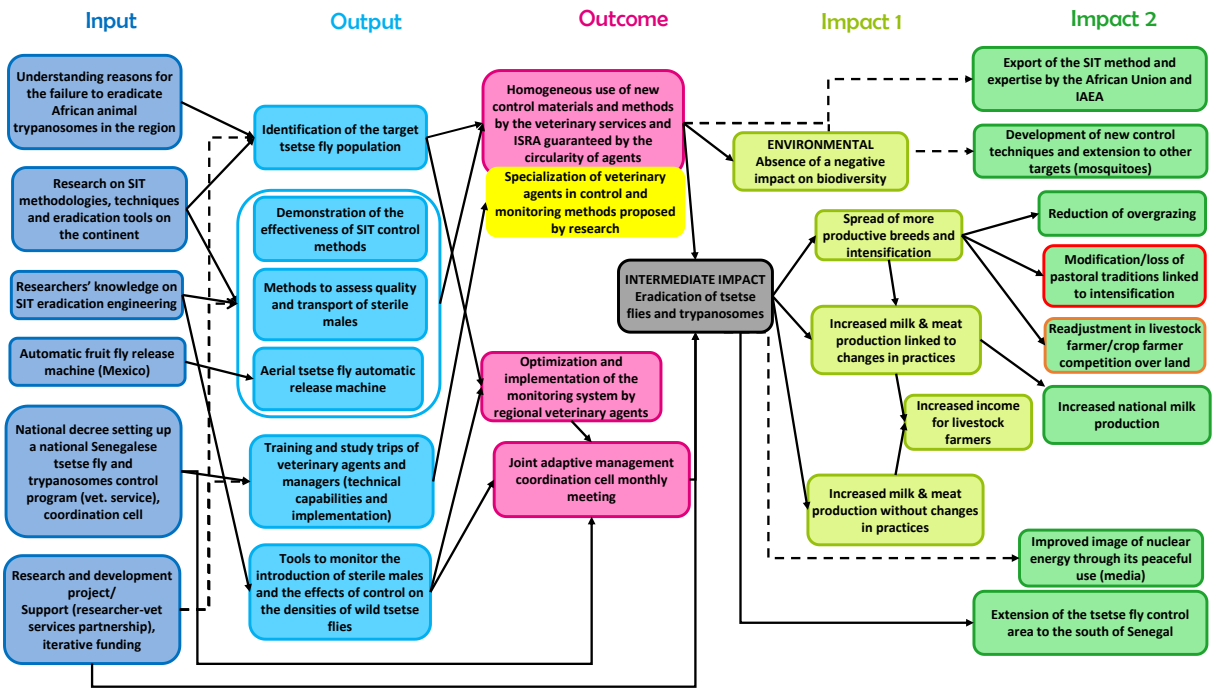

Figure 3-The impact pathway of the *in itinere* tsetse fly process (2016)

Another conclusion is that outside the eradication project, the use of participatory approaches must not be limited solely to diagnosis; rather, such approaches must be used to accompany the development of the livestock sector and notably changes in the socio-technical regime in place to amplify the impacts of the eradication project. The FAO, which participated in the participatory workshop, has shown an interest in funding this work through a TCP project, which is now being developed by the DSV (*Assistance à la finalisation du projet de lutte contre la mouche tsé-tsé dans la zone des Niayes et la valorisation des terres assainies*).

III- Which scenarios to achieve the expected impacts? What type of monitoring (role of indicators?)

III-1 Scenarios considered to link outcomes with impacts

The eradication of tsetse flies is the project's crucial intermediate impact, which leads to level 1 and 2 impacts. The methodologies developed through research and the development of the capabilities of the regional veterinary services and managers played a critical role in achieving this impact by modifying how these services operate, optimizing project monitoring, and promoting adaptive project management, which depends on regular communication between researchers and development agents. The scenarios were established by identifying the causal relations between tsetse fly eradication and change to livestock farming systems, by analogy with the situation in Zanzibar and especially through the comprehensive interviews with the livestock farmers. We also used the participatory workshop to explore the scenarios with the livestock farmers and we noted that they validated the researchers' scenarios.

III-2 Which monitoring modes are possible integrating indicators by type of impact?

The impact of the eradication project on tsetse fly density was measured by an entomological surveillance system. In block 1, tsetse flies have been eradicated since 2012; in block 2, there has been a 99% reduction in densities; lastly, in block 3, the reduction is greater than 95%. The reduction in the density of tsetse flies has already triggered a significant reduction in disease prevalence ($p<10\text{-}3$) which was measured by the annual monitoring of three sentinel herds, one a control herd and two in the eradication project area (blocks 1 and 2). This also was noted in the comprehensive interviews conducted under the framework of the project during the participatory workshop. Finally, the second socioeconomic survey made under the the ImpresS program has already revealed two significant impacts: the reduction in the proportion of trypanotolerant breeds in the herds and the reduction of cultivated areas. The largest herds also are becoming smaller and the smallest herds are becoming larger, with thus a reduction in size inequalities. Other similar surveys will be organized in the future to monitor these impacts and the sentinel systems continue to be monitored.

Type of impact	Expected impacts	Suggested indicators
Intermediate impact	Eradication of tsetse flies and trypanosomes	Density of tsetse flies
		Incidence and prevalence of animal trypanosomoses
1st LEVEL	Increased production of milk & meat without and with changes in practices	Production per animal and per farm
		Quantity of milk and meat sold per animal and per farm
1st LEVEL	Spread of more productive breeds and intensification	Percentage of different breeds in the herds
		Batching modes
		Feeding modes
1st LEVEL	Increased income for farmers	Farmers' revenue
1st LEVEL	Absence of a negative impact on biodiversity	Species richness and density of bioindicators
1st LEVEL	Reduction of overgrazing	Change in herd size in the Niayes area
2nd LEVEL	Modification/loss of pastoral traditions linked to intensification	Evolution in number and size of *Tyossan* herds
2nd LEVEL	Readjustment in livestock farmer/crop farmer competition over land	Evolution in the cropped area per farm
2nd LEVEL	Increased national milk production	Evolution in milk imports
2nd LEVEL (Scaling out)	Extension of the tsetse fly control area to the south of Senegal (Sine Saloum)	Control area involved
2nd LEVEL (Scaling up)	Exportation of the SIT method and of the expertise by the African Union and IAEA	Other countries/organizations using the same methodology
		Support for the development of SIT in other countries
2nd LEVEL (Scaling up)	Improved image of nuclear energy through its peaceful use (media)	Prizes & Distinctions
		Media
2nd LEVEL (Scaling up)	Development of new control techniques and extension to other targets (mosquitoes)	New "Boosted SIT" method developed