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Impact of tsetse and trypanosomiasis control on poverty: A case of Pate Island of Lamu County, Kenya

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The livestock rearing households of Pate Island in Lamu County of the Northern Coast of Kenya had been participating in the control of tsetse flies and trypanosomiasis. The objective of this study was to estimate the change in household wealth index resulting from tsetse and trypanosomiasis control. The study was conducted on 254 project households and 282 non-project households in the County. Using structured questionnaires, the study collected data on household characteristics, number of livestock in the household by type, household durable assets and living conditions. Principal Components Analysis (PCA) was used to construct the household wealth index as an outcome to measure the well-being of households. The results indicated that the proportion of very wealthy households was higher (16%) in the project areas than in non-project areas (3.7%). Propensity Score Matching (PSM) results showed that the mean wealth index for a project participating household was 0.699 (Std. Err. = 0.048 while -0.745 (Std. Err. = 0.077 if the household had not participated in the project denoting an increase of 1.444 in the household wealth index. In conclusion, the study shows that the tsetse and trypanosomiasis control project had brought an improvement in the wealth index of the project participated households. Therefore, it is recommended that governments mobilize resources to control tsetse flies and the disease in infested areas of Africa to improve the well-being of rural households.

Key words: Impact, tsetse, trypanosomiasis, wealth.

INTRODUCTION

Tsetse flies (*Glossina species*) transmit a fatal zoonotic disease called trypanosomiasis. The disease is known as sleeping sickness in humans and nagana in livestock. Tsetse flies infest 37 sub-Saharan African countries covering approximately 9 million square kilometres (km^2) and threaten about 60 million people and 48 million cattle (WHO, 2001). It is one of the greatest problems hindering agricultural development in the sub-humid and humid zones of Africa. Sleeping sickness was under control in Africa during the 1960s and 1970s. However in the last two decades a spread of the disease to epidemic proportions has been observed due to the breakdown of

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the control programmes causing a public health crisis in many affected areas (Smith et al., 1998). If the goal of poverty reduction and food security has to be achieved, this major hindrance to rural development needs to be removed.

To address the problem, African Heads of State and Government collectively launched the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) project in 2000 with a view of guiding the process of eradicating tsetse flies and trypanosomiasis (T&T). As part of this initiative, the African Union PATTEC (AU-PATTEC), the African Development Bank (AfDB) and the governments of affected countries prepared a proposal for a Pan-African programme, the Eradication of Tsetse and Trypanosomiasis in Sub-Saharan Africa (ETTSSA), as well as proposal for the first phase of the eradication campaign (AfDB, 2004). Six countries participated in the Phase I Project, three countries in West Africa (Burkina Faso, Mali and Ghana) and three others in East Africa (Ethiopia, Kenya and Uganda).

In Kenya, the area infested by tsetse is estimated to be 138,000 km^2 covering 38 out of 47 counties (KENTTEC, 2011). The disease impoverishes livestock farmers and threatens food security and livelihoods. The risk of human sleeping sickness outbreak is high in the Lakes Victoria and Bogoria basins and the Mara Serengeti tsetse belt all with a total human population of about 11 million people at risk of infection (KENTTEC, 2011; KNBS, 2010). The first phase of PATTEC-Kenya project was implemented from 2005 to 2011 covering a total area of 24,000 km^2 in three tsetse belts named Lake Victoria basin, Lake Bogoria and Meru/Mwea. The control of tsetse and trypanosomiasis in Pate Island served as a pilot project in the Coastal tsetse belt in an area of approximately 62 km^2 with the vector and disease control starting in 2010. The direct achievements of tsetse and trypanosomiasis eradication interventions under the PATTEC-Kenya programme include reduction of tsetse fly populations and reduced disease prevalence in livestock and in humans (KENTTEC, 2009, 2013, 2014, 2015, 2016; AfDB, 2011). The impact of these changes on income and wellbeing of households had not been quantified. It was therefore important to understand the impact of the project on household income for African governments to roll out tsetse and trypanosomiasis eradication campaign to other tsetse infested areas which had not been covered by such a programme. The objective of the study therefore was to estimate the change in the wealth index of the project households in Pate Island of Lamu County.

Review of theoretical literature

Theory of change

A theory of change (TOC) describes the causal assumptions behind the links in the results chain; what has to happen for the causal linkages to be realized (Weiss, 1995; Blamey and Mackenzie, 2007; Leeuw, 2012; Rogers, 2008). Theories of change lead to the understanding of how and why the activities of the intervention are expected to lead to the desired results. The use of TOC in development evaluations has been reviewed by James (2011); Stein and Valters (2012) and Vogel (2012) and all point out that TOC uses intuitive notions of reaching some target group, changing their motivation and behaviour.

Measurement of impacts presents a large variety of econometric complications. The ultimate objective of the analysis of a treatment or intervention would be the effect of treatment on the treated individuals. In the literature it is documented that measuring this effect econometrically encounters at least two compelling computations namely endogeneity and missing counterfactuals (Greene, 2012; Roy, 1951; Rubin, 1974). In the endogeneity of the treatment problem, the analyst risks attributing to the treatment causal effects that should be attributed to factors that motivates both the treatment and the outcome. Drawing an example from tsetse control, an individual farmer who participates in tsetse control might have well succeeded more in life than their counterpart who did not participate even if they themselves did not participate in tsetse control.

On the other hand, with the missing counterfactual problem, in order to measure the impact of tsetse control on individual farmer's income, we would have to run an individual's lifetime twice, once with participation in tsetse control and once without. But, any individual is observed in only one of the two states, so the pure measurement is impossible leading to the missing counterfactual problem. Greene (2012) points out that accommodating these two problems, the endogeneity of treatment and the missing counterfactual, forms the focal point of this enormous and still growing literature on program evaluation and Rubin's causal model (1974, 1978) provides a useful framework for the analysis. This study was anchored on the theory of change to underpin the impacts of tsetse and trypanosomiasis control interventions in Pate Island. Figure 1 is a conceptual framework showing the results chain for the control of tsetse and trypanosomiasis in Pate Island in the Coastal region of Kenya.

Conceptual framework

The study conceptualized that at the inception of the tsetse and trypanosomiasis eradication project, livestock farmers were sensitized and trained on tsetse and trypanosomiasis control using different control methods. The project staff were also given technical training on tsetse and trypanosomiasis control. The trainings and the support given in terms of initial insecticides issued to farmers, tsetse target screens, tsetse traps, and

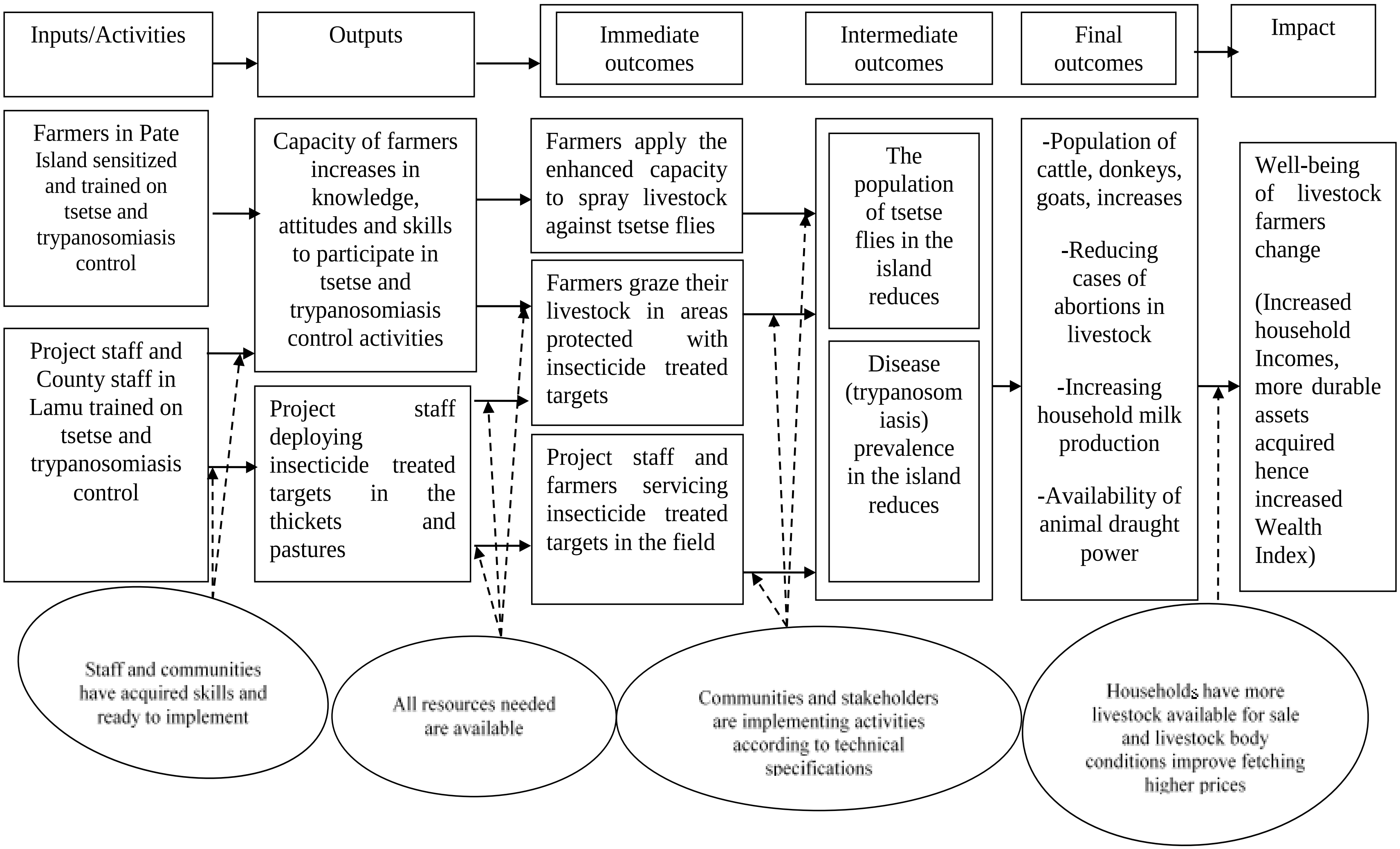

Figure 1. A conceptual framework showing the results chain for the control of Tsetse and Trypanosomiasis in Pate Island in the Coastal region of Kenya.

provision of other project operational costs served as project inputs which in the project results chain culminated into project outputs.

The outputs conceptualized in this study include the increase in farmers' capacity in terms of knowledge, attitudes and skills to control tsetse and trypanosomiasis, project officers able to deploy the insecticide treated targets in the tsetse infested thickets. The immediate and intermediate outcomes include farmers applying the enhanced capacity to spray livestock against tsetse flies, farmers graze their livestock in areas protected with insecticide treated target screens, project staff and farmers carrying out the servicing and replacement of worn out insecticide treated targets in the field.

The population of tsetse flies reduces in turn and disease (trypanosomiasis) prevalence in the intervention areas reduces. The final outcome of this is that the population of cattle, donkeys, goats and sheep is expected to increase, the cases of abortions in livestock expected to reduce and household milk production increases. The farmers in turn get more income from the sale of milk, cattle, sheep, goats and donkeys. The conceptual framework is presented in Figure 1. In the conceptual framework, the solid arrows represent the causal links between results; what has to happen for the causal linkages to happen. The doted arrows represent the underlying assumptions in the causal linkages for the planned change to occur.

METHODOLOGY

Study area

Pate Island is located in the Indian Ocean along the Northern Coast of Kenya in Lamu County lying between latitude 1°40, 20° 30 S and longitude 40° 15 and 40° 35 East (GoK, 2013). The Pate Island is the largest Island in the Lamu Archipelago, which lie between the towns of Lamu and Kiunga, close to the border of Kenya and Somalia. There are two administrative divisions in the Island namely Faza and Kizingitini (GoK, 2013).

The Island has a total area of 92.9 km^2 of which the agricultural farm land area is about 60 km^2. The Island has a livestock population of 8,150 heads of cattle, 6,250 goats and 3,200 donkeys. Lamu East Sub-county of Lamu County enjoys two rainy seasons and temperatures ranging between 23 and 32°C throughout the year. The long rains come in April and May while the short rains come in November and December. The main economic activities in the island include agriculture, livestock keeping and marine activities with the residents being predominantly Muslim.

The study site was selected because of being an isolated area. The sea acted as a natural barrier separating the island from other islands and the main land where the project had not been implemented. This minimised the interaction between the project households and non-project households hence restricting the project spill-over effect. For example, if livestock from non-project households had access to the project area grazing lands where insecticide treated target screens were deployed, the benefits would spill over to the non-project households leading to confoundedness. Figure 2 shows a map of the study area.

Sampling

Sample size determination

The population of farm households practicing livestock rearing in the study area was obtained from the extension reports of the County Government of Lamu. According to Kothari and Gaurav (2014) the formula applicable in the case of a finite population is given as:

$$n = \frac{z_{\alpha/2}^2 N\sigma^2}{(N-1)e^2 + z_{\alpha/2}^2\sigma^2} \tag{1}$$

where

n is the size of the sample

N is the size of population

e is the acceptable estimation error given by $e = z_{\alpha/2}\frac{\sigma}{\sqrt{n}}$

σ is the standard deviation of the population

$z_{\alpha/2}$ is the critical value using the N(0,1) distribution for confidence level α

In this study, the sample size was computed using the above stated formula at a Confidence level of 95% and a margin of error of 5%. The population of project households was 734 and that of non-project households 959. With the critical value $Z_{\alpha/2}$ = 1.96 and σ = 0.5, the sample size for the project households was determined as:

$$n = \frac{1.96^2 * 734 * 0.5^2}{(734-1)0.05^2 + 1.96^2 * 0.5^2} = 252.4 \simeq 253$$

and the sample size for the non-project households was:

$$n = \frac{1.96^2 * 959 * 0.5^2}{(959-1)0.05^2 + 1.96^2 * 0.5^2} = 274.5.9 \simeq 275$$

Sample selection

The sample of project households was drawn from the tsetse and trypanosomiasis controlled area of Pate Island. The area covers eight administrative sub-locations namely Kwatini, Kwatongani, Pate, Siyu, Shanga, Tchundwa, Kizingitini and Myabogi all with different number of livestock rearing households. The village roads were used as transects along which proportional samples were systematically drawn from each village until a total of 254 households was obtained for project households. The first household along each transect was randomly selected. There after every 5^{th} household with livestock was selected for interviewing. The sample of non-project households was drawn from Amu and Hindi divisions of Lamu County where the Kenya Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) had not commenced tsetse and trypanosomiasis control interventions. The sub-locations covered in Hindi division were Hindi, Bargoni, Mokowe and Kilimani while those covered in Amu division were Matondoni, Kipungani, and Manda. Households with livestock in the non-project area were sampled following the same sampling protocol adopted for the households in the project area. A total of 282 non-project households were selected and interviewed.

Data collection

Using structured questionnaires administered through household

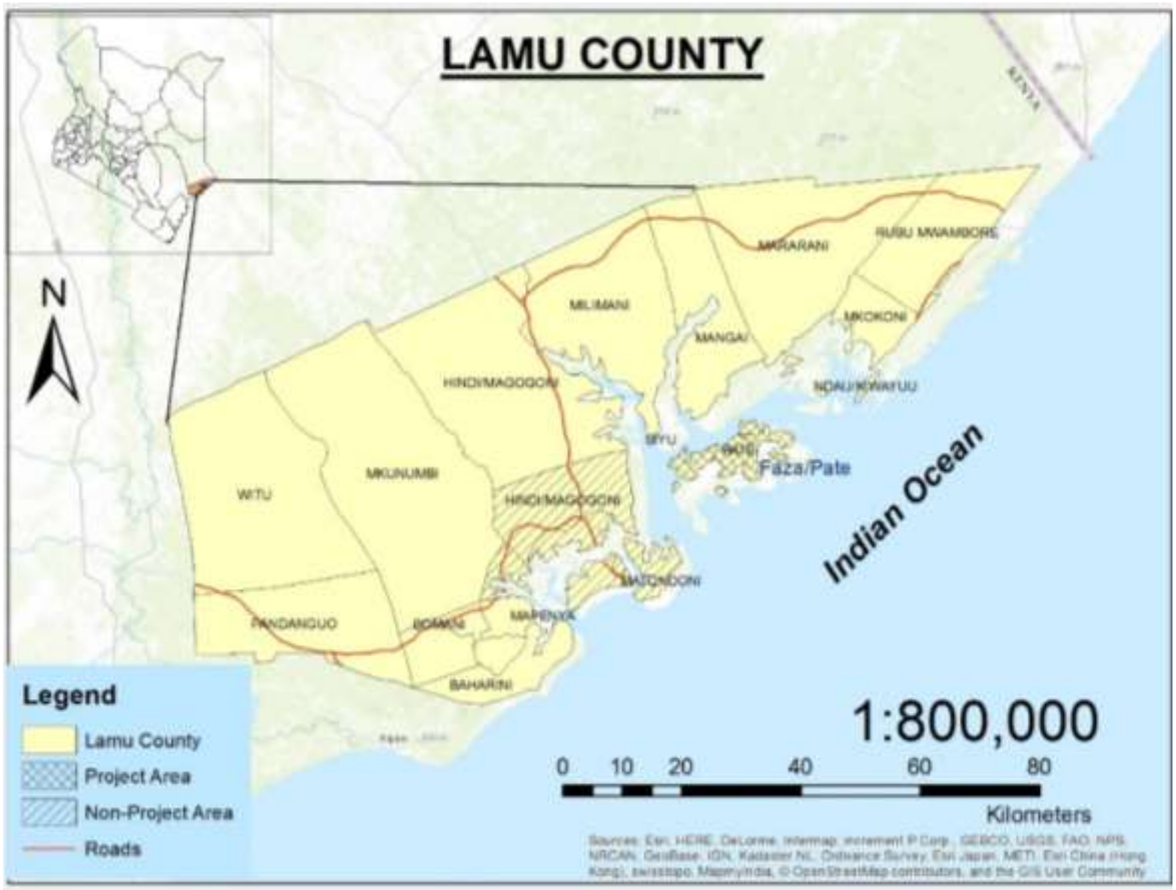

Figure 2. A Map showing the study areas of Pate Island, Amu Island and Hindi division of Lamu County, Kenya. Source: Esri, HERE, DeLorme, Intermap, Increment P Corp, GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordinace Survey, Esri Japan, METI, Esri China (Hong Kong), Swisstopo, MapmyIndia, OpenStreetMap contributors and the GIS user community.

interviews, the study collected socio-economic data including household characteristics, livestock (cattle, sheep, goats, donkeys and poultry) production, ownership of durable assets and living conditions in the household.

Indicators of household welfare

There are various indicators of welfare that may be used as outcomes to gauge impacts of a program. Baker (1960) considers poverty measures including head count index, poverty gap index, squared poverty gap and Watts's index. The head count index measures the proportion of the population living in households with income per person below the poverty line while the poverty gap for each household is the difference between the poverty line and the household income (Ravallion, 1994). The two methods are however not distribution sensitive. Some distribution sensitive measures include squared poverty gap where individual poverty gaps as a proportion of poverty line are squared before taking the mean and Watts's index which is the mean of log of the ratio of the poverty line to income (Atkinson, 1987).

According to Deaton (1997), expenditure-based economic status indicators have been found to be more reliable than indices that are income based. The main reason is the relatively high non-response rate for income based measures as well as under or over reporting typically found in income items utilized in standard of living household surveys.

Filmer and Pritchett (2001) popularized the use of Principal Component Analysis (PCA) for estimating wealth levels using asset indicators to replace income or consumption data and concluded that PCA provides plausible and defensible weights for an index of assets to serve as proxy for wealth. Asset-based measures depict an individual or a household's long-run economic status and therefore do not necessarily account for short-term fluctuations in economic well-being or economic shocks. This study estimated the wealth index as an outcome for the assessment of impact of tsetse and trypanosomiasis control. Cordova (2008) points out that the indicator together may tap a long term dimension of economic well-being of the households.

Constructing the household wealth index

The wealth index (WI) is a composite index composed of key asset ownership variables. The WI is normally used as a proxy indicator of household level wealth. This was calculated using the PCA method performed on variables which are indicators of wealth among the farm households in Lamu County, Kenya. Table 1 shows the indicators of wealth that were used in the study and the dichotomised household responses where Yes = 1 when a

Table 1. Indicators of wealth among households and dichotomised responses.

Asset	Rich household	Poor household
Land	1= Yes	0= No.
TV Set	1= Yes	0= No.
Radio	1= Yes	0= No.
Mobile phone	1= Yes	0= No.
Bicycle	1= Yes	0= No.
Car or Boat	1= Yes	0= No.
Motorcycle	1= Yes	0= No.
Cattle	1= Yes	0= No
Improved cattle	1= Yes	0= No
Donkeys	1= Yes	0= No.
Goats	1= Yes	0= No.
Dairy goats	1= Yes	0= No
Sheep	1= Yes	0= No.
Poultry	1= Yes	0= No.
Type of dwelling unit		
Roofing material	1= Iron sheet or Tiles	0= Makuti or Grass thatch
Walling material	1= Bricks or Stone	0= Mud, lime or Timber
Floor material	1= cement	0= dust

household owns asset and No = 0 when household does not own the asset in question. The dichotomised responses were used to obtain the first principal component loadings which assigned weights for assets and housing conditions giving rise to household wealth index.

The estimation of relative wealth using PCA is based on the first principal component concept. Following the example of Cordova (2008), the study expressed the wealth index (WI) for farm household in Lamu County as:

$$y_i = \alpha_1\left(\frac{x_1 - \bar{x}_1}{s_1}\right) + \alpha_2\left(\frac{x_2 - \bar{x}_2}{s_2}\right) + \ldots\ldots\ldots + \alpha_k\left(\frac{x_k - \bar{x}_k}{s_k}\right) \quad (2)$$

where:

y_i : is the wealth index for Lamu county farm household *i*.

x_1, x_2 ...... x_k: is a vector of asset variables which include ownership of land, television set, radio set, mobile phone, bicycle, a car or boat, motorcycle, cattle, donkeys, goats, sheep, poultry; whether roofing material is made of thatch or iron sheets, whether walling material is made of stones or mud, whether floor material is made of cement or earth).

$\bar{x}_1$, $\bar{x}_2$ .... $\bar{x}_k$ are means of assets x_1, x_2 ...... x_k respectively

s_1, s_2 .... s_k are the standard deviations of assets x_1, x_2 ...... x_k respectively

α_1 α_2 ,.......... α_k are weights for each variable x_k for the first principal component.

The procedure yielded a wealth index for every sampled household in the project area and the non- project area. Using the calculated wealth index, households were categorized into quintiles of wealth where quintile 1 = Very poor household, 2 = Somehow poor, 3 = Middle, 4 = Wealthy and 5 = Very wealthy household.

Estimation of the PSM estimator

This study used the propensity score, $P(D = 1 \mid X) = P(X)$, that is, the probability for an individual to participate in a treatment given his observed covariates *X*. Hence, if the Conditional Independence Assumption[1] (CIA) holds, all biases due to observable components can be removed by conditioning on the propensity score (Imbens, 2004). Assuming that CIA holds and that there is overlap or common support between the participating and non-participating household groups, the PSM estimator for ATT can be written as presented in Equation 2.

$$WI_{ATT} = E\left[WI_i(1) \mid PPART_i = 1, P(X_i)\right] - E\left[WI_i(0) \mid PPART_i = 1, P(X_i)\right] \quad (3)$$

where:

WI_{ATT} = The average treatment effect on the treated (ATT) denoting the change in Wealth Index for the households participating in tsetse control project in Pate Island

WI_i = Wealth Index for the i[th] household

$PPART_i$= Participation of the i[th] household in tsetse and trypanosomiasis control project (PPART=1 if household participated and 0 if not)

$P(X_i)$ = Propensity score defining the region of common support for project participating households and non-participating households

This is the simplest form of propensity score matching as noted by Baker (1960). This procedure involved calculating the mean value of the wealth index for the households. The difference between the calculated mean and the actual value for the project

[1] This assumption implies that systematic differences in outcomes between treated and comparison individuals with the same values of covariates are attributable to treatment

household is the estimate of the gain due to the program.

RESULTS AND DISCUSSION

The household wealth indicator variables included for the study were whether household owned assets such as bicycle, boat or car, cattle, dairy goats, donkeys, goats, improved cattle, land, mobile phone, motorcycle, poultry, a radio set, sheep and a television set. The materials used on the floor, roof and walls of the household dwelling were also included as indicators of wealth in the study area. All the variables were first dichotomized as 1=Yes and 0=No as suggested by Vyass and Kumaranayake (2006) to indicate the ownership of each household asset. The findings on general asset ownership in the study area are presented in subsequently.

Livestock ownership

It was found that 64% of the households owned indigenous cattle while the remaining percent did not. Of all the households interviewed, only 3% of had improved cattle compared to 97% who did not have. When asked about ownership of donkeys, 24.8% of the households owned donkeys while the remaining 75.2% did not have any. On the ownership of indigenous goats, the study found that 49.6% owned indigenous goats while the remaining 50.4% did not have. It was found that 2.6% of the households had dairy goats as opposed to the remaining 97.6% who did not have. Households were asked whether they owned poultry or not; in response 47.8% said they owned poultry while 52.2% did not own poultry. Finally the study found that only 8.6% owned sheep while 91.4% did not. These results are presented in Table 2.

Ownership of other assets

The study's investigation on the ownership of other assets revealed that 17% of the households owned bicycles while 83% did not have; 6.9% owned either boat or car yet the remaining 93.1% did not; 78.9% owned agricultural land while 21.1% did not. Asked whether they owned mobile phones or not, 84.1% of the households said they had phones while 15.9% said they did not. The study further found that 69.4% of the households owned radio sets while 30.6% did not; 30.6% owned television sets while 69.4% did not and finally, only 13.8% owned motorcycles while 86.2% did not. The findings are presented in Table 3.

Materials used for household dwelling

The study found that 39% of the households had the floors of their houses made of dust (earth floors) while the remaining 61% had floors made of cement; 52.1% of the households had roofs of their dwelling units made of naturally available materials such as *makuti* or grass thatch while 47.9% had their roofs made of iron sheets. Of all the households, 59% had the walling material for their dwelling units made of naturally available materials including mud, rough stones, lime or timber while 41% had the walls made of either bricks, quarry stones or cement. The results are presented in Table 4.

Wealth index for Lamu households

The response of households on the dichotomized wealth indicator variables was captured in the Statistical Package for Social Scientists (SPSS) and Microsoft Excel spread sheets. Principal Components Analysis (PCA) procedure was used to calculate the factor scores. The weights were obtained from the first principal components loadings across the households. The first principal components assigned larger weights for assets and housing conditions that varied the most across households. In contrast, the first principal component assigned smaller weights to assets and housing conditions with minimal variations across households. The orthogonalized first principal component loadings are shown in Appendix 1.

Quintiles of wealth in Pate Island, Amu and Hindi divisions of Lamu County

Using the household wealth indices obtained from the PCA procedure, households were categorized into quintiles of wealth where quintile 1 = Very poor household, 2 = Somehow poor, 3 = Middle, 4 = Wealthy and 5 = Very wealthy household. The household quintiles of wealth were cross tabulated by whether household was in project area or not. The results of the cross tabulation revealed that 16% of households in Lamu were categorized as very wealthy and found in the project area compared to 3.7% who were very wealthy and found in non-project area. The results of household quintiles of wealth are presented in Table 5.

Propensity score matching (PSM) estimator

The project households and non-project households were matched on their propensity scores calculated using pre-project underlying covariates which included age of the household head, sex of the household head, ownership of land, other major source of livelihood for the household, and years of education of the household head. The steps of calculating the PSM estimator were followed as suggested in literature (Stuart and Rubin, 2007; Caliendo and Kopeinig, 2008; Rosenbaum and

Table 2. Livestock ownership in Pate, Amu and Hindi divisions of Lamu County.

Type of livestock	Number of households (n=536)	
	Owning livestock type	Not owning livestock type
Indigenous cattle	343(64)	193(36)
Improved cattle	16(3)	520(97)
Donkeys	133(24.8)	403(75.2)
Indigenous goats	266(49.6)	270(50.4)
Dairy goats	14(2.6)	522(97.4)
Poultry	256(47.76)	280(52.2)
Sheep	46(8.6)	490(91.4)

Note: Proportion of households (%) in parentheses.

Table 3. Household ownership of other assets in Pate, Amu and Hindi divisions of Lamu County.

Other assets	Number of households (n=536)	
	Owning asset	Not owning asset
Bicycle	91(17)	445(83)
Boat or car	37(6.9)	499(93.1)
Land	423(78.9)	113(21.1)
Mobile phone	451(84.1)	85(15.9)
Radio set	372(69.4)	164(30.6)
Television set	164(30.6)	372(69.4)
Motorcycle	74(13.8)	462(86.2)

NB: Proportion of households (%) in parentheses.

Table 4. Materials used on household dwellings in Pate, Amu and Hindi divisions of Lamu County.

Part of dwelling unit	Number of households with dwelling unit type (n-536)	
	Improved	Non-improved
Floor	327(61.0)	209(39.0)
Roofing	257(47.9)	279(52.1)
Walling	316(59)	220(41)

Note: Floor (Improved floor=tiles/cement) (Non-improved= Mud, rough stones, lime or timber)
Roof (Improved roof = Iron sheets or tiles) (Non-improved = Makuti or grass thatch)
Wall (Improved walling = Brick, quarry stones, cement((Non-improved = Mud, rough stones, lime or timber)

NB: Proportion of households (%) in parentheses.

Table 5. Quintiles of Wealth among farm households in Lamu County, Kenya.

Household category	Percentile Group of the HH wealth index					Total
	Very poor	Somehow poor	Middle	Wealthy	Very wealthy	
Non-project households	103(19.2)	85(15.9)	54(10.1)	20(3.7)	20(3.7)	282(100.0)
Project households	4(0.7)	21(3.9)	55(10.3)	88(16.4)	86(16.0)	254(100.0)
Total	107(20.0)	106(19.8)	109(20.3)	108(20.1)	106(19.8)	536(100.0)
Mean Wealth index	-1.5103	-0.5992	0.1368	0.73014	1.23921	0

Rubin, 1985; Lechner, 2001). A one to one matching algorithm that was applied resulted in 136 project households and 136 non-project households.

The PSM results indicated that the mean wealth index

Table 6. Mean Household wealth index in project and non-project areas

Household category	Number of matched households	Mean Household Wealth Index	Std. Error Mean
Project households	136	0.699	±0.048
Non-project households	136	-0.745	±0.077
PSM estimator		1.444	

for a project household was 0.610 (Std. Err. = 0.048) compared to -0.745 (Std. Err. = 0.077) if the same household had not participated in the project denoting an increase of 1.444 in the wealth index. These results are presented in Table 6.

DISCUSSION

The 1.444 points rise in Pate Island livestock farmers' wealth index suggests that the tsetse and trypanosomiasis control activities that were carried out in the Island led to an increase in household income and wealth. On the other hand, the higher proportion of wealthy households found in the project area in this study (16%) compared to that in non-project area (3%) implies that livestock farmers' well-being improved as a result of tsetse control interventions.

The finding is consistent with that of Shaw et al. (2014) who compared farmers' livestock incomes for the 'with trypanosomosis' and 'without trypanosomosis' situations in Eastern Africa and found that the difference between the two income streams had potential benefits from the disease's absence. It is also consistent with the results of economic surveys conducted after the completion of the tsetse and trypanosomiasis eradication operations in Zanzibar which found that the average monthly income of farming households increased by 30% and the proportion of households with a monthly income of over 25 USD increased from 69 to 86% (Feldmann et al., 2005).

The findings of this study suggest that the tsetse and trypanosomiasis control activities that were carried out in Pate Island led to an increase in household wealth. The durable assets such as bicycle, boat or car, land, mobile phone, radio set, television set, motorcycle was a proxy for the medium to long term stream of income in the households during the project period. The control of tsetse flies and the elimination of disease transmission in Pate Island may have resulted to increased livestock numbers and quality.

Conclusion

The proportion of very wealthy households of Lamu County was higher in the project areas than in non-project areas resulting in a rise in Wealth Index among Pate Island households implying that the households had higher incomes conserved over time in durable assets such as livestock, bicycles, boats or cars, land, mobile phones, radio sets, television sets, motorcycles and in improved living conditions. In conclusion, the study shows that the tsetse and trypanosomiasis control project had brought an improvement in the wealth index of the project participated households.

Recommendations

Mobilize resources from National Government, County governments and development partners to eradicate tsetse and trypanosomiasis in vast land areas of Kenya which are still heavily infested by tsetse flies. This study has demonstrated that investments in tsetse and trypanosomiasis control pays off and enhances the well-being of rural households.

Design studies to assess impact of tsetse and trypanosomiasis control in areas which are not geographically isolated. The Pate Island study was a case of an intervention area surrounded by water serving as a natural barrier. This was an ideal situation separating the treatment group from the control group of households' hence minimal infiltrations of project output into the non-project area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix 1. The orthogonalized first principal component loadings.

Coefficient matrix	Component score					
	1	2	3	4	5	6
Whether household owns land or not	-0.051	0.145	0.109	-0.238	0.039	0.509
Household ownership of radio set	-0.059	0.128	-0.240	0.033	-0.430	0.019
Household ownership of mobile phone	-0.048	0.190	-0.097	0.173	0.463	0.133
Household ownership of bicycle	-0.179	0.243	-0.087	-0.080	-0.080	0.207
Household ownership of boat or car	0.043	0.209	0.139	0.095	-0.492	-0.112
Household ownership of a motorcycle	-0.100	0.280	-0.167	-0.147	0.028	0.158
Whether household owns cattle	0.288	-0.016	-0.073	0.119	0.116	0.091
Household has improved cattle or not	0.054	0.071	-0.138	0.538	0.140	0.380
Whether household owns donkeys	0.156	0.087	0.452	0.098	-0.066	0.133
Whether household has Goats or not	-0.263	0.074	0.214	0.155	-0.093	-0.230
Whether household has dairy goats or not	-0.056	0.094	-0.143	0.489	-0.243	0.031
Whether household has sheep or not	-0.060	0.115	0.330	0.325	0.241	-0.338
Whether household owns Poultry or not	-0.121	0.212	0.355	-0.151	0.138	0.102
House roofing material is iron sheets/tiles or not	-0.105	0.179	-0.318	-0.070	0.264	-0.442
House walling material is bricks/stones or not	0.265	0.284	-0.047	-0.084	-0.043	-0.150
House floor material is cement or not	0.256	0.291	-0.013	-0.113	0.039	-0.193

Extraction Method: Principal Component Analysis.
Component Scores.