THE IMPACT OF CHANGE IN LAND USE ON THE BURDEN OF MALARIA IN THE NYANZA DISTRICT

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Abstract

The goal of the study is to assess whether the land use change has an impact on the malaria burden in Nyanza district by focusing particularly on two sectors located in the different geographical area of Nyanza district with the high prevalence of malaria. These are Busoro sector characterized by the presence of the large rice fields and dams and Nyagisozi sector, characterized by sand quarries and mining area. The choice of the sample representing the studied population is based on the main ecological activities of the man from 2012 to 2017 in these two sectors of Busoro and Nyagisozi where the cases of malaria are high. The data needed for this work was collected through secondary data from the Health Management Information System (HMIS) for malaria cases and administrative data for the mining and irrigated areas. The analysis was done for all months of the year. The summary provided for the year corresponds to seasonal malaria cases (SOND and MAMJ). Quantitative and qualitative data were analyzed using R, an open source programming language and a software environment for statistical computing and graphics. Time series analysis was used to verify non-stationary data. A multiple regression model was used to test the relationship between the variables. The results revealed a positive slope for seasonal malaria cases total for September to December and for March to June. In Busoro sector the study revealed, for September to December, the R-squared of 0.315 and the P-value 0.246and a correlation coefficient was 0.56. For March to June, the R-squared was 0.4548 with p-value equals 0.1418 and the correlation coefficient was 0.67. This fitting model assessing the evidence for chance for malaria cases over years and the moderate correlation between malaria cases and years. In Nyagisozi sector, the study revealed, for September to December, the R-squared of 0.6311 with p-value equals 0.059 and the correlation coefficient was 0.79. For March to June, the R-squared was 0.1267 with p-value equals 0.4886 and the correlation coefficient was 0.7. This fitting model assessing the evidence for chance for malaria cases over years and a high correction between malaria cases and years.

Based on the findings the conclusion is that the number of cases of malaria had increased over the years and stabilized in these sectors after the regular operation of mines and dams for irrigation and therefore the study confirms the impact of land-use change on the spread of malaria with high frequency of malaria transmission. Therefore, the study suggests that the effects of interventions should be concentrated on irrigation areas such as chemical spraying to avoid mosquito multiplication and mine exploitation, or even more in-depth research with data for a longer period.

Keywords: Land use change, Malaria burden, irrigated zone, mining zone

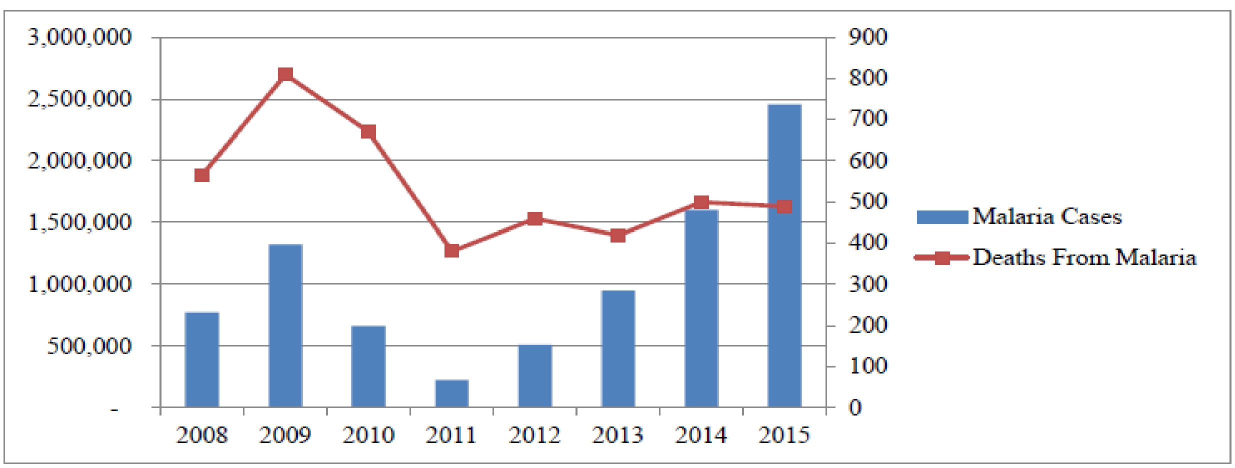
INTRODUCTION

Land use change is the main force behind ecological and social change in many countries around the world; it is primary driven by resources needs and external economic motivation. Alongside, transformation of the land is the main drivers for the emergence of malaria. A study by Andres et al (2017) showed that the most striking example of this interaction is the early emergence of plasmodium falciparum malaria which is basically linked to the development of frontier agricultural settlement. The rapid adaptation of anopheles vectors and plasmodium parasites to environmental changes, added to the multiple ways in which humans quickly modify landscapes, continue to contribute to the expanded distribution of malaria throughout the developing frontiers of the world. In additional, WHO (2005a), showed how man-made ecological transformations have occurred at an unprecedented magnitude over the past 50 years. Prominent among them are water resource development projects: estimated large and small dams have been built and some million hectares of land is currently under irrigation worldwide. This agreed with Patz et al. (2000), that in the tropic during construction of dams and canals excavation pits provide breeding sites for mosquitoes where they lay buoyant egg masses. Likewise, surface irrigation which mainly used for flooding of rice fields creates temporary shallow water bodies, which form ideal breeding sites for malaria vector. However, the relationships between malaria and land use changes are discussed in the light of high local variation in impact on malaria transmission. Also, rice cultivation in West Africa and Americas has a deep-routed relationship with malaria transmission (Wielgosz et al, 2012).

To support this idea, WHO (2005b) has shown that the development, management and exploitation of water resources have long changed the dynamics of malaria transmission and frequency, but analyzed how environmental risk as well as the incidence and prevalence of related malaria are sparse. WHO (2005c), viewed stated that globally more than two billion people globally live in areas where they are at risk of contracting malaria and the estimated annual incidence of clinical malaria is greater than 300 million cases annually. They also stated that more than one million people die every year from the direct causes of malaria, with children under age of five years living in Sub-Saharan Africa at high risk. According to the WHO (2016) report, malaria remains an acute threat to public health, particularly in sub-Saharan Africa, home to 90 percent of the world's malaria cases. Despite global efforts to eradicate malaria, in sub-Saharan Africa more continue to suffer and die from the disease. The severity of this disease has led to the establishment of World Malaria Day on April 25 of each year, since 2007, to recognize global efforts to fight malaria by providing "education and understanding of malaria" and to spread information on "intensified implementation of national malaria-control strategies.

In Rwanda, the burden of malaria is at high frequency especially in regions where those human interventions are traced. The Health Management Information System (HMIS) data from June 2015, has classified 19 of the country's 30 districts as high-burden with 11 of these districts accounting for over 76% of malaria disease in the country. Of these, five high-burden districts are Bugesera, Gisagara, Gatsibo, Kirehe, Nyanza and Nyagatare. It mentioned that since 2011, Rwanda has seen an 11- fold increase in reported malaria cases from 225,176 cases reported in 2011 to 2,662.706 in 2015.

Figure1.Malaria incidence in 11 districts primarily, in the Eastern and Southern regions.



Source: Rwanda HMIS data

According to James K. Kamuhanda (2016), malaria in Rwanda is one of the major health issues to be tackled diligently by both researchers and government officials.

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USAID (2015) indicated that in 2005 malaria was estimated to be responsible for 40% of morbidity and 62% of mortality among children less than five years of age as well as for 34% of morbidity and 31% of mortality among persons older than five years of age. Similarly, the Rwanda Ministry of Health report of 2009-2011, reported that Malaria continues to be the top cause of death among patients at district hospitals and that it is the fourth most deadly disease in Rwanda after neonatal, lung and cardiovascular diseases. According to NISR (2012), the population density in Nyanza is estimated to be 482 people per km^2 (the total population is approximately 323,719). Ecological transformations have occurred at an unprecedented magnitude over the last 10 years in Nyanza district. Among them, water resources development projects: Large dams of 2,770,000 m3 capacity, marshlands of 2,484 ha and mines of 30 ha. For these reasons, Nyanza has experienced more cases of malaria in last six years: 21991 (2012), 60,334 (2013), 118,040 (2014), 162,392 (2015), 129,628 (2016), 127,881(2017).

Due to serious disease burden caused by malaria in Nyanza district, there is a need to measure the extent to which Land use change has had an impact on malaria. Busoro and Nyagisozi sectors have been chosen as case study because their particularity of having the large rice fields and marshlands and mining activities.

METHODOLOGY

Study area

The study area is made of two sectors of the District of Nyanza namely the **Busoro** sector located in the north-eastern of the district, it is constituted of soft plateaus and characterized by the presence of vast rice fields and dams where it occupies 17% of the district dam area and the **Nyagisozi** sector located in the southwestern part of the district, it is made of raised hills and, is characterized by sand quarries and a mining area where it occupies 342.75 Ares of mining.

Figure 2. Map showing the study sectors (Busoro and Nyagisozi) in Nyanza District

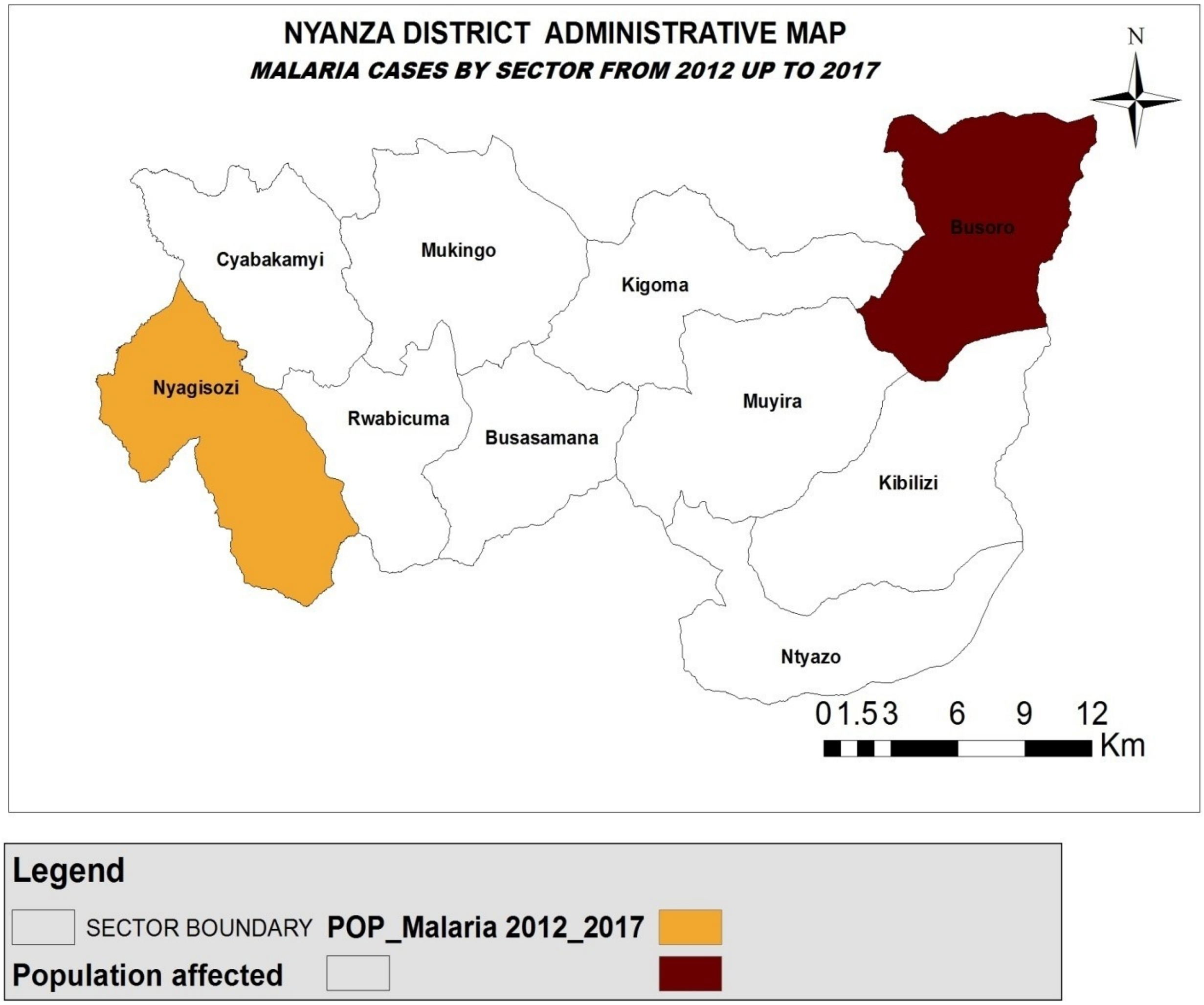

Figure3. The rice fields in the valley of Nyarubogo in Busoro sector; pictures taken November 20, 2018

Figure4. Mining and quarrying in Nyagisozi sector; pictures taken November 26, 2018

Materials and Methods

Population and Sample size

The study is concerned with the whole Nyanza District malaria cases together with irrigated area, dams, mine and marshlands as the main human ecological activities since 2012 to 2017 where the choice of the sample to represent our population in study is drawn in Busoro and Nyagisozi sectors where there are high malaria cases as the map shown in figure 2.

Data Sources and Data collection method.

The data needed for this work was collected through secondary data. Secondary data used for this was collected from Health Management Information System (HMIS) for malaria cases and administrative data for mining and irrigated area.

Data Analys

The analysis was carried out for all months of the year because there is no missing information. The provided summary for year is the seasonal malaria cases (SOND and MAMJ). Quantitative and qualitative data were analyzed using R, an open source programming language and software environment for statistical computing and graphics; and the Statistical Package for Social Science (SPSS). Time series analysis was used to check the non-stationary data. Multiple Regression model was used for testing relationship between variables (dependent and independent variables).

RESULTS AND INTERPRETATION

The first analysis used seasonal malaria cases summaries. The analyses were for two rains seasons, since the main rain seasons are from Mid-September to December and March to

May. The data was summarized to the total malaria cases for the rain season (September to December) and for the rain season (March to May). For March to May season, we added month of June due to that it is very important for the irrigation in marshlands.

To see the behavior of possible trends malaria cases, we first look at the seasonal malaria cases totals. The overall pattern from September to December season (SOND) is shown in Figure 5belowshowing that the highest malaria cases were 3571 recorded in 2015. The smallest was 352 malaria cases which occurred in 2012 in Busoro Sector. A positive slope was observed for the seasonal malaria cases total for September to December (SOND) of 955.2 per year. The R-squared was 0.315 with p-value equals 0.2465. This fitting model assessing the evidence for chance for malaria cases over years. The trend was not statistically significant at 5% level of significance. The correlation coefficient was 0.56 which shows a moderate correction between malaria cases and years.

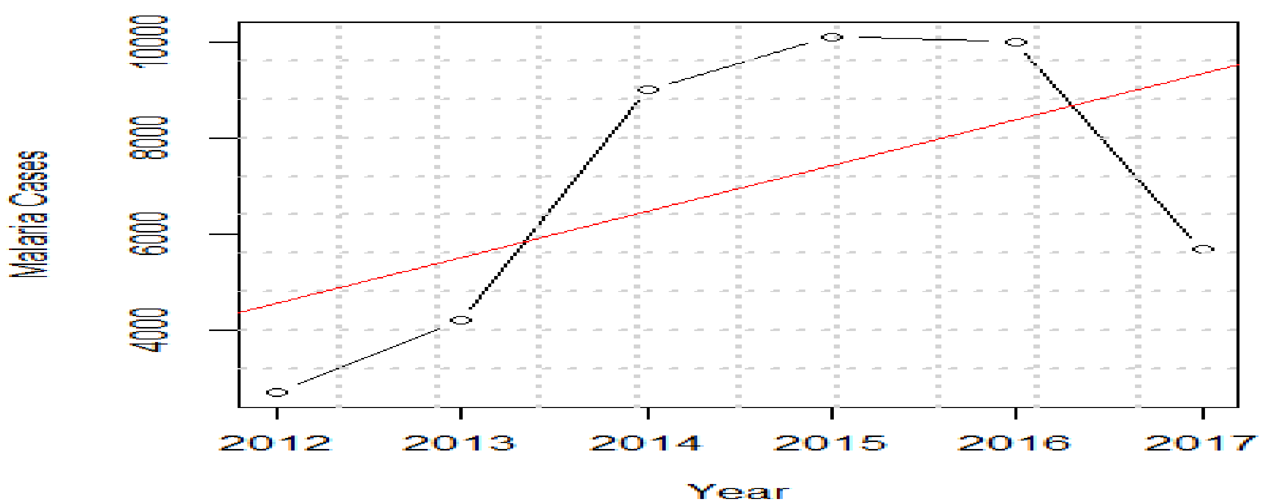

Fig.5 Seasonal Malaria Cases totals (September to December) for Nyanza District (2012-2017) in Busoro Sector

The overall pattern from September to December season (SOND) is shown in Figure 6 below, which shows that the highest malaria cases were 2015 recorded in 2016. The smallest was 27 malaria cases which occurred in 2012 in Nyagisozi Sector.

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A positive slope was observed for the seasonal malaria cases total for September to December (SOND) of 1177 per year. The R-squared was 0.6311 with p-value equals 0.059. This fitting model assessing the evidence for chance for malaria cases over years. The trend was not statistically significant at 5% level of significance. The correlation coefficient was 0.79 which shows a high correction between malaria cases and years.

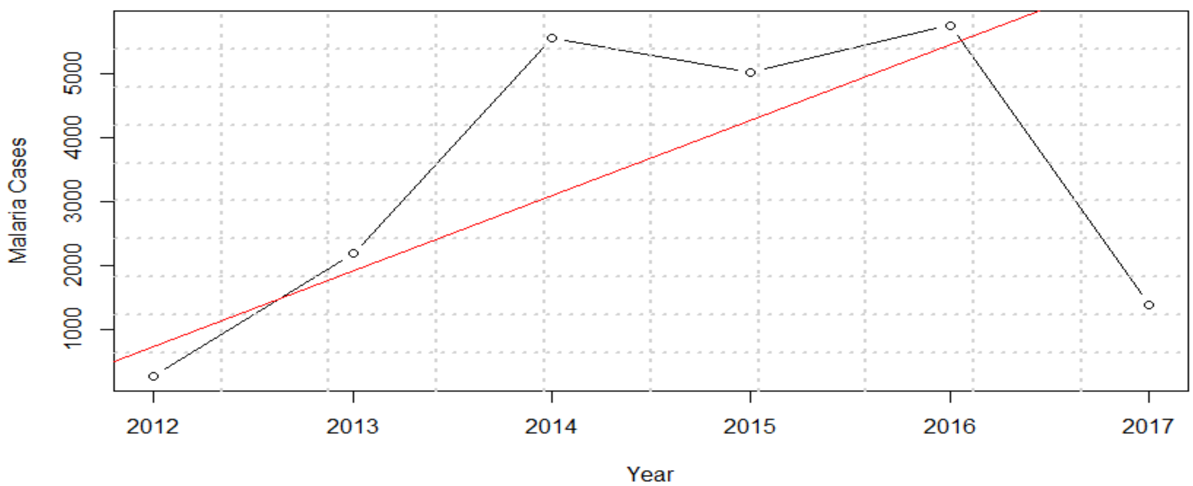

Fig.6 Seasonal Malaria Cases totals (September to December) for Nyanza District (2012-2017) in Nyagisozi Sector

To see whether there was an observed change during March to June malaria cases season (MAMJ), we first studied the seasonal totals. The overall pattern from March to June season (MAMJ) is shown in Figure 7. It shows that the highest malaria cases were 4351 recorded in 2015. The smallest was 238malaria cases which occurred in 2012 in Busoro Sector. A positive slope was observed for the seasonal malaria cases total for March to June season (MAMJ) of 1729.4per year. The R-squared was 0.4548 with p-value equals 0.1418. This fitting model assessing the evidence for chance for malaria cases over years. The trend was not statistically significant at 5% level of significance. The correlation coefficient was 0.67 which shows a moderate correction between malaria cases and years.

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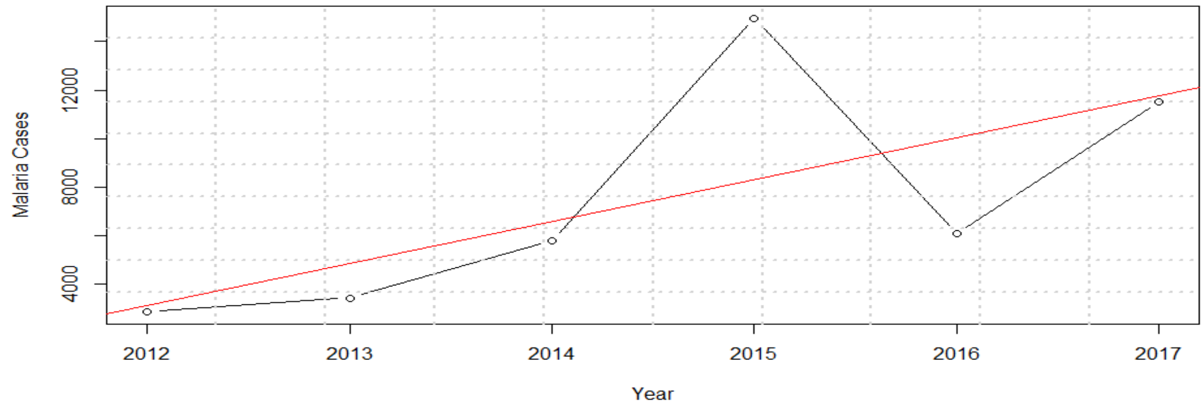

Fig.7 Seasonal Malaria Cases totals (March to June) for Nyanza District (2012-2017) in Busoro Sector.

The overall pattern from March to June season (MAMJ) is shown in Figure 8 below. It shows that the highest malaria cases were 2059 recorded in 2016. The smallest was 2malaria cases which occurred in 2012in Nyagisozi Sector. A positive slope was observed for the seasonal malaria cases total for March to June season (MAMJ) of 451.2per year. The R-squared was 0.1267 with p-value equals 0.4886. This fitting model assessing the evidence for chance for malaria cases over years. The trend was not statistically significant at 5% level of significance. The correlation coefficient was 0.7 which shows a high correction between malaria cases and years.

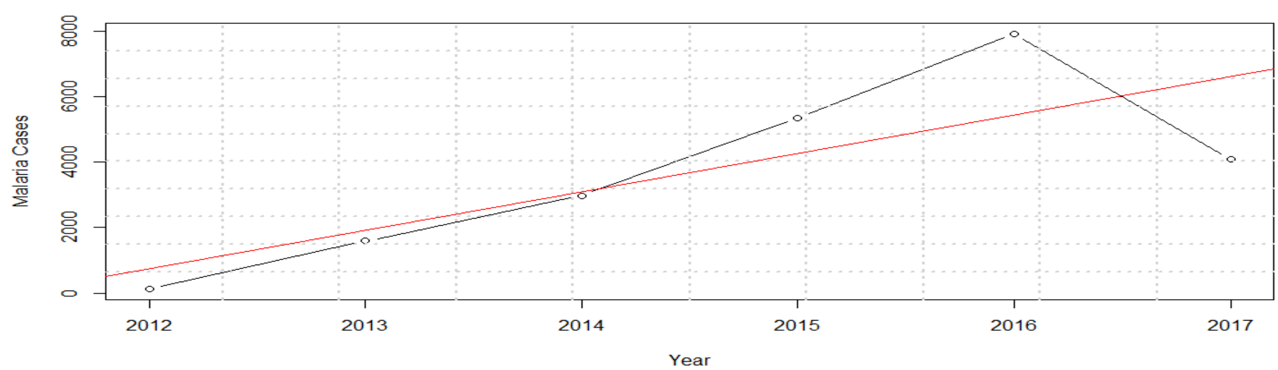

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Fig. 8 Seasonal Malaria Cases totals (March to June) for Nyanza District (2012-2017) in Nyagisozi Sector

A development and Water project activities like Dams (artificial lakes) in a given region are among risk factors comprise a number of components which affect transmission of malaria to susceptible population; putting them together influences mortality (condition of being mortal and of dying) and morbidity (quality of being sick or unhealthy), therefore burden of malaria. Figure 9 shows different levels of causality between water projects development in the region and malaria. Through creation of dams for various economic and agriculture developments, there is modification of atmospheric system and water flow for irrigation. This activity affect an increase of larval and adults mosquito. It will have a significant impact on increase of malaria vectors species and plasmodium which will results an increased anopheles density in the region. Without taking into account the strategy for fighting against malaria this is most likely to results a higher malaria transmission. Factors like local economy improvement, infrastructure, and health management behavior might bring negative impacts on the control of the disease. Hence, human behavior has important implication for personal protection and treatment seeking behavior.

Fig. 9 Causality between water projects development in the region and Malaria

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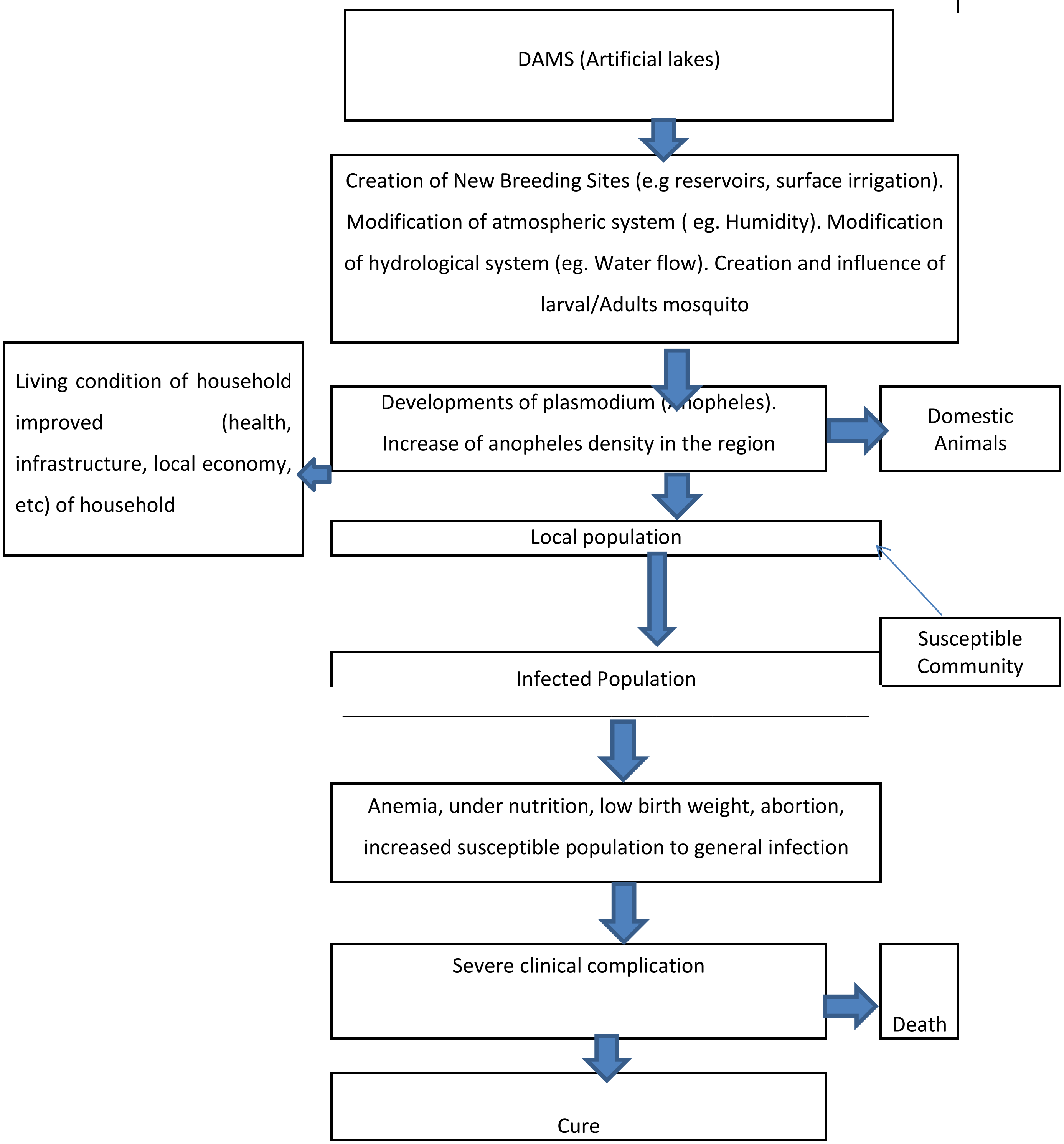

The Table 1 below shows a summarized study in Busoro Sector and Nyagisozi sector which are a stable malaria transmission region in the district among the people living close to irrigated project and mining areas. Briefly, the study shows that rice fields has high anopheles densities due to irrigation in marshlands having more malaria cases compared to the mining area. The dams have been introduced around 2013

with stable irrigation for rice fields cultivation which contributed to the increase of mosquito density in Busoro Sector. This is shown by comparing both 2012 and 2017 malaria cases percentage with population size of the sector from population census 2012. It also shows that malaria cases have been increasing in Nyagisozi sector after introduction of mine exploitation in 2014.

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Table 1: Effect of irrigations and mining on malaria cases in Nyanza District for sectors with high frequency of malaria transmission

Study Site	Population Sample	Irrigation Construction/Dams, Mine surface and Marshland	Overall Malaria Cases		
			Season	2012	2017
Busoro Sector	Population 34,037	Rice Fields	Cases in SOND season in percent	SEP (1.04%) and DEC (1.88%)	SEP (3.33%) and DEC (3.88%)
			Cases in MAM season in percent	MAR (0.70%) and MAY (2.90%)	MAR (10.5%) and MAY (10.3%)
Nyagisozi Sector	Population 25,939	Mine Surface	Cases in SOND season in percent	SEP (0.10%) and DEC (0.55%)	SEP (0.87%) and DEC (1.20%)
			Cases in MAM season in percent	MAR (0.007%) and MAY (0.23%)	MAR (4.52%) and MAY (4.82%)

Conclusion

In this study we focused on irrigation from dams and mine activities because there are among the main important factors which affects increase of anopheles mosquito hence transmission of malaria to susceptible population. We use malaria cases from Busoro and Nyagisozi sectors from Nyanza District to assess the existence of trends in the malaria cases data at Nyanza District due to land use change over the years and measure the impact of mine, irrigation from dams on malaria cases.

Monthly malaria cases data were averaged to form four months averages for the months of September to December corresponding to the short rainy season in Rwanda which create humidity in whole country. Since Rwanda counts two main rain seasons, we also averaged the monthly rainfall data for March to May season considered to be the main season. The study found that there has been an increase of malaria cases over years and became stable in these sectors after regular exploitation of mine and dams for irrigation. This study shows the impact of land use change on the spread of malaria and suggests that the effects of interventions should focus on irrigation areas (dams) like spray of chemical products to avoid multiplications of mosquito and mine exploitation, even further research with data for longer period.

Acknowledgment

We are very grateful to all authors of their works on malaria cases we have reviewed, among them the service of Health Management Information System (HMIS) and the District' administrative that provided secondary data on malaria cases from the study area.

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