I- Introduction:

Malaria is one of the world’s greatest health challenges, with 250 – 450 million clinical cases and around one million deaths per year. 90% of the cases occur in sub Saharan Africa (Greenwood and Mutabingwa, 2002). It is difficult to overstate the burden of a lethal disease that threatens over 1/3 of the world’s population (Trigg and Kondrachine, 1998) or the economic, political and social toll it takes on its poorest countries. The disease disproportionately affects pregnant women and children, who are most susceptible to its fatal effects (Roll Back Malaria Project, 2003). The disease is currently responsible for 23 – 37% of the total child mortality in Africa (Korenromp et al., 2003).

Different species of Anophelines mosquitoes can transmit malaria. In Sub-Africa, the major vectors are *Anopheles gambiae s.l.*: with four molecular forms (Bamako, Mopti, Savane and Arabiensis) and *Anopheles funestus* (Toure & al 1983)

Irrigation in Sub-Saharan Africa can be a mixed blessing. It contributes to greater food production; however, it may increase the incidence of diseases such as schistosomiasis and malaria (Service 1989; Dzodzomenyo et al. 1999; van der Hoek & 2004). Irrigation project lead to an increasing
mosquito density in the surrounding villages (occupied by the farmers) dominated by species able to transmit both malaria and lymphatic filariasis. Nonetheless, several investigators have reported malaria transmission to be the same, or even less, in irrigated areas with high vector densities than in nearby non-irrigated areas with lower numbers of mosquitoes: I. jumba and Lindsay 2001, Diuk Wasser et al. 2005.

In Mali, West Africa Dolo et al. (2004) found densities of *Anopheles gambiae Giles* in the irrigated region of Niono, in excess of 550 bites per person per night, compared with “only” 30-50 bites per person per night in nearby non-irrigated villages. At the same time, Sissoko et al. found that malaria parasites prevalence varied according to agricultural (34% in irrigated area versus 47% in non-irrigated area). They also have observed among children under 5 years old an incidence rate of .7 per 1000, per day in irrigated village (constant over the year) versus 3.2 per 1,000 per day during the rainy season in non-irrigated area (where the incidence get extremely low during the dry hot season). Similar patterns were observed within villages of the same zone. The scientific supports both authors advanced to explain this discrepancy according included:

1) The nuisance of so many mosquitoes in irrigated area might compel more people to use bed nets;
2) The greater prosperity of irrigated areas might permit access to better health care, protection, or both; or,

3) The mosquitoes that emerge from the high-density irrigated areas during the rainy season might be less efficient at transmitting malaria, e.g., if they do not survive as well

4) High density of Anophelines in larvae stages lead to small larvae size which reduces the adult body size and small adults do not survive well so they are less efficient to transmit malaria

Further field experiments showed a modest positive relationship between densities of immature and larval size and a strong relationship between larval and adult size. Adult survivorship was found to be higher in non-irrigated areas. However, there was no effect of size on survivorship between comparable samples, rejecting “The competition hypothesis” (Manoukis & al; 2005)

The exact mechanism of reduced transmission in Niono is not yet clear. Among several possibilities is the “bed net uses”, a test of which is the topic of this study done in summer 2007.

The hypothesis holds that the potential for negative health impacts of water projects must also be juxtaposed with the positive effect that dams and irrigation schemes contribute substantially to renewable energy production,
food security, and social and economic development. This, in turn, can provide rural households with greater capacity to purchase essential commodities, including drugs and insecticide-treated nets (ITNs), as well as improved access to health care services and education compare to the near non project area.

Several aspects of this hypothesis are supported by previous work in the irrigated zone as:

- Observed high density during the rainy season in irrigated area (density greater than 1,000 *Anophelines* per house)
- Decrease in both survivorship and anthropophagic (percentage feeding in human) rate during high density period
- Best accessibility to both season for villages in irrigated area than non-irrigated ones.

Reliable analyses of income related behavior to health are fundamental for the prevention and control of diseases, for evidence-based guidance of health policy and planning, and for intersectorial action for the reduction of transmission in developing countries.

This study present data from a rapid survey (cross sectional) for 2 irrigated villages and 2 non-irrigated villages in the Niono area. Descriptive analysis on the study population and deep analysis of income, education, bednet uses
and others socio-economical factors are presented.
II. GENERAL REVIEW:

Discovery:

The malaria parasite has probably afflicted humans since prehistoric times. This idea is suggested by fossilized mosquitoes displaying fossilized parasites dating to the Paleozoic period (Russell, 1952). Enlarged spleens from 3,000 years old Egyptian mummies (Sherman, 1998) also indicate the presence of malaria. Until about 1700 CE no treatment was known to Europeans, at least none that differed from the treatments for other maladies. With the importation of chiconia bark from the Andean rain forests of Peru in the 1640s (see Honigsbaum 2001 for an entertaining and complete account), European doctors had their first chemotherapy for malaria. The availability of what we now know as quinine enabled some, such as Torti in Italy, to differentiate differentiating fevers alleviated by chiconia from others that did not respond.

Differentiating malaria fevers from others enabled it to be named. In English, it became known as malaria after the Italian mal’aria (“bad air”) when Horace Walpole imported the name in 1740. He also referred to it as the “fever that comes to Rome every summer” (Russell, 1952), so that it was sometimes called the “Roman fever”. In any event, the name indicates that early medicine had little idea of what caused malaria or how it spread.
An important date for research on malaria vectors to control the disease is 20 August 1897. On that day Ronald Ross, who had been trying to find evidence of the parasite in mosquitoes mostly in Secunderabad, India, found pigmented cells on the outside of the stomach of a dissected specimen (probably *An. stephensii*). As he wrote to his mentor Patrick Manson in London on 22 August 1897: I am so familiar with the mosquito’s stomach that these bodies struck me at once; & you may imagine how much more struck I was when, on focusing carefully I found they contained pigment indistinguishable in color, shape etc from that of the *haemamoeba!*” (Bynum and Overy, 1998).

Ross was not the first to hypothesize that mosquitoes could transmit disease. Raimbert had showed that flies could disperse anthrax in 1869. Others had suspected mosquitoes specifically transmitted malaria. In 1854 Louis Baruperthuy, working in Caracas, Venezuela, had suggested that living germs in mosquitoes caused malaria. Alphonse Laveran identified and described *Plasmodium malariae* from human blood in 1880 while working in Algeria, and in 1884 Laveran also suggested that mosquitoes could actually transmit malaria (Harrison, 1978). They were among several others, but Manson especially mentored and encouraged Ross to pursue the
question, competing with Italian, German and American researchers (Bynum and Overy, 1998).

From Ross and Manson’s correspondence it is clear they knew little about the mosquito. They did not systematically distinguish the species being dissected, and so spent additional time surveying species that we now know cannot transmit malaria. In fact, Ross referred to “a grey one” (probably *Culex pipiens*) and a “brindled one” (probably *Aedes aegypti*). The one that eventually yielded the parasite was “a big brown fellow”. This illustrates how little was known and how little attention was given to the insect by those who were medical doctors.

The early focus by these men was entirely on the parasite. Occasionally this led to errors, such as those committed by Manson himself some 20 years earlier.

Manson had shown in 1877 that mosquitoes contained filariasis-causing worms from his work in China the previous decade or so. His lack of knowledge about the mosquito prevented him from understanding how transmission actually occurs. He did not know that the species he was studying could live more than very few days (they did not survive for long in his laboratory) or that they could have more than one feeding in their lifetimes. Manson was thus unable to follow the worm’s full development
to the mosquito’s proboscis, so the actual mode of transmission of filariasis was not correctly elucidated in his work (Harrison, 1978). In 1898 Grassi, Bignami and Bastianelli in Italy described the malaria cycle between humans and mosquitoes. About 50 years later the achievements from the end of the 19th century would spur researchers and governments to work on a vision of malaria eradication.

II-2 Malaria life cycle:

The malaria parasite life cycle involves two hosts. During a blood meal, a malaria-infected female Anopheles mosquito inoculates *sporozoites* into the human host [1].

*Sporozoites* infect liver cells [2] and mature into *schizonts* [3], which rupture and release *merozoites* [4]. (Of note, in *P. vivax* and *P. ovale* a dormant stage [*hypnozoites*] can persist in the liver and cause relapses by invading the bloodstream weeks, or even years later.)

After this initial replication in the liver (*exo-erythrocytic schizogony A*), the parasites undergo asexual multiplication in the erythrocytes (*erythrocytic schizogony B*). *Merozoites* infect red blood cells [5]. The ring stage trophozoites mature into *schizonts*, which rupture releasing *merozoites* [6]. Some parasites differentiate into sexual *erythrocytic stages*
(gametocytes) [7]. Blood stage parasites are responsible for the clinical manifestations of the disease.

The gametocytes, male (microgametocytes) and female (macrogametocytes), are ingested by an Anopheles mosquito during a blood meal [8]. The parasite’s multiplication in the mosquito is known as the sporogonic cycle C. While in the mosquito's stomach, the microgametes penetrate the macrogametes generating zygotes [9]. The zygotes in turn become motile and elongated (ookinetes) [10] which invade the midgut wall of the mosquito where they develop into oocysts [11]. The oocysts grow, rupture, and release sporozoites [12], which make their way to the mosquito's salivary glands. Inoculation of the sporozoites [1] into a new human host perpetuates the malaria life cycle.
**Figure 1:** Schema of the Life Cycle of Malaria. Source: www.cdc.gov
II-3 Eradication

The first efforts to reduce or eliminate malaria were those of the Ancient Greeks and Romans, who “improved” swamps and water drainage; they knew these to be associated with disease (Russell, 1952). After the discovery of the parasite and its mode of transmission, efforts focused on eliminating mosquito larvae to eliminate transmission. In 1899 Ross led anti-larval measures in Sierra Leone. Another effort that year in Cuba by William C. Gorgas, a U.S. army major, was highly successful. It was to become a template for later efforts, such as subsequent programs in Malaya led by Watson and in Egypt by Ross (1901 – 1904) (Gilles and Warrell, 1993).

The most famous project to follow the Cuban mold was the eradication effort in the Panama Canal Zone. Gorgas himself led that effort while the United States government built the canal. Without this, construction of the canal would likely not have been completed at that time; indeed, an earlier French effort was abandoned in 1893 after thirteen years of work due to the high number of fatalities (suggested to be around 22,000), many of them from malaria. Despite controversy and political opposition Gorgas strictly enforced a costly vector elimination program resulting in elimination of Yellow Fever and massive reduction in malaria within the Canal Zone.
During the decade of its construction it has been estimated that about 2% of the US workforce was hospitalized at any given time. The figure for the earlier French construction was about 30% (Spielman and D’Antonio, 2001).

The next two and a half decades brought possibly the most impressive instance of vector elimination. The 1939 – 1940 campaign, which eliminated an invasive population of Anopheles gambiae from North Eastern Brazil, led by Fred Soper (Killeen et al., 2002; Coura et al., 2006) marks a turning point in how governments confronted malaria and its vectors. The United States government and the Rockefeller Foundation for which Soper worked were convinced that An. gambiae could spread north and eventually threaten the U.S. with renewed malaria transmission. Soper advocated complete vector extirpation to eliminate malaria, and convinced the Brazilian government of President Getulio Vargas that the region could be made malaria free, as he argued it was before, by getting rid of the foreign mosquito (Soper and Wilson, 1943). Others, such as Evandro Chagas, argued that improving the living conditions of the people in the region and treating them with quinine was a better course of action in battling the parasite. (Valentine, 2005). Soper won the day and permission to conduct a military-
style operation treating breeding sites with Paris Green, a larvicide, and attacking adults with pyrethrum sprays (Harrison, 1978). In 1940 the area was declared free of *An. gambiae*, but interestingly it was not free of malaria. The area had not been completely malaria free before the introduction of *Anopheles gambiae*, so the outbreak of the disease just before 1939 may have been worsened by that species, but the parasite was able to sustain itself through other, native, species for years before and after-words. The heyday of malaria eradication programs probably started in 1943. At that time serious attempts were undertaken to eliminate malaria from the United States (Oaks and Mitchell, 1991), and there was a blossoming of research on malaria vectors around the world (e.g., MacDonald 1946). This was spurred by the serious problem malaria presented to troops fighting in World War II, and continuing for U.S. armed forces in Korea and Vietnam. Thus the U.S. military funded significant numbers of entomological studies from that point to the present day.

In general the resources and effort in these programs was directed to massive spraying rather than in-depth medical entomology. However even this focus of vector eradication programs was based on some new understanding of the vector. The shift to adult mosquitoes from larvae was precipitated by MacDonald’s classic model that showed that killing adult
mosquitoes was a more efficient way to reduce transmission potential (MacDonald, 1957). During the Eight World Health Assembly in 1955 (WHO, 1955) a plan for worldwide malaria eradication was presented, largely relying on residual spraying of dichlorodiphenyltrichloroethane (DDT). This compound’s insecticidal properties were excellent, described in 1939 by a Swiss chemist named Paul M Muller. However, the problem of insect resistance was known from the start (WHO, 1955), based on the results of an eradication program conducted in Greece after World War II. In those years An. sacharovi became resistant to DDT and by 1956 resistance was found in both adults and larvae to chloroquine and dieldrin, completely different insecticidal compounds (Harrison, 1978). So the time frame for eradication was purposely made as short as possible (under a decade).

Sub-Saharan Africa was excluded from the WHO effort of 1955, though many individual projects were launched there over the next decade. While the eradication campaign generated successes in North America and Europe, it achieved only temporary or little reduction of malaria in the rest of the world for technical, social, economic and political reasons (Oaks and Mitchell, 1991). By 1969 the goal of eradication for the remaining malarious regions of the world was replaced with control (WHO, 1969).
II-4 Control

The mainstream eradication efforts of the 1950’s and 1960’s did not include sub-Saharan Africa for two reasons: First, the problem there was thought to be too severe and local capacity was judged to be lacking for implementation of an eradication program. Second, there was the view that young African children in particular should not be treated for their first infection of malaria to allow immunity to develop, advanced by some malariologists in the mid 1930s. Indeed a group of experts at the 1950 WHO meeting argued for drug therapy as a main weapon rather than vector control in Africa for fear that weakening adult immunity could lead to devastating epidemics (Harrison, 1978). Areas of holoendemic (stable) malaria transmission were thought best left alone. For these regions, and soon for all remaining areas with endemic malaria, control was judged to be a more reasonable objective.

Control is defined as “Reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level as a result of deliberate efforts” (Molyneux et al., 2004). It is worth noting that this is a significant philosophical shift from the optimistic idea that the transmission cycle can be interrupted and the disease eliminated completely from an area (Najera, 1989), epitomized by such book titles as “Man’s mastery of malaria”
(Russell, 1955). Despite Africa’s being treated separately from the major eradication efforts of the mid 20th century, there were about 20 pilot projects carried out there during the eradication efforts by national governments and the WHO. These often ended with poor results, partially because they did not include careful measurement of epidemiological parameters or of the entomological details within the areas where programs were being carried out (Molineaux and Gramiccia, 1980).

Due to these failures and the rise of resistance to insecticides in the mosquitoes and drug-resistant Plasmodium, much of the optimism of the previous years was lost after 1970 (Trigg and Kondrachine, 1998) and until quite recently as discussed below. There were some bright spots, however. One of the most important was the so-called “Garki Project” a joint WHO/Government of Nigeria initiative that ran from 1969 – 1976 (Molineaux and Gramiccia, 1980). Though it ran at a significant cost at the time, the Garki project addressed all aspects of the malaria cycle in one location for an extended period of time. Workers collected extensive baseline data pre-intervention, tested an intervention based on residual spraying and mass drug administration, and created a mathematical model of malaria transmission to be parameterized by and inform their field data. The Garki project was so carefully directed and thoroughly funded because
plans to control malaria tend to be more complex than those to eliminate it. This work gave enhanced prominence to modeling efforts, which continues to this day.

In the Garki project there was a heavy focus on entomological work and measurement, including parameters such as vectorial capacity (C) used to inform the model. It was not the first attempt to use entomological knowledge to understand the effect of interventions with mathematical models. Ross pioneered this approach in 1911 (Ross 1911; see Fine 1975). Most of the models developed since then are systems of differential equations, typically based on “compartments,” where individuals in a population are divided into classes (“susceptible” or “infected” for example). A compartment approach is the basis for the classic MacDonald (1957) extension of the Ross archetype, which showed that reducing the life span of the adult mosquito vector was an efficient way to drop transmission below the minimum threshold that permits the parasite to remain endemic. The model created as a result of the Garki project also followed a compartment approach, but was very detailed: it included seven rather than the usual three human categories. The high degree of detail enabled the study of immunity and super infection, outstanding questions for many years (Macdonald, 1965). The Garki project was one of several advances in
modeling of the era, centered around a dynamical approach, allowing a wider view of the population biology of disease agents (Anderson and May, 1979).

Despite the dispiriting collapse of eradication efforts, optimism seems to be returning to the malaria and Anopheles research communities. Major causes for enthusiasm are recent efforts aimed at vaccine development. Another idea that has done much to revive interest in Anopheles entomology particularly is the possibility of controlling the disease through the introduction of a genetically modified vector, first proposed in the 1980’s (Aultman et al., 2001).

Today several labs are working intensely on developing the genes and approaches that might be used under such a control program, buoyed by the recent investment from the public and private sectors. The work in this dissertation shows that, just as in the past, details of vector biology are of critical importance to control.

II-5 Profile of poverty in Mali:

In 2002, the final PRSP (Poverty Reduction Strategy Paper) published by the government of Mali Republic derived the measurement of poverty of living conditions from the basis of a poverty index Is calculated for each locality.
This index varies from 0 points for the poorest locality to 20 points for the least poor locality by setting the line for poverty and extreme poverty, respectively, at ten (10) and five (5) points for the Is.

In Mali, poverty affects nearly two thirds (63.8%) of the total population, and nearly a third lives in extreme poverty. The extent of poverty, measured here as the investment effort needed by poor localities to obtain an Is equal to the poverty line of 10 points, is assessed at 42.3%.

The breadth of poverty varies according to the area (urban, rural), the sector of activity (primary, secondary or tertiary), age and gender. In fact, 88% of the poor population is based in rural areas and poverty affects many more women than it does men. The incidence of poverty is 75.9% in rural areas compared with 30.1% in urban areas. Furthermore, double the investment effort is needed in the social sectors in rural areas (where depth of poverty is 45.8%) in order to bring poor localities up to the poverty line, compared with urban areas where the depth of poverty is 22.3%. The vast majority of the poor work in the primary sector, which accounts for nearly 90% of jobs held by the poor. Actually, the poverty of localities is not always explained by the absence of essential socio-economic infrastructure in the immediate vicinity. In fact, a fair amount of socio-economic infrastructure exists but is not functional.

The Ségou region (which has Niono as one of its six districts) has a poverty incidence of 68.2%, or more than two-thirds of the population. Among the poor, nearly 40% are completely destitute. The rates of formal education
and literacy are still low. The health status of the population remains among the worst in the country in terms of the indicators used. Infant mortality there is very high. Employment and under-employment rates are close to the national averages.

The region continues to struggle with inadequate basic infrastructure (schools, health centers, telecommunications, transport), difficulties of access to bank lending and to land, the disorganization of producers, and high levels of illness (STDs, AIDS). The region has enormous potential: water and land resources, hydro-agricultural developments, and industrial units. The strategy for fighting poverty must focus on exploiting the rice sector, intensifying vegetable cultivation (shallots, chilies, tomatoes, watermelons), promoting the sale and processing of local products (kenaf, shea nut, jujube, calabash, nere, tamarind, cotton, cattle), and the granting of credit.
III OBJECTIVES

General objective

Assessing the difference in socio economical status and bed nets uses for malaria control among 2 irrigated and 2 non-irrigated villages in the Niono area.

Specific objectives:

- Assess difference in socio economic status among household between irrigated and non-irrigated area as it affects malaria

- Determine prevalence of malaria among children under 5 years old per zone

- Determine the proportion of household using simple bed nets and/or Insecticides Treated Nets to prevent malaria in susceptible population.

- Determine the correlation between so-economics status, bednets uses and malaria prevalence among household in each area.

- Assess the malaria vector density in irrigated and non-irrigated area using the indoor spray catch technique.
**IV Methods:**

**IV-1 Study area: Niono**

The district of Niono is located in the Sahelian area of Mali, 350 km north of Bamako near the town of Segou. It is accessible year round via a newly paved road from Markala. Three distinct climatic seasons can be distinguished: a wet season of about three months (July to September), a cold dry season (October to February), and a hot dry season (March to June). Overall there are about 400 mm of annual precipitation. Various villages were included in the studies: 2 irrigated villages and 2 no-irrigated ones (exact locations are given in Table 1.1). The Niono irrigation project was established in 1932. Since that time the population of the irrigated area has increased to 150,000 people mostly of the Miniaka, Bambara, Peulh, Bela and Bozo ethnic groups. Large majorities in Niono are Muslim. The main irrigated crop grown in the region is rice, though there is also some vegetable cultivation, livestock such as cattle and goats, and fishing.

The area outside the irrigation project is less densely populated with Bambara, Fulani (Peulh), Maure and Sarakole peoples. There are millet and
sorghum cultivation and come cattle, mostly raised by the Fulani.

The gravity-irrigation system is fed by the Niger River at the Markala Dam and managed by the Office du Niger. Originally the project was intended to produce rice and cotton for the whole of West Africa, but cotton cultivation is no longer practiced due to pest problems and rising water table levels (Dolo et al., 2004). Rehabilitation and improvement projects were initiated in the 1980s and are ongoing. Since a 1990 deregulation, double cropping and the introduction of privately owned husking machines has increased productivity per hectare. The pattern of irrigation and rice cultivation is in step with the seasons. In general, flooding for irrigation begins in June/July and the rice is harvested in October/November. There is variation in the precise rice cultivation schedule between fields because cropping cycles are constrained by the water distribution scheme (Klinkenberg et al., 2003). Most fields are cultivated one time per year but some farmers are able to grow a second crop (double cropping) between January and May.

The large irrigated riziculture area in Niono (Figure 1.3) means that breeding sites are available for Anophelines year round (Klinkenberg et al., 2003; Dolo et al., 2004). However, not all stages of rice growth produce mosquitoes equally. The peak production of Anophelines occurs in August/September, when the rice has been transplanted, but is not yet dense
enough to shade the water. The peak in malaria transmission typically occurs shortly after the peak mosquito production, and is low when the fields are fallow during January to June. In some of the irrigated areas, and in some years, a second rice crop is also grown, beginning in March, and harvested in June. In such areas there are *Anopheles* and malaria transmission through much of the year, with less marked seasonality (Dolo et al., 2004).

**Table 1: Presentation of village surveyed**

<table>
<thead>
<tr>
<th>Villages</th>
<th>Type</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niessoumana</td>
<td>Irrigated</td>
<td>-5.965029</td>
<td>14.327370</td>
</tr>
<tr>
<td>Tissana</td>
<td>Irrigated</td>
<td>-5.913179</td>
<td>14.361729</td>
</tr>
<tr>
<td>Dogobougou</td>
<td>Non-irrigated</td>
<td>-6.131009</td>
<td>14.159499</td>
</tr>
<tr>
<td>Toumakoro</td>
<td>Non-irrigated</td>
<td>-6.182710</td>
<td>14.060489</td>
</tr>
</tbody>
</table>

**IV-2 Data collection:**

This is a cross sectional study. Parasitemia among children between 0 and 5 years old was estimated since this range is expected to be the most vulnerable in the endemic setting. The survey was carry out in late August when the prevalence of malaria is usually higher in Niono area. For each village after a general census of all households, each household with at least a child under 5 years old was selected. Household chief and women in
charge of the children were invited two respond to appropriate survey questionnaire (see Appendix 1 & 2). Any children reported to have fever the day of the survey or within the last two weeks were invited to give a few blood drop. Children were identified by gender and age. The blood smear were stored in WHO collection boxes and stained with Giemsa 3% for 45mn, 24 hours after collection and read with occular10, objective 100 to estimate number of parasites per 300 leukocytes. Once in the main laboratory at Malaria Research and Training Center in Bamako, 10% of the blood smears were selected to check for accuracy.

We used for the survey the WHO standard tools for Malaria Indicators Survey (MIS): Household men and women questionnaires. 

http://www.rollbackmalaria.org/partenership/wg/wg_monitoring/surveytaskforce.htm

At the same time, a team of two entomologist collected malaria vectors to assess vector density and survivorship per village using two different methods:

- **An indoor collection by spraying insecticide in the sleeping room of each child selected in the study.** *Anophelines* mosquitoes will be identify, classify by abdominal status (unfed, blood fed, half gravid and gravid), count and process. Mosquitoes will be store in labeled vials with Carnoy’s fixative.
The blood fed and half gravid mosquitoes will be analyzed by ELISA technique to identify the origin of the blood.

- A human landing catch or night catch will be perform in each village from 6:00pm to 6:00 am, inside and outside of human dwellings at two different place in the same night. The day after, mosquitoes will be identify, count and dissect to determine the parity using Detinova’s method. This method is used to estimate the survivorship of malaria vector (Detinova. 1962).

If Hypothesis 1 and 2 are true, we expect

- The living stand, population behaviors in term of self-protection against malaria to be significantly different between the irrigated area and non irrigated of Niono

- A negative correlation between use of bed nets, vectors density and the number of infected children (under 5 years old)

- A negative correlation between vectors density, and vectors survivorship.

- A homogenous distribution of malaria case and vector density within villages of same area but different between the 2 zones.

**IV-3 Data Analysis:**

Data were stored in Excel and Analyzed in Stata 9.0. We performed
descriptive analysis for demographic and household characteristics variations. Information on the ownership of household assets and annual per capita value of food were used to develop a socioeconomic status (SES) index that was used to determine the effects of socioeconomic status on the outcome variables of interest. The assets were ownership of land, house, motorcycle, car, refrigerator, television set, radio, electricity generator, cows and goats. Annual per capita food was also included as a proxy variable of household because food consumes more than 50% of household income. We also present data on malaria vectors density and the parity rate of Anopheles gambiae s.l the main vector for each village.

Simple regression was used to show the correlation between ownership of ITNs, household socio economics status, and malaria prevalence among children under 5 years old. We also performed a logistic regression to determine the odd for a household owning at least one ITNs to the socio-economics status, the presence of at least one child with a positive parasitemia, household more likely to purchase pre-treated bed nets and the mean person per household.
V- RESULTS
V-1 Household’s characteristics and demography:

*Table 2:* Descriptive statistics of household characteristics per zone.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Irrigated zone N=159 (55.59%)</th>
<th>Non-irrigated zone N=123 (44.41%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD) 95% CI</td>
<td>Mean (SD) 95% CI</td>
</tr>
<tr>
<td><strong>Household characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HH inhabitants</td>
<td>8.22(4.59) 7.5 - 8.94</td>
<td>8.55(6.38) 7.4 - 9.7</td>
</tr>
<tr>
<td>Room per HH</td>
<td>2.98(.13) 2.7 - 3.25</td>
<td>2.52(.16) 2.13 - 2.86</td>
</tr>
<tr>
<td>Children &lt;5 y. old / HH</td>
<td>2.05(.09) 1.86 - 2.23</td>
<td>2.37(.12) 2.13 - 2.62</td>
</tr>
<tr>
<td>Children reported sick per HH</td>
<td>1.11(.08) .95 - 1.27</td>
<td>1.58(.1) 1.37 - 1.79</td>
</tr>
<tr>
<td><strong>HH. Chiefs (men)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>40.01(.85) 38.3 - 41.67</td>
<td>43.96(1.04) 40.9 - 45.02</td>
</tr>
<tr>
<td>Years in school</td>
<td>2.13(.31) 1.5 - 2.76</td>
<td>.61(.25) .11 - 1.11</td>
</tr>
<tr>
<td>Wife per men</td>
<td>1.5(.04) 1.4 - 1.6</td>
<td>1.41(.04) 1.33 - 1.5</td>
</tr>
<tr>
<td><strong>Household Women</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>20.03(1.01) 18.02-22.04</td>
<td>20.66(.84) 22.31 - 22.31</td>
</tr>
<tr>
<td>Years in school</td>
<td>.52(.13) .24 - .80</td>
<td>.08(.04) .16 - .16</td>
</tr>
<tr>
<td>Children selected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>2.09(.1) 1.9 - 2.3</td>
<td>2.01(.1) 1.8 - 2.2</td>
</tr>
</tbody>
</table>
The main characteristics of the 249 household enrolled (132 in the irrigated zone and 117 in the non-irrigated zone) are presented by zone in table 1. Of these the average number of people per household was 8.22 (7.5 – 8.9) in irrigated area versus 8.6 (7.4-9.7) in the non-irrigated area. The mean number of room was 3 I in the irrigated villages and 2.5 for the non-irrigated ones. The number of children per household under age 5 years old was a slightly higher in the non-irrigated area 2.4 (2.1-2.9) compare to the irrigated ones 2.05 (1.9 – 2.2). According to the chief of the households, in average 1 kid per household had have fever within the last 2 weeks) in the irrigated area versus 1.6 in the non-irrigated one.

The mean age of the household chief was 40 years old in irrigated area (95%CI = 38 – 41.7) and 44 years in the non-irrigated zone (95%CI = 41 – 45). A household chief in the irrigated spent an average 2.13 years at school compare to 1 year in the non-irrigated area I. The average spouse per men in the non-irrigated area was 1.4 versus 1.5 in irrigated area. Women married ages varied from 20 years old (irrigated area) to 20.7 years in the non-irrigated one. Women in both areas spend in average less than 1 year at school.

The mean age of children participating to the study was 2.1 in irrigated area and 2 in non-irrigated area.
Graph 1: Household chief distribution by age group and by zone.

In irrigated villages 40% of the household chiefs were between 30-39 years old and 30% between 40-49 years old, only 5% were 60 and over while in
the non-irrigated ones, 33% were between 40-49 years old and 25% between 30-39 years old, 12% were 60 and over.

Graph2: Number of wife per household chief per zone

In the irrigated area 36% of the men has 2 wives versus 37% in non-irrigated villages and 7% got 3 wives 1% had 3. Few household chief in the non-irrigated zone (1%) got 4 wives.
Graph 3: Proportion of children under 5 years old per household per zone
In both zones, 90% of households count 1 to 4 children under the age. In the non-irrigated zone 3% of them had 5 to 6 children under 5 years old versus 1% in the irrigated zone. 1% household in the non-irrigated area had 7 to 9 children less than 5 years old.

Graph4: Household’s socio economic status distribution per zone
The socio economic status of household was significantly different between the 2 zones (X²= 37.8; p=.000). In the irrigated area, 36.36% of the households were bellowing the median compare to 75.21% in the non-irrigated zone.

**Graph 5:** Distribution of children with fever by gender by zone
The number of female was significantly higher than male in both zones with a ratio of 1.13 in irrigated and 1.18 in the non-irrigated zone.

*Graph 6: Distribution by age group by zone of mothers of children with fever*
36% of mothers or women in charge of selected children were between 15 and 19 years old in the irrigated area and 34% between 20 and 29 years old. In the non-irrigated 32% of mothers were between 15 and 19 years old and 38% between 20 and 29 years old. About 23% of them were between age 30 and 39 in irrigated area versus 21% in non-irrigated are.

Graph7: By zone distribution of spouses position in marriage

Approximately 82% of mothers who participated were first spouse in both areas of whom respectively 19% in irrigated villages and 18% in non-irrigated villages were second spouse and 1% was 3rd spouse.
Graph8: proportion of mothers by having an economic activity by zone
Women in irrigated villages were more active in terms of activity that can improve household’s incomes than their counterparts in the non-irrigated zones. Around 80% of women in the irrigated area reported having an economical activity in general kitchen garden versus 61% in the non-irrigated area.

V-2 Bed nets:

**Table 3. Ownership of mosquito nets:** Percentage of households with at least one and more than one mosquito net (treated or untreated), ever-treated and insecticide treated net and average number of each type per household, by age and zone

<table>
<thead>
<tr>
<th>background characteristics</th>
<th>Percentage of household that have at least one net</th>
<th>Average number of nets per household</th>
<th>Percentage of household that have at least one ever treated net</th>
<th>Average number of ever-treated net per household</th>
<th>Percentage of household that have at least one ITNs¹</th>
<th>Average number of ITNs¹ per household</th>
<th>Number of households</th>
</tr>
</thead>
<tbody>
<tr>
<td>gated</td>
<td>99</td>
<td>4.2</td>
<td>79.0</td>
<td>2.7</td>
<td>37.6</td>
<td>1.1</td>
<td>4²</td>
</tr>
<tr>
<td>ana</td>
<td>98</td>
<td>4.6</td>
<td>74.5</td>
<td>2.6</td>
<td>36.2</td>
<td>1.1</td>
<td>4²</td>
</tr>
<tr>
<td>soumana</td>
<td>98</td>
<td>4.6</td>
<td>74.5</td>
<td>2.6</td>
<td>36.2</td>
<td>1.1</td>
<td>4²</td>
</tr>
<tr>
<td>non-irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>obougou</td>
<td>81</td>
<td>2.3</td>
<td>34.5</td>
<td>1.5</td>
<td>16.4</td>
<td>0.6</td>
<td>5²</td>
</tr>
<tr>
<td>makoro</td>
<td>98</td>
<td>4.7</td>
<td>77.0</td>
<td>3.0</td>
<td>22.6</td>
<td>0.8</td>
<td>6²</td>
</tr>
</tbody>
</table>

¹ An ITN is 1) A factory-treated net that does not require any further treatment, 2) A pretreated net obtain within the past 12 months, 3) A net that has been soaked with insecticide within the past 12 months.
The proportion of households with at least one bed net was very close for both areas, approximately 98-99% (except Dogobougou where only 81% of households had at least one bed net). The average number of persons using a bed net varied from 2.3 to 4.7 in the non-irrigated area and from 4.2 to 4.6 in the irrigated area. The proportion of households that had at least one ever-treated bed net was very low in Dogobougou (34.5%) but closer in the other villages (around 75%).

Around 36% of households in the irrigated area have at least one ITNs compared to 18.5% in the non-irrigated one. The average number of ITNs per household was more than 1 in the irrigated villages but less than 1 in the non-irrigated villages.
V-3 Prevalence of malaria and case management

Table 4. Prevalence and prompt treatment of fever: Percentage of children under five years of age with fever in the two weeks preceding the survey, and among those children who took antimalarial drugs, who took the drugs the same/next day after developing the fever, and who sought treatment from health facility, by village and zone

<table>
<thead>
<tr>
<th>Background characteristics</th>
<th>Percentage of children with fever the last 2 weeks</th>
<th>Percentage who took anti-malarial drugs</th>
<th>Percentage who took anti-malarial drugs same/next day</th>
<th>Percentage who sought treatment from health facility</th>
<th>Number of children with fever</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissana</td>
<td>51.9</td>
<td>93.2</td>
<td>74.9</td>
<td>23.6</td>
<td>106</td>
</tr>
<tr>
<td>Niesoumana</td>
<td>58.2</td>
<td>89.0</td>
<td>67.6</td>
<td>25.4</td>
<td>71</td>
</tr>
<tr>
<td>Non-irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogobougou</td>
<td>62.9</td>
<td>67.3</td>
<td>56.5</td>
<td>18.8</td>
<td>85</td>
</tr>
<tr>
<td>Toumakoro</td>
<td>70.7</td>
<td>74.7</td>
<td>60.2</td>
<td>16.9</td>
<td>118</td>
</tr>
</tbody>
</table>

A total of 177 children under age 5 years old (more than 55%) in irrigated area have had fever within the last 2 weeks compare to 203 (68%) in the non-irrigated villages. Among those who had fever, 90% of them in the
irrigated village have had antimalarial drugs (about 70% the same or next day when fever occurs). In non-irrigated villages, 70% have had antimalarial drug and less than 60% took anti-malarial drug the same or next day when fever appears. Around 24% of those children sought treatment from health facility in irrigated villages compare to 18% in the non-irrigated village.

Table 5: Source of antimalarial drugs: Percentage distribution of source of the drugs by village and zone

<table>
<thead>
<tr>
<th>Background characteristics</th>
<th>Already had drug at home</th>
<th>Community health center</th>
<th>District health center</th>
<th>Shop</th>
<th>Number of children who took drug</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irrigated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissana</td>
<td>0</td>
<td>61.0</td>
<td>1.0</td>
<td>38.0</td>
<td>100</td>
</tr>
<tr>
<td>Niesoumana</td>
<td>0</td>
<td>61.1</td>
<td>0.0</td>
<td>38.9</td>
<td>59</td>
</tr>
<tr>
<td><strong>Non-irrigated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogobougou</td>
<td>0</td>
<td>75.4</td>
<td>0.0</td>
<td>24.6</td>
<td>65</td>
</tr>
<tr>
<td>Toumakoro</td>
<td>0</td>
<td>80.7</td>
<td>0.0</td>
<td>19.3</td>
<td>62</td>
</tr>
</tbody>
</table>

In both areas, none of the household (0%) has antimalarial drugs at home. Nonetheless, the source of the drugs varied between zones.

In irrigated area, about 60% reported purchasing antimalarial drugs at the community health center, 1% at the district health center and 38% in the stores.
In non-irrigated more than 75% of household purchased the drugs at the community health center versus 24% at the local stores.

Table 6. Use of mosquito nets by children: Percentage of children under five years of age who slept under a mosquito net (treated or untreated), an ever-treated mosquito net, and an insecticide-treated net (ITN) the night before the survey, by village and zone

<table>
<thead>
<tr>
<th>Background characteristics</th>
<th>Percentage of children &lt;5 yrs who slept under a net last night</th>
<th>Percentage of children &lt;5 yrs who slept under an ever-treated net last night</th>
<th>Percentage of children &lt;5 yrs who slept under an ITN last night</th>
<th>Number of children under age 5yrs old</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irrigated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissana</td>
<td>98.2</td>
<td>52.5</td>
<td>22.7</td>
<td>204</td>
</tr>
<tr>
<td>Niesoumana</td>
<td>97.8</td>
<td>37.8</td>
<td>15.3</td>
<td>122</td>
</tr>
<tr>
<td><strong>Non-irrigated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogobougu</td>
<td>52.6</td>
<td>12.9</td>
<td>5.9</td>
<td>135</td>
</tr>
<tr>
<td>Toumakoro</td>
<td>77.8</td>
<td>28.3</td>
<td>9.7</td>
<td>167</td>
</tr>
</tbody>
</table>

In the irrigated area, around 98% of children under five years old slept under a net the night before the survey compare to 53% in Dogobougu and 78% in Toumakoro (non-irrigated villages). Among those whom slept under a net, an average 45% in irrigated area used an ever-treated net while less
than 20% of them were effective ITNs. In the non-irrigated zone, 20% of these children slept under an ever-treated net and nearly 8% were ITNs.

**Table 7. Parasitemia among children under 5:** Percentage distribution of blood smear positive of *plasmodium falciparum* by village and zone

<table>
<thead>
<tr>
<th>Background characteristics</th>
<th>Number of children</th>
<th>Percentage of positive</th>
<th>Number with gametocytes</th>
<th>Number with trophocyte</th>
<th>Mean trophocyte per 300 microl</th>
<th>Mean gametocyte per 3000 microl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissana</td>
<td>90</td>
<td>16.67</td>
<td>0</td>
<td>90</td>
<td>78.3(548.50)</td>
<td></td>
</tr>
<tr>
<td>Niesoumana</td>
<td>65</td>
<td>18.46</td>
<td>1</td>
<td>64</td>
<td>423(2661.6)</td>
<td>1.5(</td>
</tr>
<tr>
<td>Non-irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogobougou</td>
<td>78</td>
<td>50</td>
<td>0</td>
<td>78</td>
<td>3081.6(9600)</td>
<td></td>
</tr>
<tr>
<td>Toumakoro</td>
<td>115</td>
<td>31.3</td>
<td>2</td>
<td>113</td>
<td>8477(25783.7)</td>
<td>1.6(</td>
</tr>
</tbody>
</table>

For the irrigated villages, of the 155 children under 5 years old for which blood smear results were available 17.6% were parasitemic versus 40.65% in the non-irrigated area. Distribution of the presence of either gametocyte of trophocyte by villages is presented in table 6. A few proportion of children had gametocytes in Niessouma (3.1%) and Toumakoro (2.6%). The mean trophocyte count per 300 micro liters was very high for the non-
irrigated villages: 8,477 for Toumakoro and 3,081 for Dogobougou. There was no difference between the mean gametocyte per 3,000 micro liters between the 2 areas.

**V-4 Simple linear regression**

**Table 8: Association of owning ITNs, socio economic status and malaria prevalence**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Has at least one ITN</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Socio economic status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than the median</td>
<td>21.32</td>
<td></td>
</tr>
<tr>
<td>High than the median</td>
<td>38.05</td>
<td>p=.004</td>
</tr>
<tr>
<td><strong>At least one parasitemic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>15.28</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>29.94</td>
<td>p=.016</td>
</tr>
<tr>
<td><strong>Proportion of parasitemic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>86.11</td>
<td></td>
</tr>
<tr>
<td>.1%-.25%</td>
<td>1.39</td>
<td></td>
</tr>
<tr>
<td>.30%-.50%</td>
<td>5.56</td>
<td></td>
</tr>
<tr>
<td>&gt;50%</td>
<td>6.94</td>
<td>p=.03</td>
</tr>
</tbody>
</table>

The difference of Owning an ITN between the two socio economic groups was statistically significant $X^2 = 8.4$, p=0.04. We also observed a significant difference between the facts that household has at least one child infected with malaria parasite by ownership of ITN ($X^2 = 5.8$, p=0.02. 86% of household with no child infected by malaria parasite had ITNs, 6.94% of those household had more than half of children who a positive blood smear.
V-5 Logistic regression model

**Table 9: Odd ratio of ownership of ITNs, socio economic status, means inhabitant, household buying pre-treated nets and household with at least one child’s blood smear positive.**

<table>
<thead>
<tr>
<th>Has at least one ITN</th>
<th>Odd Ratio</th>
<th>P-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio economic status</td>
<td>1.96</td>
<td>0.028</td>
<td>1.07 - 3.58</td>
</tr>
<tr>
<td>At least one parasitemic</td>
<td>0.54</td>
<td>0.1</td>
<td>0.25 - 1.14</td>
</tr>
<tr>
<td>Mean inhabitant</td>
<td>1.07</td>
<td>0.007</td>
<td>1.02 - 1.13</td>
</tr>
<tr>
<td>Purchased pre-treated net</td>
<td>1.5</td>
<td>0.001</td>
<td>1.17 - 1.91</td>
</tr>
</tbody>
</table>

The probability of having at least one ITN in the household increase by around 2 with an unit increase in household socio economic status (p value = 0.02). This probability also increases by 1.07 fold with an unit increase in the number of inhabitant for the household. Household, which purchased at least one pre-treated net, were 1.5 times more likely to have ITN than the ones who do not. With at least one child parasitemic in the household the probability that such household own at least one ITN, were reduced by half.
V-6. *Anopheles gambiae* s.l density and parity rate

**Table 10. Malaria vector density:** Mean density of *Anopheles gambiae* s.l per room, per sleeper by village and by zone

<table>
<thead>
<tr>
<th>Background characteristics</th>
<th>Mean density per room (SD)</th>
<th>Mean density per sleeper</th>
<th>Mean number of sleeper (SD)</th>
<th>Man biting rate</th>
<th>Parity rate(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissana</td>
<td>432.7(326.8)</td>
<td>159.1</td>
<td>3.6(1.3)</td>
<td>233.3/men/night</td>
<td>59.0</td>
</tr>
<tr>
<td>Niesoumana</td>
<td>603.6(341.9)</td>
<td>144.2</td>
<td>4.6(1.3)</td>
<td>212.8/men/night</td>
<td>63.5</td>
</tr>
<tr>
<td>Non-irrigated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogobougou</td>
<td>89.7(22.7)</td>
<td>14.5</td>
<td>6.9(2.6)</td>
<td>67.3/men/night</td>
<td>72.7</td>
</tr>
<tr>
<td>Toumakoro</td>
<td>90.3(30.1)</td>
<td>17.9</td>
<td>5.8(2.04)</td>
<td>33.3/men/night</td>
<td>68.9</td>
</tr>
</tbody>
</table>

The density of *Anopheles gambiae* s.l, the main malaria vector in Mali was statistically different between the two zones. The mean density was higher in both irrigation area with respectively 432 and 603 *Anopheles* per room in Tissana and Niessouma and a density per sleeper of 159.1 and 144 mosquitoes/people sleeping in the house. In the non-irrigated villages, the density was relatively lower than 100 mosquitoes per room and a density per sleeper around 14.5 in Dogobougou and 17.9 in Toumakoro.
The man biting rates varied significantly between the 2 area. Data showed more than 200 bites per person per night in the irrigated zone versus 50 bites per person per night in the non-irrigated. Meanwhile, the parity rate was much higher in the non-irrigated zone (about 70%) compare to 60% in the irrigated villages.
VI Discussions:

The methodology was based on a cross-sectional study and the results of such a study may be different at another time of year. The present study was conducted during the rainy season when malaria vectors are present everywhere in Niono district. Therefore, the density of vectors in human habitations and clinical malaria cases detected in children under 5 years old may be lower during the dry hot season specifically in the non-irrigated area of Niono.

In the irrigated area, the prevalence of malaria among children less than 5 years old was 16.67% in Tissana and 18.46 in Niessoumana. The villages in non-irrigated zone presented at the same time a prevalence of 50% in Dogobougou and 31.3% in Toumakoro. Overall the difference in proportion of children under 5 with fever in the last 2 weeks whom had blood smear positive to *plasmodium falciparum* was statistically significant between the 2 areas ($X^2 = 26.9$ and $p = 0.000$).

The results from our study are comparable to those of a recent study in northern Tanzania, which showed 2.4–2.7 times higher incidence of malaria
in a non–irrigated area compared to a rice irrigated area, at low malaria prevalence levels of 12.5 and 29.4% (in 1–4-year-olds) for the irrigated and non-irrigated areas, respectively ([Ijumba et al., 2002]).

In irrigated area, 36.4% of household live below the median poverty index (7.0) while in non-irrigated area around 75.2% of household are in low socio economic status. The difference in poverty of living conditions defined as the lack of food, education, health, housing, etc was highly significant between the 2 areas (p=0.000).

Among children under 5 years old, prevalence of malaria was significantly different between irrigated and non-irrigated villages with respectively 17.56% and 40.7% (p=0.000).

In general bed net use rate was very high in both village more than 90% except for Dogobougou in the non-irrigated area were less than 60% of household own a bed net. Nonetheless, the proportion of household owning an Insecticide treated net (ITN) was different between irrigation and non-irrigation zone. Among children under 5 years old, 20% slept under an ITN the night before our survey versus 8% in the non-irrigated zone.

For both areas, 38.05% of household with index higher than 7.0 has at least one insecticide treated net compare 21.32% for the ones with index lower or equal to 7.0, the difference was statistically significant (p=0.004). This
funding are likely to show an unequal distribution of ITN use and malaria cases among children. Additional studies need to be done at different time in the year (like during the dry hot season which is also a second period in the year fro rice cultivation in irrigated area)

Our study do not take in account the density of Anopheles funestus which is the second vector in Niono since this specie is more representative during the dry cold season (from December to February). The density of Anopheles gambiae s.l was significantly higher in irrigated area with an average of 500 Anophelines per room for a density per sleeper equal to 150 mosquitoes/people sleeping in the house. In the non-irrigated villages, the density was relatively lower than 100 mosquitoes per room and a mean density per sleeper equal to 15 mosquitoes.

This study showed results comparable to those found by Dolo et al, 2004 regarding Anopheles gambiae s.l the major vector transmitting malaria in this area. While the density and the man-biting rate were quite higher in the irrigated villages, the parity rate was much lower in these villages compare to the non-irrigated ones. These results support a high contact between vectors and host in the non-irrigated area, which can be a way to think of lack of self-protection against mosquito bite in those villages compare to those with low parity rate.
Using logistic regression to asses the odds of having at least one ITN according to socio economic status, having at least one child parasitemic, household likely to buy pre-treated net and number of inhabitant per household, this study showed a 2 fold increase in the probability of having at least one ITN with a one unit change in household socio economic status (p value = 0.02). Households with more inhabitants were 1.07 times more likely to own at least one ITN. Household, which had purchased at least one pre-treated net, were 1.5 times more likely to have ITN than the ones that purchased a non-treated net and get to treat them in the village or a health center. The probability of having a child blood smear positive per household decreased half when the household own at least one ITN.
VII Conclusion:

In conclusion, this study found a relatively high rate of ITN uses in irrigated area compare to the non-irrigated one. The difference in socio economic status of household was important between the two zones. Since the population structure was much similar between zones and difference in vector density was highly significant, one can think of the irrigation project as a source of improvement for the population living in the surrounding village in terms of income and access to facility and health care which gives awareness and use of disease control tools such as insecticide treated net known so far one the most effective way to reduce malaria transmission in population at risk.
VII References:


3. CDC (2007). "Malaria." WWW.CDC.GOV.


IX. Appendix