



The paddy, the vector and the caregiver: lessons from an ecosystem approach to irrigation and malaria in Northern Côte d'Ivoire

Renaud De Plaen^{a,*}, Marie-Louise Seka^b, Amalaman Koutoua^b

^a International Development Research Centre (IDRC), P.O. Box 8500, Ottawa, Ont., Canada K1G 3H9

^b Département de Sociologie, Université de Cocody, Abidjan, Côte d'Ivoire

Abstract

Malaria is one of the most serious public health problems in the world. For the last few decades, numerous studies have focused on the potential links between environmental transformations (such as the expansion of irrigation) and malaria occurrence. Most of these studies have been based on relatively simple models outlining the interactions of the host–vector–parasite triad. In this paper, we investigate the links between the intensification of irrigated rice cultivation and malaria. In an attempt to complement biomedical and entomological approaches we propose a model that recognises the influence of human–vector contacts on transmission processes, but stresses the importance of taking into consideration socio-economic and cultural factors in the management of disease episodes, and how these can be affected by transformations of natural resource management strategies. Using a case study in Northern Côte d'Ivoire, we investigated the complex mechanisms by which agriculture-generated changes in ecosystems and socio-economic organisation influence disease risks and produce new scenarios in the management of disease. Our results show that the socio-economic transformation and gender repositioning induced, or facilitated, by the intensification of lowland irrigated rice cultivation influence the health care system for malaria in the study area. They lead to a reduction of the capacity of women to manage malaria episodes among children and influence their vulnerability to the disease. We argue that these elements contribute to higher malaria prevalence in villages involved in double cropping of rice annually.

© 2003 Elsevier B.V. All rights reserved.

Keywords: Côte d'Ivoire; Malaria; Irrigation; Gender; Farming systems

1. Introduction

Malaria is one of the most serious public health problems in the World with an estimated 2.7 million deaths each year. Nine tenths of cases and deaths oc-

cur in Africa especially among children under the age of 5 years (Samba, 2001; Breman et al., 2001). Conservative figures estimate that between 300 and 500 million clinical attacks of malaria occur each year in the African region (WHO, 1997) but true figures are likely to be higher. In most cases, malaria is caused by the protozoan parasite *Plasmodium falciparum* transmitted mainly by the *Anopheles gambiae* complex and by *A. funestus* (Hay et al., 2000).

* Corresponding author. Tel.: +1-613-236-6163x2545; fax: +1-613-567-7748.

E-mail address: rdeplaen@idrc.ca (R. De Plaen).

The disease is not new. The cycle of malaria and the role of the *Plasmodium parasite* were described for the first time almost a century ago. Attention to linkages between environmental changes, human evolution and malaria can be tracked back to the late 1950s when Livingstone linked the distribution of sickle-cell trait to iron-based agricultural expansion, larger population concentration in villages and the endemic spread of malaria in West Africa (Livingstone, 1958). Since then, numerous researches have focused on malaria and attempted to comprehend the relationship between the spread of the disease and environmental changes. Most of them however, have been based on relatively simple models outlining the interactions of the host–vector–parasite triad.

They have led to the design and implementation of large-scale intervention programs aiming to control vector populations or reduce human–vector contacts. Interventions have included indoor residual spraying (IRS), insecticide treated nets (ITN), and larval control programs. Important financial and human resources have also been channelled toward the development of a vaccine (which may not be available for another 20 years), more efficient drugs and genetic manipulation that may interrupt the parasite cycle within the vector.

In Southern Europe and the United States, the combination of well-orchestrated public education campaigns, large scale insecticide spraying, the availability of effective treatments and functional health care delivery systems and the improvement of living conditions successfully eliminated malaria from areas that were otherwise vulnerable to transmission. In Asia, vector control measures (based on integrated vector control strategies and insecticide spraying) have been used with relative success to reduce anopheline populations and control the spread of the disease. However, over the same period of time it seems that, in sub-Saharan Africa, the malaria situation has either remained constant or continued to worsen.

The poor results of malaria control interventions in sub-Saharan Africa lead a growing number of researchers from the international scientific communities to acknowledge that malaria in Africa is more complex than in other parts of the world and that interventions that proved successful elsewhere may not be adapted to the African situation. Yet, there are still very few attempts to adapt research and intervention approaches to account for such complexity. There is

clearly a need to complement traditional biomedical and entomological approaches by new, systemic approaches to malaria in sub-Saharan Africa.

2. Conceptual framework

While recognizing the importance of both host–vector contacts and of the parasite cycle, this paper argues that there is a need to expand classical approaches to malaria that focus primarily on the pathology, and to consider socio-economic and cultural factors that influence risk behaviours, vulnerability of human populations and treatment seeking opportunities in case of illness.

To our knowledge, very few models, in the medical social sciences literature account for the interactive role of environmental, social, economic, cultural and biological factors that generate malaria. Several researchers have recognised the importance of ecological, cultural, social and economic factors in health and have attempted to demonstrate the key role played by one or another of these sets of factors on the shaping of the epidemiological profile and health-related behaviour of rural populations (Adler et al., 1994; Marmot and Theorell, 1988; Kleinman, 1980). Several studies focused specifically on the influence of socio-economic and cultural variables on malaria (Mwenesi et al., 1995; Legrand and M'Baké, 1993; Lipowsky et al., 1992; Agyepong, 1992; Fabricant and Kamara, 1991; Bonnet, 1990; Mc Kinley, 1975). Few, however, tried to identify systematically how factors of the different categories interact with one another, how their interactions are affected by modifications of agricultural practices and resulting environmental changes, and how they contribute to model the epidemiological profile of rural populations.

In this study, we propose a framework which: (a) distinguishes a series of variables (environmental, cultural, social, and economic) that interact to create the conditions that shape malaria incidence in northern Côte d'Ivoire; (b) highlight mediations (intermediary elements) through which these variables are affected by inland valleys irrigated rice cultivation; and (c) unveils the processes at work in the production of malaria incidence. Specifically, we argue that the processes through which the health profile and related behaviours in a particular population are influenced

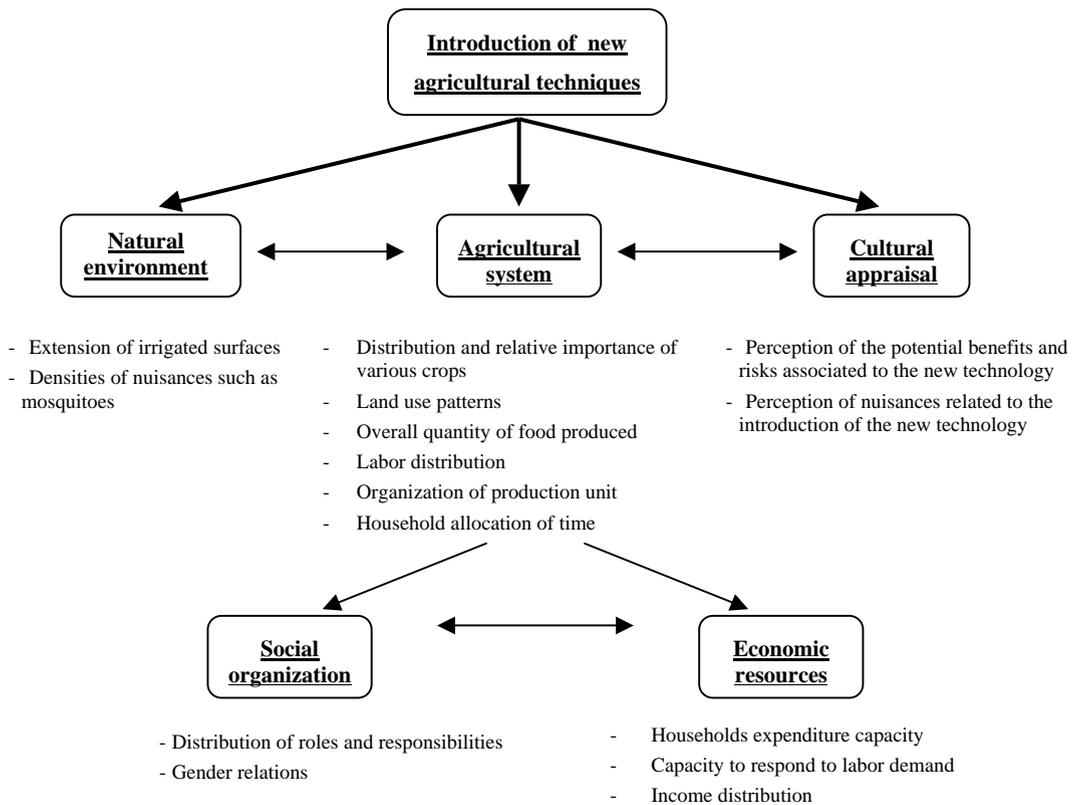


Fig. 1. Multiple ways in which new agricultural practices can affect the daily life of farmers (De Plaen, 2001).

by a new agricultural practice, take place simultaneously in multiple aspects of the life of farmers and therefore necessitate consideration of the influence of the new technique on the natural environment, cultural appraisal, social organisation and distribution of economic resources, the last two being influenced by the transformation of farming systems (Fig. 1).

The model developed in this research recognises the influence of human vector contacts on transmission processes, and of socio-economic and cultural factors on health behaviours and disease management strategies. It also stresses the fact that a good understanding of how irrigation intensification affects malaria also requires a consideration of the new technique on the farming system as a whole (Fig. 2). It is rooted in three main approaches: the new critical epidemiology (Farmer, 1999; Fassin, 2000), medical anthropology (Bibeau, 1999; Pedersen, 1996), and the Farming Systems approach (Brush and Turner, 1987). It is also

strongly influenced by the Ecosystem approaches to human health framework, promoted by the Canadian International Development Research Centre (IDRC).

Ecosystem approaches to human health start from the premise that the health of the human population is shaped by a range of factors from the natural environment, socio-economic organization and lifestyle of communities and that better management of the ecosystem can contribute to improve human health. Therefore, ecosystem approaches to human health seek to better comprehend the interaction between various components of the ecosystem (biophysical, social and cultural), how they influence the prevalence of health problems among human populations and to identify more efficient ecosystem management strategies that can contribute to improve the health and life conditions of human populations and the sustainability of the ecosystem in which they live (Forget and Lebel, 2001).

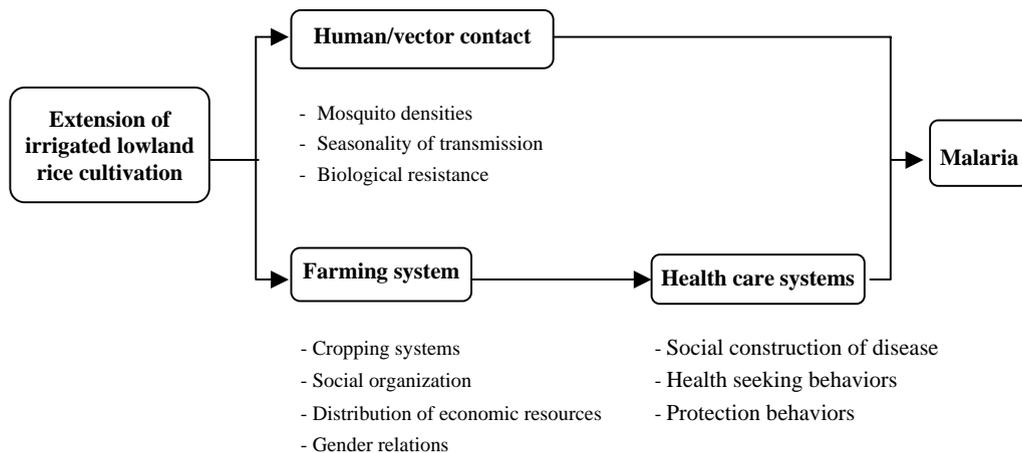


Fig. 2. An ecosystem approach to the transformations induced by lowland irrigated rice agriculture on malaria (De Plaen, 2001).

They are “system based” and are based on three principles: (1) the need for full collaboration between researchers of different disciplinary backgrounds, as a condition to capture the complexity of relations between various health determinants such as: bio-physical and epidemiological factors, natural resource management strategies, socio-economic conditions, social relationships, gender dynamics, and the integration of scientific and local knowledge; (2) the full involvement of communities and other stakeholders in the various stages of the research, from the identification of the research question to the design and conduct of the research, the interpretation of results and the identification of potential interventions; (3) the need to pay specific attention to social inequalities and gender relations as they relate to natural resource management, risk factors and health behaviours.

In this paper, we use a case study on how the intensification of lowland irrigated rice cultivation in Northern Côte d’Ivoire can affect malaria incidence to illustrate how an Ecosystem approach to human health permits to better understand the ways through which the transformation of natural resource management techniques can influence malaria. We suggest that there are multiple factors beyond the Anopheles population, level of exposure, health services and technologies (prophylaxis, mosquito nets) to explain why a disease such as malaria shows significant decline or increase under certain conditions. We investigated the complex mechanisms by which factors such as agriculture-generated changes in ecosystems, gen-

der repositioning in the family organisation as a result of access to new crops, and production activities combine together in increasing disease risks and producing new scenarios in the management of disease.

3. Case study: lowland irrigated rice cultivation and malaria in Northern Côte d’Ivoire

Results presented in this paper have been generated by a research conducted in 1997–1998 by the Health Consortium of the West African Rice Development Association (WARDA)¹ and on subsequent data collected for a Ph.D. Thesis in Geography. Through the systematic comparison of communities involved in single or double cropping of rice in inland valleys, the study specifically considers how irrigated rice cultivation transformed agricultural activities (calendar, workload, crop distribution), the social organisation (decisional structure, intra-household relations, and household members’ autonomy and responsibilities),

¹ This research was undertaken within the framework of the WARDA/WHO-PEEM/IDRC/DANIDA/Government of Norway Health Research Consortium on the Association between Irrigated Rice Production Systems and Vector-Borne Diseases in West Africa. The Consortium received technical assistance from the International Development Research Center (IDRC), Ottawa, Canada and financial support from the International Development Research Center (IDRC), Ottawa, Canada, the Danish International Development Agency (DANIDA) and the Royal Government of Norway.

the cultural values and the economic organisation of productive units (sources of income, household distribution and management of income), and how such transformations influence the health of farming communities.

4. Materials and methods

Research activities were conducted in six villages located near Korhogo, in the savannah zone of northern Côte d'Ivoire: Kaforo, Nambekaha, Naoualakaha, Kohotiery, Fapaha, and Nongotchenekaha (Fig. 3). The six communities selected for this research were mostly composed of Sénoufo farmers and are located within a radius of 25 km of Korhogo. They share the same commonalities with the exception of the number of harvests (R1—one harvest of lowland rice annually and R2—two harvests of lowland rice annually) and the presence or absence of hydraulic infrastructure in their inland valleys.

The data collection was organised along two main axes: one intensive, and one extensive. The more extensive part of the research was conducted at the village level and dealt with a comparison of agricultural practices in the six communities. Simultaneously, we conducted a more intensive research on health-related

behaviour, harvest management, resource distribution and decision-making power within a restricted number of households in each community. This more intensive study not only looked at practices, but also at the knowledge held by people and to their discourses about such practices.

A team of four fieldworkers (three women and one man) was used to conduct the research. They were selected in the research area (but not in any of the communities under study) and therefore shared a very good knowledge of both the language and local culture. Data collection involved extensive period of fieldwork (8 months) living in the selected communities and sharing the life of villagers and was completed by 18 months of shorter visits to the selected communities.

Data collection techniques involved mapping of agricultural fields, questionnaires, individual (180) and group (24) semi-controlled interviews and detailed, thematic interviews with key informants (20). Local representations and practices related to health and agriculture were collected through case histories and interviews with key informants. In parallel to the interviews, fieldworkers carried out participant observation in order to compare, and supplement, discourses of respondents to actual behaviour and practices. All interviews were conducted in the local

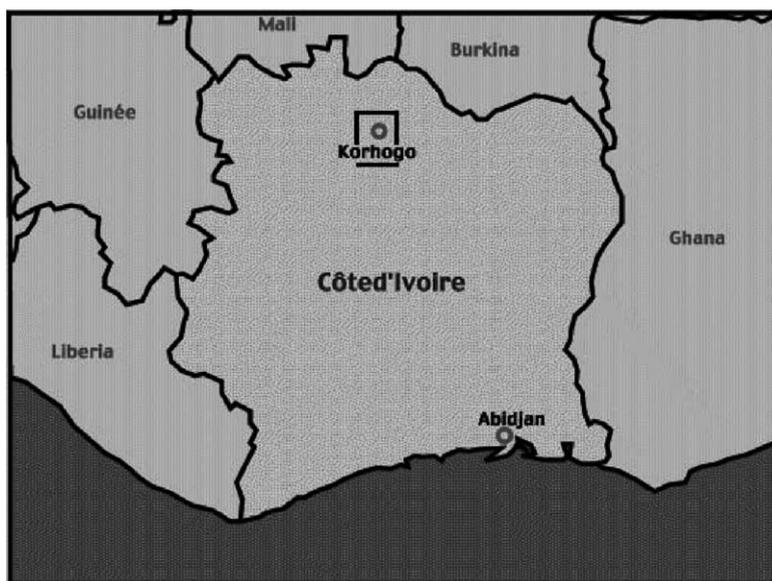


Fig. 3. The study area: six villages in the Korhogo area, northern Côte d'Ivoire (Source: Encarta, 2000).

language. They were later translated and codified using NUD*ist software.²

5. Results

In order to fully illustrate the complementarity of our study to more classical studies of malaria, we will first outline the main results of entomological and parasitological studies of how irrigation affects the disease in Northern Côte d'Ivoire. These results also represent a basis for the interpretation of socio-economic data. The paper then describes how the intensification of irrigated rice cultivation transformed productive activities (beyond lowland rice cultivation), the socio-economic organization and the distribution of responsibilities within households and how such transformations combine together to influence the health care system and vulnerability of children to malaria in Northern Côte d'Ivoire.

According to a study conducted by the Health Consortium of WARDA, the extent of flooded surfaces associated to the extension of irrigated rice cultivation can be strongly correlated to the density of the main malaria vector (*A. gambiae*) (Briët et al., 2003a). Results from the entomological team however also indicate that there is no clear correlation between malaria transmission and flooded surfaces in lowlands, due to the influence of intra-specific competition on the lifespan of the mosquito population (Briët et al., 2003a). Irrigation therefore has an impact on vector densities but this does not necessarily result to any significant increase in malaria transmission. Parasitological results however, indicate that the number of new malaria episodes per child per year is higher in villages with two crops of rice than in villages with a single crop of rice annually (Henry et al., 2003). These results suggest that while irrigation does not contribute to increased malaria transmission, other mechanisms do influence malaria incidence, potentially by influencing children's vulnerability to the disease.

Identifying such mechanisms required the systematic identification of socio-economic transformations induced by the intensification of irrigated rice cultivation and the assessment of how these transformations influenced health behaviours and malaria's health care system in villages of the two agroecosystems. The systematic comparison of R1 and R2 villages showed that:

1. Despite the general assumption that increasing rice production would increase rice commercialisation and economic benefits for producers, most farmers did not consider rice a cash crop. While part of the production could be sold in case of cash shortages, the main source of income for rural households in the study area was cotton cultivation, which is managed by the head of the household (De Plaen, 2001).
2. While there has been an increase in lowland rice production in R2 villages, resulting from the second cropping cycle, such increase took place at the expense of other food crops previously grown on the uplands. Furthermore, despite increased rice production, food security issues appeared to be more problematic in R2 than in R1 villages with 61% of respondents from R2 villages complaining of being unable to achieve food auto-sufficiency, compared to 42% in R1 villages (Fig. 4).
3. Women in R2 villages assumed a greater share of the food production and contributed more to feeding the household than in R1 villages. In R1 villages, 61% of respondents claimed that the head of the household (a man) was the one providing most of the food to the household, but this proportion fell to 34% in R2 villages (Fig. 5).
4. The extension of irrigated rice cultivation resulted in a reduction of women's personal income. Several sources of revenue available to women in R1 villages disappeared in R2 as a result of the extension of agricultural activities to the dry season (lowland irrigated rice is mainly grown by women) and the fact that rice was mostly used for household consumption rather than sold on the market (Fig. 6).
5. Despite lower mosquito densities, more money was spent on household and personal protection against mosquitoes in R1 than in R2 villages. Inhabitants in R1 villages purchased more commercial mosquito

² NUD*ist is a computer package designed to handle non-numerical and unstructured data in qualitative research analysis. It supports the process of coding the data in an index system and allows searches of the text or of patterns of coding in the database. It is commonly referred to as "content analysis software."

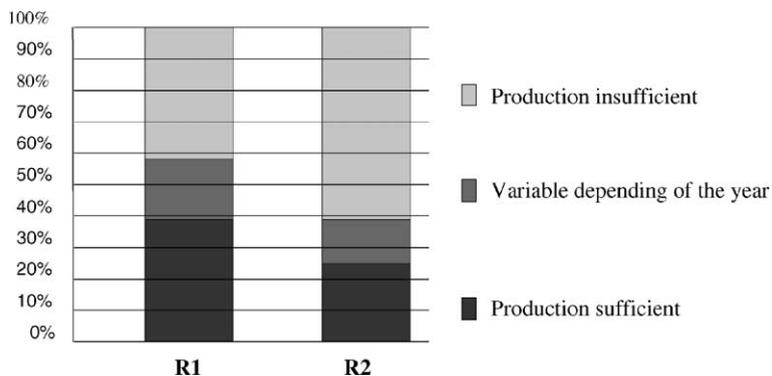


Fig. 4. Bar chart of the percentage of respondents out of 200 interviews who responded to the question whether the food produced by the household was sufficient in rice cultivating villages with a single annual rice growing cycle (R1) and double cropping villages (R2) (Briët et al., 2003b).

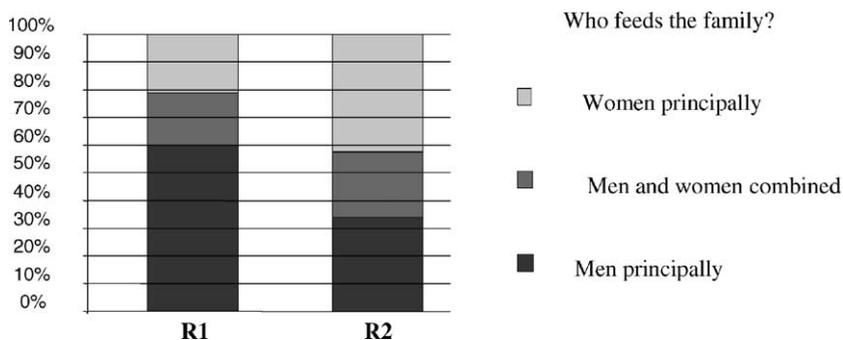


Fig. 5. Bar chart of the percentage of respondents out of 200 interviews who answered to the question which gender was responsible for feeding the family in rice cultivating villages with a single annual rice growing cycle (R1) and double cropping villages (R2) (Briët et al., 2003b).

repellents (insecticide sprays and fumigating coils) than in R2 villages (Fig. 7).

6. Women played a greater role in deciding which treatment to seek upon the appearance of malaria

symptoms in R1 than in R2 villages. In R2 villages, 66% of respondents claimed that the decision about the type of therapeutic option to seek in case of malaria episode was exclusively made by

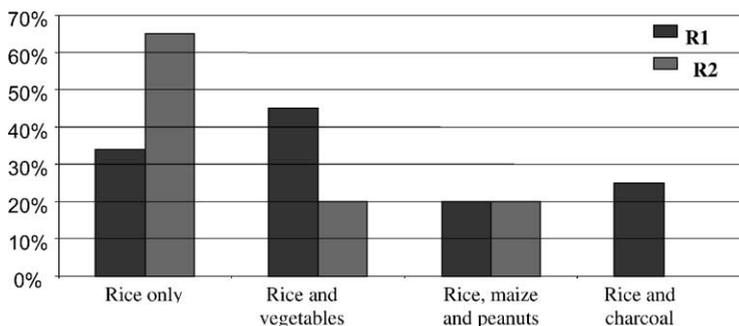


Fig. 6. Bar chart of the percentage of respondents out of 200 interviews who answered to the question which were the main sources of income for female members of the household in rice cultivating villages with a single annual rice growing cycle (R1) and double cropping villages (R2) (De Plaen and Geneau, 2002).

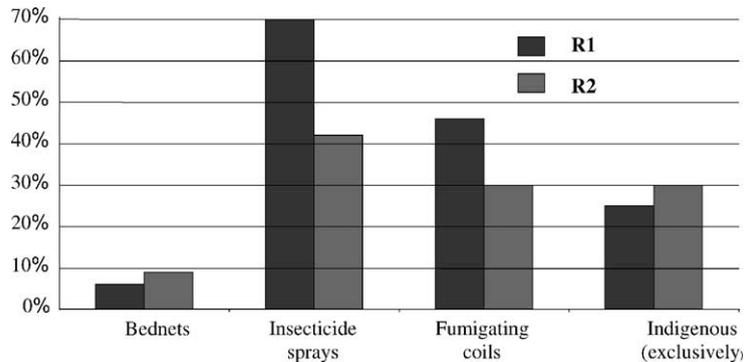


Fig. 7. Bar chart of the percentage of respondents out of 200 interviews who mentioned specific means of protection against mosquitoes in rice cultivating villages with a single annual rice growing cycle (R1) and double cropping villages (R2) (De Plaen and Geneau, 2002).

men but only 47% did so in R1 villages (Fig. 8a). Women also assumed a greater share of the costs of anti-malarial treatments in R1 than in R2 villages. In 89% of cases, both men and women contributed to pay for anti-malarial treatments in R1 villages, while in R2 villages, men and women shared health expenses in only 69% of the cases (Fig. 8b).

- Finally, it appears that, in R1 villages, when the first anti-malarial treatment failed, inhabitants tended to proceed with a second therapeutic option faster than those from R2 villages, but the latter referred more often to modern health facilities as a second option than the former (Fig. 9a–c).

6. Discussion

To understand the full importance of the findings of this study, it is essential to see that these various

results are mutually interdependent, how they are actually linked to transformations of the agricultural production system, socio-economic status of villages and household members, and intra-household relations; and how they contribute, in concert, to the reshaping of the malaria epidemiological profile of rural populations in northern Côte d'Ivoire.

It seems that the intensification of lowland rice production resulting from irrigation led to the transfer of food production, previously grown on family fields on the uplands, to lowlands individual fields cultivated by women. Traditionally, among the Sénoufos, the whole family under the direction of the head of the household produces most food consumed by a household on family fields. The head of the household is the sole responsible for the management of the harvest but is in charge of providing food for all his dependents. Food produced on lowlands (rain season rice and vegetables) is stored in women's individual granaries and is

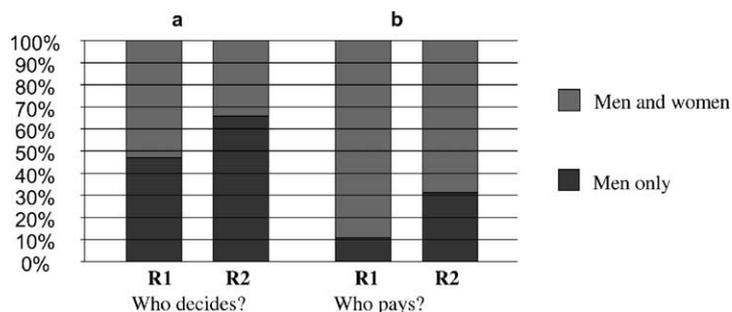


Fig. 8. (a and b) Bar chart of the percentage of respondents out of 200 interviews who answered to the question which gender was responsible in case of a suspected malaria episode for decision making (8a) and for the payment for the treatment (8b) in rice cultivating villages with a single annual rice growing cycle (R1) and double cropping villages (R2) (Briët et al., 2003b).

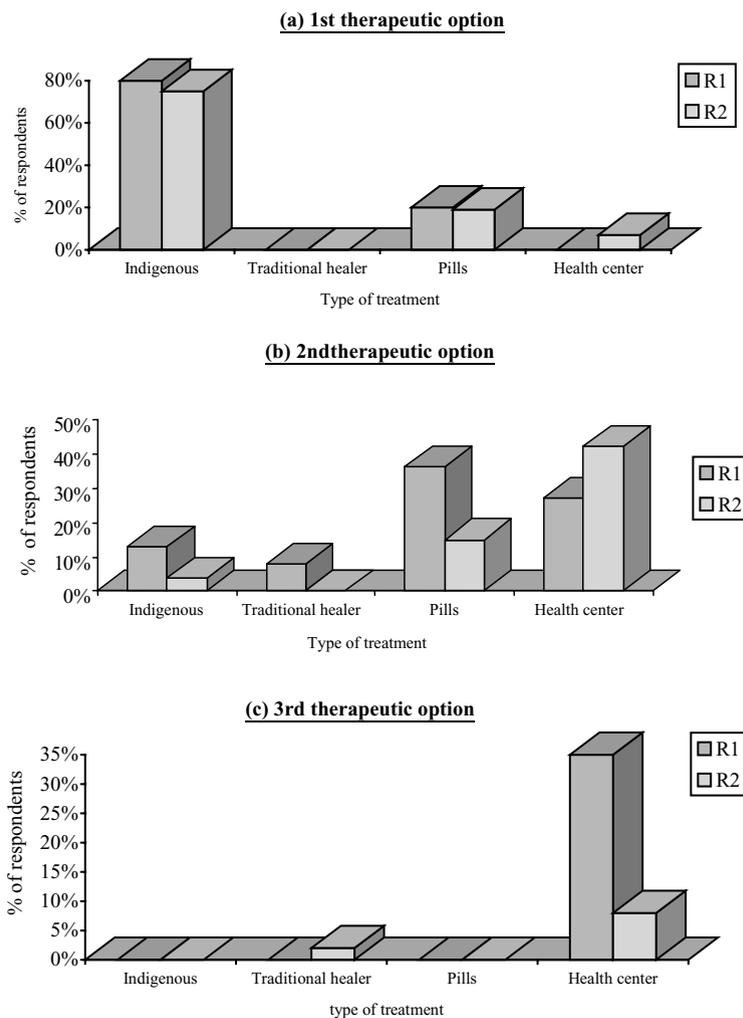


Fig. 9. (a–c) Bar chart of the percentage of respondents out of 200 interviews who mentioned the type of treatment sought in case of a (malaria) episode as first (a), second (b) and third (c) therapeutic recourse in rice cultivating villages with a single annual rice growing cycle (R1) and double cropping villages (R2) (De Plaen, 2001).

used for their own personal needs. Men are in charge of providing the staple food while women provide ingredients for the sauce (from their individual fields).

The transfer of food crops from upland family fields to women's lowland individual fields resulted in a transfer of the responsibility to produce and provide food for the household, from the head of the household (men) to the women. Such transfer of responsibilities is more important in R2 than in R1 villages. It gives women more control on the management of the harvest, but forces them to assume a greater share of household responsibilities that were previously as-

sumes by men (De Plaen and Geneau, 2002). In R2 villages, results indicate that several households rely principally on women's harvest to feed the household.

The expansion of agricultural activities to the dry season (thanks to irrigation techniques) also had strong consequences on women's economic status. In villages with a single harvest of rice annually, women gather most of their income from dry season activities (vegetable gardening in the lowlands, shea butter and *sumbala*—a spice made out of the *néré* seeds—production, charcoal selling and art craft). In R2 villages, women spend most of the dry season in

the lowland, attending the second crop of rice and are unable to engage in several of their traditional income generating activities. A larger proportion of women from R2 therefore depend on the selling of some of its rice production to access money in case of emergency. However, as the rice produced in the lowlands is required to feed the household, they have little flexibility to sell part of their production to compensate for the lost income and often face a net reduction of their economic revenues.

One of the most counterintuitive findings of the research relates to food security issues. It was always assumed that increasing food production through lowland rice irrigation would contribute to improve food security for households involved in two harvests of rice annually. Our results showed the contrary. It is possible to explain these findings, at least partly, from the processes described above: the reduction of food crops production on the uplands, the transfer of responsibilities for producing food and feeding the household, and to the necessity for an increasing number of women to sell some rice to access cash, all combine together to produce a reduction of the net quantity of food available to households. However, these results were collected in a year of good climatic conditions and one must acknowledge that, thank to irrigation, R2 villages are less vulnerable to climatic instability.

The second step for the research was to identify the links between these transformations and potential changes in health behaviours that may explain different malaria epidemiological profiles in villages with one or two harvests of rice. Our basic premise has been that vector densities, host–vector contacts and biological resistance of human population to the parasite can influence malaria, but that the pathology can also be influenced by protective behaviours and the rapidity of reaction when the first symptoms of malaria appear.

According to the results of the Health Consortium of WARDA, while irrigation leads to higher mosquito densities, there is no correlation between malaria transmission and flooded surfaces due to a negative correlation between the proportion of infective vectors and vector densities (Briët et al., 2003a). The socio economic data collected in this study indicates that, due to cultural reasons, disease prevention through prophylaxis treatments is not common in the study area and that households from R1 villages use more commercial mosquito repellents (fumigating coils

and insecticides spray) than in R2. There is almost no use of bed nets in any of the studied communities. Since results from the Health Consortium indicate that inoculation rate is similar in the two sets of villages (130 infective bites/person/year), it is unlikely that less protective measure use can explain higher malaria incidence in R2 communities.

It seems therefore essential to look more deeply into disease episodes management and health seeking practices. According to our experience, the capacity of an individual to react to the onset of a disease depends from three factors: (1) knowledge and recognition of the disease symptoms; (2) capacity to decide which treatment to initiate for specific diseases; (3) capacity to assume the costs associated to the treatment (or to access the treatment).

According to our research, there is no variation in the cultural construction of malaria (causes, symptoms, consequences) between the various communities investigated. There are, however, differences in the ways malaria episodes are managed in the two sets of communities, and that such differences can be linked to socio-economic transformation (De Plaen et al., unpublished).

Among the Sénoufos, the head of the household is the one in charge of all the basic needs of his dependents, including health. However, a second principle stipulates that the person who takes a decision regarding health treatment is the one that has to pay for it. Our research indicates that in villages with a single harvest of rice, women are more actively involved in the decision making process and in assuming the costs of treatment than in villages with two harvests of rice. In all communities, it is the women who initiate the first treatment against malaria (through indigenous remedies). If the first treatment does not succeed, women in R1 villages quickly start a second set of treatments referring to traditional healers or with anti-malarial pills bought on the market. It is only after the failure of the second treatment that the responsibility of the patient is transferred to the head of the household who may refer to a health centre. In R2 villages, if the first treatment initiated by the mother fails, the patient is often directly transferred to the responsibility of the head of the household (as a second option). The second treatment however is initiated much later in R2 villages than in R1 villages (De Plaen et al., 2003).

Our data suggest that the difference of involvement between women of R1 and R2 villages, in treating sick children is linked to differences in their economic status. Women from R1 villages are better off financially and can therefore more easily afford the costs of treatments resulting from their involvement in the decision-making process. The longer gap between the initiation of the 1st and 2nd treatments appears to have an impact on the severity of malaria symptoms and on the general health status of the children (therefore influencing vulnerability to new disease episodes).

Therefore, it appears that one of the ways through which irrigation affects malaria in Northern Côte d'Ivoire is through its impact on the farming system (crop distribution and labour organisation, harvest management, etc.), the socio-economic organisation (distribution of roles and responsibilities within the household), and financial status of women, and through the ways such transformations affect women's capacity to react to the disease.

In conclusion, it is important to re-emphasize that this paper does not propose ecosystem approaches to human health as alternatives to more classical, epidemiological approaches to malaria. To the contrary, it stresses the complementarities between these approaches and need to integrate epidemiological, social and economic approaches to address the complexity of malaria in sub-Saharan Africa.

References

- Adler, N.E., Boyce, T., Chesney, M.A., Cohen, S., Folkman, S., Kahn, R.L., Syme, S.L., 1994. Socioeconomic status and health. The challenge of the gradient. *Am. Psychol.* 49, 15–24.
- Agyepong, I.A., 1992. Malaria: ethnomedical perceptions and practice in an Adangbe farming community and implication for control. *Soc. Sci. Med.* 35, 131–137.
- Bibeau, G., 1999. Une troisième voie en santé publique. *Ruptures. Revue Transdisciplinaire en Santé* 6, 209–236.
- Bonnet, D., 1990. Anthropologie et santé publique: une approche du paludisme au Burkina Faso. In: Gassin, D. (Ed.), *Société du Développement et Santé*. Paris, Ellipse.
- Breman, J.G., Egan, A., Keusch, G.T., 2001. The intolerable burden of malaria: a new look at the numbers. *Am. J. Trop. Med. Hyg.* 64, (Suppl. 1–2), iv–vii.
- Briët, O.J.T., Dossou-Yovo, J., Akodo, E., van de Giesen, N., Teuscher, T.M., 2003a. The relationship between *Anopheles gambiae* density and rice cultivation in the savannah zone and forest zone of Côte d'Ivoire. *Trop. Med. Int. Health* 8, 439–448.
- Briët, O.J.T., De Plaen, R., Teuscher, T., Henry, M.C., Dossou Yovo, J., Geneau, R., Akodo, E., Audibert, M., 2003b. Single or double cropping of rice in the Savannah zone of Côte d'Ivoire: impacts on malaria. Paper Presented at the International Forum on Ecosystem Approaches to Human Health. Montreal, 18–23 May 2003.
- Brush, S.B., Turner II, B.L., 1987. The nature of farming systems and views of their changes. In: Turner II, B.L., Brush, S.B. (Eds.), *Comparative Farming Systems*. The Guilford Press, New York, 1987.
- De Plaen, R., Geneau, R., Teuscher, T., Koutoua, A., Seka, M.L., 2003. Living in the paddies: a social science perspective on how inland valley irrigated rice cultivation affects malaria in Northern Côte d'Ivoire. *Trop. Med. Int. Health* 8, 459–470.
- De Plaen, R., 2001. Contracting malaria in the paddies: a farming systems approach to malaria in Northern Côte d'Ivoire'. Ph.D. Thesis. Geography Department, Rutgers University.
- De Plaen, R., Geneau, R., 2002. Riziculture de bas-fond, autonomie des femmes et paludisme dans le Nord de la Côte-d'Ivoire. *Les Cahiers d'Étude et de Recherche Francophone—Section Agriculture* 11, 17–23.
- Fabricant, S.J., Kamara, S.W., 1991. The financing of community health services in Sierra Leone: seasonality, socio-economic status, gender and location factors affecting access to services. UNICEF Bamako Initiative Technical Report Series, No. 8, p. 29.
- Farmer, P., 1999. *Infections and Inequalities: The Modern Plagues*. University of California Press, Berkeley.
- Fassin, D., 2000. *Les Enjeux Politiques de La Santé*. Éditions Karthala, Paris.
- Forget, G., Lebel, J., 2001. An ecosystem approach to human health. *Int. J. Occup. Environ. Health* 7, S3–S8.
- Hay, S.I., Rogers, D.J., Toomer, J.F., Snow, R.W., 2000. Annual *Plasmodium falciparum* entomological inoculation rates (EIR) across Africa: literature survey. Internet access and review. *Trans. R. Soc. Trop. Med. Hyg.* 94, 113–127.
- Henry, M.C., Rogier, C., Nzeyimana, I., Assi, S.B., Dossou-Yovo, J., Audibert, M., Mathonnat, J., Keundjian, A., Akodo, E., Teuscher, T., Carnevale, P., 2003. Inland valley rice production systems and malaria infection and disease in the savannah of Côte d'Ivoire. *Trop. Med. Int. Health* 8, 449–458.
- Kleinman, A., 1980. Patient and Healers in the Context of Culture: An Exploration of the Borderland Between Anthropology, Medicine and Psychiatry. University of California Press, Berkeley.
- Legrand, K.T., M'Baké, C.S.M., 1993. Teenage pregnancy and child health and mortality in the urban Sahel. *Studies in Family Planning*.
- Lipowsky, R., Kroeger, A., Vazquez, M.L., 1992. Socio-medical aspects of malaria in Colombia. *Soc. Sci. Med.* 34, 625–637.
- Livingstone, F.B., 1958. Anthropological implications of sickle-cell gene distribution in West Africa. *Am. Anthropol.* 60, 533–562.

- Marmot, M., Theorell, T., 1988. Social class and cardiovascular disease: the contribution of work. *Int. J. Health Serv.* 18, 659–674.
- Mc Kinley, J., 1975. The help-seeking behavior of the poor. In: Kosa, J., Zola, I. *Poverty and Health*. Harvard University Press, Cambridge.
- Mwenesi, H., Harpham, T., Snow, R.W., 1995. Child malaria treatment practices among mothers in Kenya. *Soc. Sci. Med.* 40, 1271–1277.
- Pedersen, D., 1996. Disease ecology at a crossroads: man-made environments, human rights and perpetual development utopias. *Soc. Sci. Med.* 43, 745–758.
- Samba, E., 2001. The malaria burden and Africa. *Am. J. Trop. Med. Hyg.* 64 (Suppl. 1–2), ii.
- World Health Organization, 1997. World malaria situation in 1994. Part I. Population at risk. *Wkly. Epidemiol. Rec.* 72, 269–274.