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AGRICULTURAL CHANGES, WATER QUALITY AND HEALTH: INVESTIGATING THE HEALTH STATUS OF POPULATIONS LIVING IN AN AGRICULTURAL IRRIGATED AREA, USING SPATIAL ANALYSIS, IN PHRAE PROVINCE, THAILAND

Vincent Herbreteau[1,2], Jean-Paul Gonzalez[1,3], Wasana Khaungaew[4], Gérard Salem[1,5] and Jean-Louis Janeau [6,7]

[1] Institut de Recherche pour le Développement (IRD), Research Unit 178 (Fundamentals & Domains of Disease Emergence), [6]Research Unit 176, Paris, France;
[2] Center for Vectors and Vector-borne Diseases, Faculty of Sciences, Mahidol University, Thanon Rama VI, Phyathai, Bangkok 10400, Thailand;
[3] Research Center for Emerging Viral Diseases / Center for Vaccine Development, Mahidol University at Salaya, 25/25 Phutthamonthon 4, Nakhon Pathom 73170, Thailand;
[4] Phrae provincial Public Health Office, Ministry of Public Health, 25 Banmai road, Muang, Phrae 54000, Thailand;
[5] Université Paris-X, 200 avenue de la République, 92001 Nanterre cedex, France;
[7] International Water Management Institute – South-East Asia (IWMI-SEA), Kasetsart University, Po Box 1025, Bangkok 10903, Thailand
Corresponding author: Vincent.Herbreteau@ird.fr

ABSTRACT:

Drastic environmental changes have occurred in Thailand during the twentieth century, along with the population growth and consecutive agricultural development consequently threatening the ecosystems. Infrastructures, and especially water reservoirs, were built to increase and improve the agricultural production. These changes have modified irreversibly the biotopes and, above all, the hydrographical network and water quality. In an effort to assess and monitor their consequences on human health, a health Geographic Information System was developed in Phrae province, North Thailand, focusing on the Mae Thang watershed, its reservoir and irrigated area downstream. In partnership with Phrae provincial Public Health Office, all patients' cases from 78 different pathologies, reported in Phrae rural areas from 1997 to 2004, were integrated and incidences were calculated among all the 693 villages, where patients and families live. Health infrastructures were also localized to assess the health offer, access, and recourse. Overall higher prevalence was recorded in Mae Thang study area as compared to the whole province, especially for infectious diseases that could be linked to water quality, as well as for upstream villages compared to those downstream. Marked geographical heterogeneity in disease prevalence between villages showed the importance of the choice of the study scale and the need for a public health survey at the village level to answer the hypotheses raised by the present observations.

KEY WORDS: GIS, human health, water quality, environmental changes, North Thailand

1. INTRODUCTION

Understanding and measuring the consequences of environmental changes on human health is a tough task, taking up the activities of many researchers in different fields, comprising ecology, epidemiology or health geography. It benefits polluting activities whose environmental and health impact cannot really be assessed. This paper does not aim to enlighten clear effects of the environmental changes on human health but to illustrate an ongoing research on evaluating the environmental changes that could have an effect on human health and defining ways to find signs in populations. Health is determined by many interacting factors from the environment of people, global or local, and their activities conditioning the exposure and from their own condition, immunity, use of health services, determinants of vulnerability (Epstein, 1997). Epidemiological records are usually the only source of information to get an historical track of the health status but their analysis through the numerous biases inherent to the records is highly perilous.

In a fast evolving context, driven by a rapid economic growth, Thailand has been subjected to radical demographical, social and economic changes, echoing on the global health status. From 8.2 millions inhabitants, at the time of the first census, in 1909, to 60.6 millions in 2000, the population was nearly multiplied by ten in a century. The demand for agricultural products increased consequently, leading to clearing forests and draining swampy areas. This agricultural expansion was realized more by increasing lands than increasing productivity, which has remained low, due to production constraints, primarily scarce lands, and a lack of investment. Forest

fires are still occurring with an important rate, generally caused by people encroaching forested areas for cultivation, even if Thailand has now large protected areas covering about 13.4 millions of hectares (Thai Royal Forestry Department, 2003).

The study site was identified in Phrae province as exemplary for the problematic: a watershed, suffering from massive deforestation and intensification of agriculture; eroded and polluted soils; a dam at the outlet with poor quality water, used for irrigating a large agricultural plain. This project was initiated in the frame of the program "Usages des Sols et Sédiments : Impacts Sanitaires" supported by the Development Research French Institute (IRD) and realized in collaboration with the Ministry of Public Health (MOPH) and the National Park, Wildlife and Plant Conservation Department at Phrae.

2. MATERIALS AND METHODS

2.1 Study site

Located in the northern region of Thailand (17.5°N - 18.3°N; 99.5°E - 100.2°E), Phrae province stretches along the large flood plain of the Mae Yom River, bordered by two mountainous North-South alignments. With an overall area of 6,538.6 square kilometers, Phrae scarcely preserves 69.3% covered by forests, mostly on the highlands (Royal Forest Department, 2003). In spite of its remote location, 551 kilometers from Bangkok, Phrae has never appeared isolated, benefiting from the richness of its teakwood forests to develop economically. However, deforestation, forest fires, encroachment, agricultural expansion have been threatening forested areas.

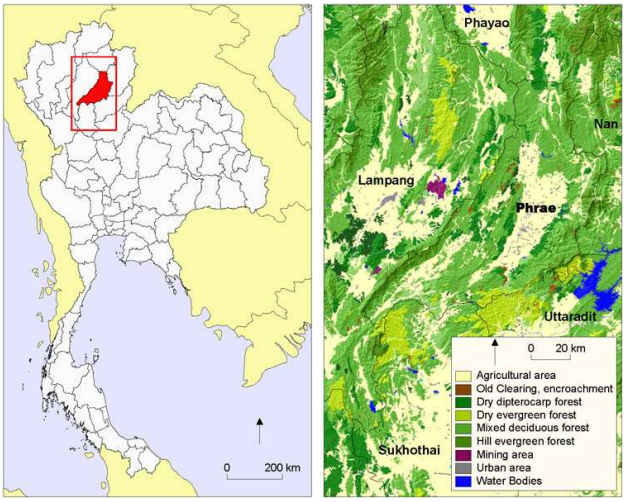


Figure 1. Location and land cover of Phrae province in Thailand (from Landsat V TM images in 2000).

The Mae Thang study area, located in Rong Kwang district, one of the eight administrative district of Phrae province, was chosen as a representative example of the environmental changes occurring in northern Thailand. In 1995, a dam was constructed at the outlet of the 120 sq. km. Mae Thang watershed, to develop agriculture downstream by irrigating lands. The study area follows the course of water from the highlands to villages within the irrigated area (from 1,800 to 250 meters above sea level). Two villages are identified in the watershed, with scattered houses and a total population of 1,428 inhabitants. In the irrigated area, population is grouped together in ten villages with a total of 4,882 inhabitants, most of them farming rice fields around or raising cattle. Many farmers from these villages commute everyday to the watershed where they have lands and increasingly produce corn.

Since the Eighties, the Thai Ministry of Public Health has progressively provided every district with a hospital and every sub-district with a health center to reach nowadays a full coverage of the territory. Then, there is one health center in the watershed, two in the irrigated area and two others nearby.



Figure 2. Phai Yo health center, a typical 2-floor building built in 1999, with 3 health officers

Ten kilometers from the study area is located Rong Kwang hospital, where acute patients are sent after consultation in any of these health centers.

2.2 Cases geo-referencing

Every clinical case from 78 different pathologies, recorded in the health centers or hospitals, are reported in a few days to the provincial office of the MOPH at Phrae. Since 1997, records keep track of the location of the patient's village, the place of consultation and date of the onset of the symptoms.

Using *SavGIS*®, a GIS freeware developed by the IRD, a GIS was set up with Phrae provincial Public Health Office to provide a dynamic mapping of the epidemiological records. The location of each health infrastructure in the province (10 hospitals and 119 health centers) was recorded with a Global Positioning System. The location of villages was obtained from the National Statistic Office (NSO), responsible of the National Census. Codes for villages from MOPH and NSO differ significantly and were linked together according to their Thai names. As the extent of villages is not delimited, villages are geo-referenced with an approximate center point. Then every reported case could be geo-referenced either at the village of residence or the place of consultation.

3. RESULTS

3.1 Measurements of environmental changes

Since the seventies, agricultural lands are expanding in the Mae Thang watershed, starting with slash-and-burn cultivation of soya bean. In the eighties, agriculture was intensified with a second cultivation of mungbeans, contributing to massive soil erosion (Janeau et al 2003). Since the end of the nineties, international companies have been increasingly leading agricultural activities, promoting corn cultivation and providing farmers with seeds, fertilizers and pesticides. Downstream of the dam, rice cultivation is still the main activity, boosted in production by irrigation. Important streaming has been measured in the Mae Thang watershed: from 20 to 30% for annual regular rainfall, with 10-15 $g.l^{-1}$ of soil losses, directed to the dam. Nevertheless, no contamination by heavy metals was found in the reservoir (Cd, Pb). During the dry season, Fe and Mn appear under the thermocline, water is impoverished in O_2 and H_2S is produced. Cyanobacteria, from unclarified origin, (*Cylindrospermosis sp.*, *Limnothrix*, *Lyngbia*, *Pseudanabaena*, *Raphidiopsis*) are the majority of the plankton biomass. These bacteria are not harmful for humans but could cause minor gastric problems. High mortality observed in fisheries should be one of the consequences of these phenomena. Methane is produced in the deepest water stratum, where is extracted water for irrigation. From the reservoir, water is mostly used to cultivate rice. Direct contact with water may be occasional for farmers at risk of water-borne diseases infection. Use of water for bathing or cooking is not yet evaluated.

The increasing use of chemical fertilizers and pesticides (mostly insecticides and weed killers) in agriculture has some consequences on health, which are difficult to estimate in term of gravity and incidence due to limited report and unknown diagnostic. However some cases of pesticide poisoning are also increasingly recorded over the country by the MOPH, showing a significant correlation with the quantity of pesticides used (Figure 3).

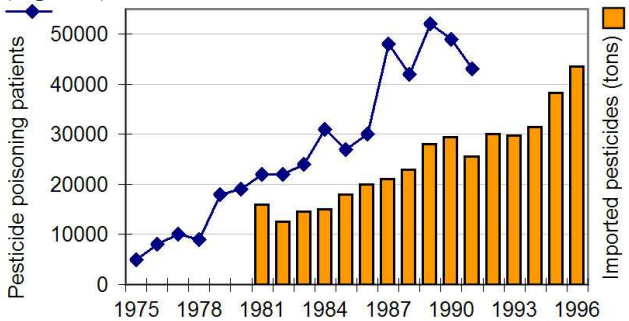


Figure 3. Comparison between records of pesticide poisoning and imported pesticides in Thailand (Sources: MOPH, 1993; Department of Agriculture, 1998)

The correlation observed at a country scale can be used to estimate in the study area a theoretical number of poisonings.

3.2 Health status of the Mae Thang area, compared to Phrae province

Compared to Phrae province, all pathologies taken together present higher incidences every year, up to 1.8 times higher in 2000 (Figure 4).

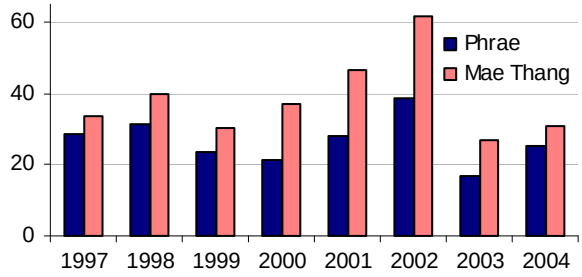


Figure 4. Incidence of all reported diseases in Mae Thang area and Phrae province, Thailand (Sources: MOPH, NSO)

Three hypotheses can be formulated: a higher number of cases, a higher recourse to health care, or an easier access to health services. Most of the reported infectious diseases are diarrheas that can be from various origins but possibly linked to water quality. Two epidemics of conjunctivitis were recorded in 1998 and 2002 in both province and study area (figure 5).

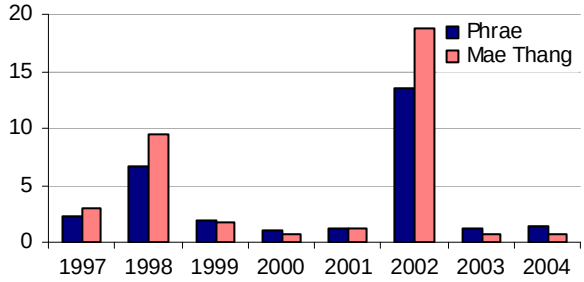


Figure 5. Incidence of conjunctivitis in Mae Thang area and Phrae province, Thailand (Sources: MOPH, NSO)

During the other years similar or lower records were reported from the Mae Thang area, showing that recourse and access to health services are not the real factor explaining the higher incidences. Food poisonings differ also from one year to another (figure 6).

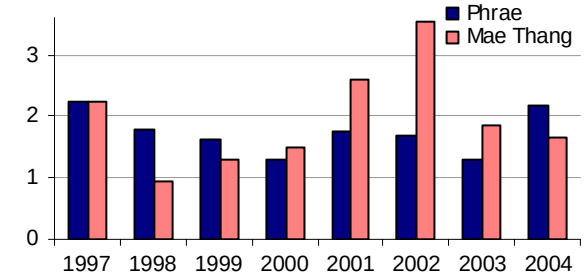
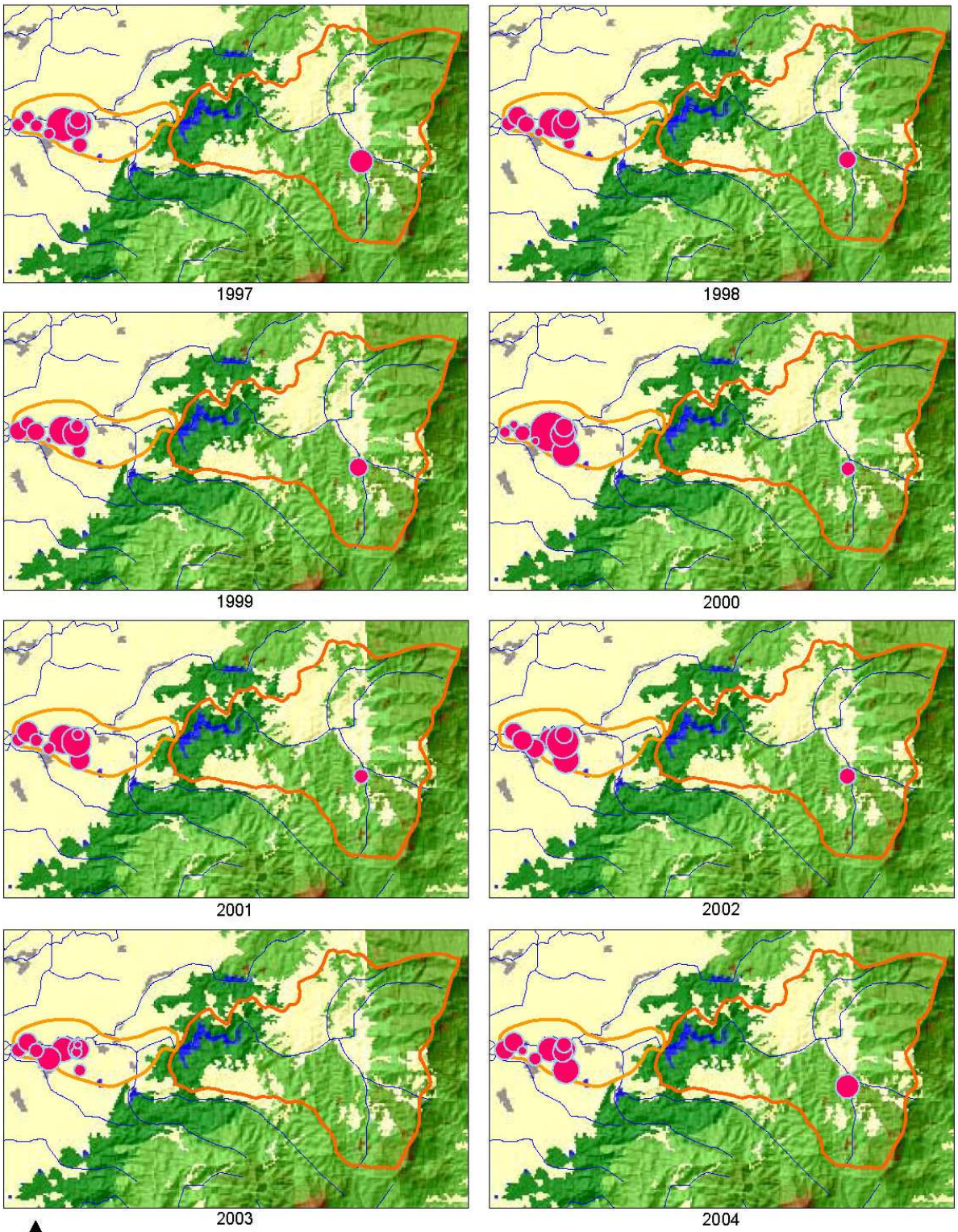


Figure 6. Incidence of food poisoning in Mae Thang area and Phrae province, Thailand (Sources: MOPH, NSO)

Figure 7. Incidence of diarrhoea in Mae Thang catchment and downstream, from 1997 to 2004 (Phrae, Thailand)



In 2002 high incidence of food poisoning remains unexplained but could have an environmental origin. High incidences of leptospirosis, transmitted from rats to humans through water, were also recorded in the Mae Thang area, during the epidemics starting in 1998. It illustrates the exposure of villagers to the infection by water-borne diseases.

3.3 Spatial approach of the health status

Incidences were calculated for 1,000 inhabitants by village and maps realized for each pathology. Few cases were reported from the two villages located in the watershed, probably due to a lower record of real incidences. Houses are isolated and access to health services more difficult. Populations are also living with lower incomes and may have a limited recourse to health care. Within the irrigated area, villages upstream show higher incidences than those 2 kilometers downstream for diarrhea (up to 2 times higher), conjunctivitis and food poisoning. Exposure and vulnerability should be higher in these villages, but cannot be assessed with the present data. Leptospirosis incidences vary from one village to another every year. Higher incidences were also recorded in the villages surrounded by rice fields. Further public health investigations are needed and planned to understand what can be the differences between villages in consumption habits, use of water or daily trips to rice fields.

4. DISCUSSION

Dealing with epidemiological data necessarily reflects the quality of the health system, practices and recourse to health services. An increasing incidence of an emerging disease, such as leptospirosis in Phrae, does not necessarily implies it did not exist before. The overall incidence of records (all pathologies together) is on average 2,692 for 100,000 inhabitants in Phrae, while it is 4,889 in Loei, a comparable province, 200 kilometers to the South-East of Phrae (489,590 inhabitants in Phrae and 631,408 in Loei). In both provinces, the percentage of diarrhea in total records is stable with an average of 56% for Phrae and 50% for Loei. It seems that reports of diseases are low in Phrae with many possible causes implicating the health system, service, quality and access but also the health behavior. More investigations are finally needed to assess the use of health services and estimate, from epidemiological reports, the theoretical incidences.

5. CONCLUSION

This work constitutes a first attempt of epidemiological mapping at a village scale in Thailand, raising the difficulties to deal with different coding systems. Administrative entities are not fixed but evolving, increasing in number consequently to the economic development. Among them, villages are not clearly defined, without borders, their number or even names depending on ministries or governmental agencies. There is a real need to agree on a common definition and classification of villages and also subdistricts in Thailand, and a need to provide administrative maps at each level (provinces to villages), matching with the different step of the evolution of the administrative divisions, and made on a national common agreement.

Understanding the consequences of environmental and especially agricultural changes on health needs long term investigations to observe and measure the dynamics. However, some signs can already be interpreted. Spatial analysis enabling different scales of study has proved to be a real support of analysis showing unknown radical differences in incidence a few kilometers apart, which cannot be observed with aggregated geo-referenced data at other scales.

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