

Households' Relocation Decision in Air Pollution Context of Cotonou

Fanougbo AVOCE VIAGANNOU¹, Ph. D

Abstract

The purpose of this paper is to analyse the determinants of the decision to relocate households in the context of air pollution in Cotonou. The study used the database produced in 2010 by the "Centre for Studies, Training and Research in Development" of the University of Abomey-Calavi in Benin, as parting of an assessment of the health effects of air pollution in Cotonou. A logit model of relocation decision was estimated using a sample of 584 households. The results showed that monthly average income, health expenditure, health status and secondary and higher education levels positively influenced the household's decision to relocate. Moreover, it appears necessary to reduce health expenditure whilst improving the health status of the population, without neglecting the improvement of income levels; as well as the strengthening of secondary and higher education. Thus, taking into account the effects of air pollution in policies is still relevant to achieve sustainable development.

Keywords: air pollution; households' relocation decision; health expenditure; migration; sustainable development; Cotonou.

1. Introduction

Air pollution is always a negative externality. It generates significant costs for the population, especially health costs of both morbidity and mortality. The recent works on these costs concerning the city of Cotonou show the importance of the damage that this air pollution causes to the populations (Avoce Viagannou, 2018; Avoce Viagannou, 2015). Mishra and Goyal (2015) confirm that the quality of air is the very important environmental situation we face in the developing countries. For these authors, recently, the harmful effects of air pollution on human health are of increasing concern. This particular feature of air pollution sometimes leads populations exposed to migration from a highly polluted area to a less polluted one. Therefore, some population movements find their justification in the consequences of air pollution (Mueller and al., 2014). In fact, environmental factors have been mentioned in the first systematic theory of migrations of Ravenstein (1889). This author postulated that an "unattractive climate" was, and continue to be a major factor causing migratory streams. As an explanatory factor, the environment has almost disappeared from the literature on migration in neoclassical economic theory (Harris & Todaro, 1970). According to these authors, migration depends on the one hand, the income differential net of the costs of migration between countries of departure and destination; and on the other hand, the difference in factor endowments (capital and labour). Also, bad or oppressive laws, hostile social environment, economic motivations can also trigger migratory flows (Piguët and al., 2011).

Today, environmental issues are resurfacing at a high intensity with growing concerns about climate change (Gemenne, 2011). For this purpose, there is an increased tendency to research the relationship between environmental change and population displacements (Thiamand Crowley, 2014). This is justified by the abundant scientific production raising, since the 1980s. The role of environment in migratory flows is creating contradictory debate between environmentalists and migration specialists (Piguët and al., 2011). The environmentalists considered environmental degradation as the sole determinant of migration, rather than one of several determinants as opined by migration specialists (Piguët and al., 2011; Castles, 2002; Black, 2001).

Generally, among many others, the environmental factors that determine population displacements are desertification, salinisation of agricultural land, rising sea levels (Tacoli, 2009) and on the other hand, natural disasters ie floods, cyclones etc. (Gonin and Lassailly-Jacob, 2002).

¹ Senior Lecturer and Deputy Head of Planning Department, The Benin School of Applied Economics and Management (ENEAM), Laboratory of Public Economy (LEP), University of Abomey-Calavi (UAC), Postal Box: 05 BP 1652 Cotonou, Benin
Phone: +229 97 44 34 59; +229 94 52 52 66 Email: fanougbo.viagannou@eneam.uac.bj; fanougboisaac2@yahoo.com

Nearly 99 million people have been forced to relocate because of floods between 2000 and 2008 and about 39 million due to tropical cyclones and storms (Vos and al., 2009). These movements are internal and often short-lived because populations cannot afford long-distance travel (Paisand Elliott, 2008). Compared to cyclones and floods, drought and desertification cause more progressive mobility patterns (Goninand Lassailly-Jacob, 2002) of people in order of 83 million per year (Vos and al., 2009). On the other hand, sea level rise is a situation that is observed much later and shows a linear trend over a long full stop (Piguet and al., 2011). Gibbons and al. (2006) show that in Chesapeake (US Atlantic Coast), the rise of the sea by 0.35 cm per year forced resident populations to abandon their homes. Temperature is also a factor in the decision to migrate (Ruohong and al., 2014). Using data from 42 migrant-receiving countries of all origins, these authors showed that the variability of weather, specifically a rise in temperature, influences the international migration of agricultural countries. Barrios and al. (2006) show from panel data, that rainfall influences rural exodus in sub-Saharan Africa. Similar results were obtained by Feng and al. (2010) in Mexico. This migration is the result of poor agricultural yield due to climate change (Feng and al., 2012). This failure in agricultural yield is caused by the decrease in rainfall; this has an important effect on mobility in Bangladesh whilst the flood has a moderate effect (Gray and Mueller, 2012). Similar finding was reported in Pakistan by Mueller and al. (2014). The climate changes that cause these displacements of the population are reinforced by the pollution of the air which acts on the greenhouse effect.

The questions of air pollution are nonetheless explanatory because of the displacement of populations. In addition to the greenhouse effect, air pollution generates social and economic costs related to the diseases it causes, and also mortality costs. These constraints of health costs, state of health degraded by air emissions, are some factors that justify the displacement of households from a highly polluted city to a less polluted one. Several authors have based their research on the link between air pollution and emigration (Qin and Hongjia, 2015; Yazdanparast and al., 2013). All this supposes that a city exposed to air pollution can experience displacements of its population towards less polluted places.

Despite efforts to fight against air pollution, the municipality of Cotonou considered the most polluted in the country. Indeed, Benin has a framework law on the environment, the environmental police is set up, environmental taxes instituted, all this to fight against the degradation of the environment. From the results of the survey carried out by "Centre for Studies, Training and Research in Development" (CEFRED) in the context of the health costs of air pollution in Cotonou in 2010, nearly 42% of respondents have plans to move from the city because of the embarrassment that pollution creates for them. The probability of deciding to leave the city for reasons of pollution does not seem to be zero. In such an environment the understanding of the factors that lead some populations to make the decision to relocate from Cotonou is necessary. The various works (World Bank, 2002) previously carried out in the field on the city in terms of air pollution, had not yet oriented analysis on the determinants of the decision of households to reallocate in such context. These various studies highlighted the importance of air pollution in the city (highlighting the concentration levels of air pollutants); in the same way, the real sources of the latter are evoked with the different affections engendered and their costs. But the analysis in terms of population displacement has not really been addressed. Knowledge of these factors helps to strengthen and guide appropriate environmental policies.

The purpose of this paper is therefore to analyse the determinants of the decision of households to reallocate in the context of air pollution in the city of Cotonou.

The paper is structured in five sections. Apart from the previous section, the second section presents a brief review of the literature on the subject. The methodology of the study and the statistical and econometric results are presented in the third and fourth section respectively. The last section provides conclusions and policy recommendations.

2. Literature review

The environment as an explanatory factor of population displacement is debated in the economic literature. One school of thought, migration specialists, think that environment plays a minor role in the migration of population and it is not worthy of interest to focus on this factor (Gray and Mueller, 2012; Mueller and al., 2014). International migration or internal migration (mobility or relocation) of populations is not the only consequence of the environmental changes of climate change (Gray and Mueller, 2012; Mueller and al., 2014).

Furthermore they suggested that they are any empirical analysis due to lack of data supporting the opposite of their thoughts. Mortreux and Barnett (2009) have shown that in Tuvalu, most potential migrants do not move because of climate change. Naude (2010) also shows that natural disasters do not really influence international migration in sub-Saharan Africa. In the real estate sector in China, there are moves due to rising rental demand (Kinnan and al., 2016). Other factors, including air pollution, can force people to move. Hsieh and Liu (1983) find that air pollution positively influences emigration of the labour force.

Similarly, for OECD countries, Xu and Sylwester (2016) have concluded that a positive correlation is observed between air pollution and the emigration rate of individuals who are more educated. In the context of the earthquake in China between 1996 and 2010, Chen and al. (2017) confirmed the previous results by revealing that the air pollution had a significant effect on migration. Based on those who are interested in emigration, Qin and Hongjia (2015) have focused their research on the impact of air pollution on this interest. They show that when the index of air quality grows by 100 points today, the number of searches on the word "emigration" will increase by 2.3 to 4.7% the next day. Moreover, this result is more pronounced when this index exceeds 200 points and differs from one host country to another. In the United States, in the short term, a higher quality environment is a dominant factor that explains inter-regional migration (Hsieh and Liu, 1983). A similar conclusion is drawn in Italy on the 2010 polluted air emission data from the Institute for Research and Environmental Protection. On the basis of a comparative analysis, Germani and al. (2018) show that populations in the highly polluted northern regions (pollution due to advanced industrialisation and urbanisation) are migrating to regions where air quality is better. It is this same industrialization-urbanization that exposes children aged 5 to 11 to respiratory diseases due to air pollution in China (Yazdanparast and al., 2013). To avoid pollution, parents decide to migrate to healthy places rather than pay for better air quality (Renaud and al., 2011). Hunter (2005) discovered that the environmental hazard influences the decision of residential migration. Chu and al., (2017), interested in understanding parents' propensity to migrate and their willingness to pay to have a quality environment, use a multivariate logistic model of data collected from a community in the Wuchang region. These authors find that the potential migrants are hospitalized (36.4%) on the one hand and part of the community (30.7%) on the other hand; particularly those with the highest average annual income (50,000 Yuan) and with a high level of knowledge of air quality issues among hospital patients.

It follows from the above that the decision to relocate from a polluted environment does depend on several factors. Indeed, the degraded state of the air recognized by the population, the state of health of the populations exposed to pollution, justify making this decision. In addition, the level of household income and pollution abatement costs also lead people to decide to leave the polluted area.

3. Methodology

3.1 Data

This study used the database collected in 2010 by the "Center for Studies, Training and Research in Development" of University of Abomey-Calavi, as part of an assessment of the health effects of air pollution in Cotonou. The database includes information on the socio-economic characteristics of 584 heads of households in the city. It also details the information on the conditions suffered by individuals and due to air pollution as well as the various costs in terms of morbidity and mortality. In this database the statistical units provided information about their plans to move or not from the city due to air pollution.

3.2 Estimated model

This paper explains the probability that individuals move or not due to air pollution. A discrete choice model is needed. The appropriate model was chosen based on the AIC information criteria, the Schwartz criterion and the Maximum Likelihood. Indeed, based on the available data. The Logit model presents the best convergence criteria compared to the Probit model (AIC of Probit Model: 779.5552; AIC of Logit Model: 778.6726).

Logit is based on the assumption that errors follow a logistic distribution.

Considering a linear function $Y_i = X_i\beta + \varepsilon_i$, Y_i is the unobservable dependent variable, X_i a set of characteristics of the individual i , β is the vector of the parameters and ε_i the error. We introduce a latent variable Y^* ; unobservable but perceived by the respondent and indicating the utility associated with the occurrence of the phenomenon. Taking Y^* as an index whose large values are associated with higher probabilities of realisation of the phenomenon, we have in this paper:

$$\begin{cases} \Pr ojMove_i = 1 & si & \Pr ojMove_i^* > 0 \\ \Pr ojMove_i = 0 & si & \Pr ojMove_i^* \leq 0 \end{cases} \text{ The variable } \Pr ojMove_i^* \text{ becomes a}$$

dependent function of independent variables X_i such as: $\Pr ojMove_i^* = X_i\beta + \varepsilon_i$. Thus, we have:

$$\begin{aligned}
 Prob(ProjMove_i = 1) &= Prob(ProjMove_i^* > 0) \\
 &= Prob(X_i\beta + \varepsilon_i > 0) \\
 &= Prob(\varepsilon_i > -X_i\beta) \\
 &= Prob(\varepsilon_i / \sigma > -X_i\beta / \sigma)
 \end{aligned}$$

The distribution being symmetrical in the case of the Logit model, so

$$Prob(\varepsilon_i / \sigma > -X_i\beta / \sigma) = Prob(\varepsilon_i / \sigma < X_i\beta) = Prob(ProjMove_i = 0)$$

$$Prob(ProjMove_i = 0) = 1 - Prob(ProjMove_i = 1)$$

The distribution function of the logistic law is as follows (Wooldridge, 2002):

$$G(z) = \Lambda(z) = \frac{\exp(z)}{1 + \exp(z)}$$

The set of variables likely to affect the probability of decision to move individuals from the database are basically those identified in the literature or their proxy. The variables selected are as follows:

The dependent variable “**Project to move (ProjMove)**” is a dichotomous variable that takes the value 1 when the individual has a project to move because of air pollution and 0 when he has no plan to move despite the environment polluted. The explanatory variables and signs are in the Table 1.

Table 1: Variables and expected signs

| VARIABLES | DESCRIPTION | Units | EXPECTED SIGNS |
|--------------------|---|---|---------------------------|
| Project to move | Project to move from the city (dichotomous) | 1=yes, 0= otherwise | Explained Variable |
| Average Income | Average monthly income | FCFA | + |
| Health expenditure | Monthly health expenditure | FCFA | + |
| Treatment Cost | Treatment Cost of the disease | FCFA | + |
| Housing time | Housing time in the city | Years | - |
| Smoker | Being a smoker | 1=yes, 0= otherwise | - |
| Age | The age of the household's head | Years | - |
| Agesquare | Age square | Years | + |
| Health Status | Health status | 1= yes: if the respondent has suffered from an embarrassing illness two months prior to the survey that led to the database, 0= otherwise | + |
| Troublesome | Air pollution is troublesome | 1= yes: when the individual recognizes that the air pollution is troublesome, 0= otherwise | + |
| Education Level | Individual level of education | 1= level1(primary), 2=level2 (secondary), 3= level3 (higher), 4= level4 (none): | + |

Source: Author

4. Results and discussion

The results are presented, analysed and discussed. In this section, the statistical analysis is done to appreciate the characteristics of the data of the database. Also, the determining factors of the move decision are identified.

4.1. Statistical analysis

This analysis provides an overview of the sample studied in relation to variables likely to influence the decision to move individuals (heads of households) in a context of air pollution.

In the exploited database, of the 584 household heads, 242 had a plan to move out of the city entirely due to pollution. Of this number, 233 recognized pollution as troublesome as shown in Table 2:

Table 2: Crossing variables "project to move" and "Annoyance of air pollution" (from the database)

| | | Are you planning to move completely from the city of Cotonou in the next two years due to air pollution? * | | TOTAL |
|----------------------------------|----------------------------|--|------------|-------|
| | | Project to move from the city | | |
| Does air pollution hinder you? * | Annoyance of air pollution | NO | YES | |
| | | NO | 19 | 9 |
| YES | 323 | 233 | 556 | |
| TOTAL | 342 | 242 | 584 | |

* Questions extracted from the database

Source: Author, Extract Descriptive Statistics

This table 2 shows that most people, who plan to move from the city because of air pollution, recognise this pollution as embarrassing.

Table 3 presents the essential characteristics of the individuals in the database. About 41% of the workforce in this database has a relocation project due to pollution. On average, these individuals spend around 9,400 FCFA on rent per month; some paying no rent and the highest rent is 150,000 FCFA. Similarly, each individual has an average monthly income of about 61,000 FCFA; this average monthly income varies between 25,000 FCFA and 105,000 CFA.

The respondents spent on average about 12,450 FCFA on health. The cost of treatment reported, due to the morbid episode prior to the survey used to build the database, averages about 9,900 FCFA. In addition, the average time spent in Cotonou by the respondents was about 22 years, and the average age was about 38 years old. Individuals who have admitted to smoking were in a proportion of about 12%. The youngest was 18 years old and the oldest was 82 years old. About 72% of individuals reported having an uncomfortable illness two months prior to the survey used to produce the database. Also, about 95% of household heads have recognized that air pollution is troublesome.

Table 3: Descriptive statistics of variables

| Variables | Number of observations | Average | Standard Deviation | Minimum | Maximum |
|------------------------|------------------------|-----------|--------------------|---------|---------|
| Project to move | 584 | 0.4143836 | 0.4930376 | 0 | 1 |
| Average Income | 584 | 61061.64 | 27817.77 | 25000 | 105000 |
| Health expenditure | 584 | 12448.12 | 16998.16 | 0 | 170000 |
| Treatment Cost | 584 | 9907.209 | 27247.71 | 0 | 400000 |
| Housing time | 584 | 22.22389 | 14.08584 | 0.25 | 68 |
| Smoker | 584 | 0.1164384 | 0.3210248 | 0 | 1 |
| Age | 584 | 37.76027 | 10.33209 | 18 | 82 |
| Agesquare | 584 | 1530.046 | 908.9572 | 324 | 6724 |
| Health Status | 584 | 0.7191781 | 0.4497859 | 0 | 1 |
| Troublesome | 584 | 0.9520548 | 0.2138335 | 0 | 1 |
| Education Level | 584 | 2.085616 | 1.000167 | 1 | 4 |

Source: Author, after estimation under STATA

4.2. Determinants of household's relocation decision

In accordance with the methodology adopted, the analysis of the factors likely to influence the decision to move leads to estimate a LOGIT decision-making model of the relocation of the city of Cotonou in a context of air pollution. Table 4 presents the estimation results of this model.

Table 4 shows an overall significance of the [Prob> chi2 = 0.0000] model. Indeed, all the explanatory variables considered give a definite contribution to the explanation of the decision to move. Five variables are positively significant; it is the average monthly income, the monthly health expenditure, the state of health, the level of secondary education and the level of higher education. This sense of meaning meets our expectations. Thus, the average monthly income is positively significant at 10%. In fact, the decision to move is influenced by the income of individuals, which reflects the fact that the probability of moving increases with income. The more income a person has, the more likely they are to complete their relocation project. Indeed, from a theoretical point of view, income is a determining variable in the demand for a good in microeconomics. It helps to cope with consumer spending. The higher the income, the more the consumer increases the demand for normal good, the prices remaining unchanged. In a similar way, any individual whose income increases, will have more ease in coping with the moving expenses that are here the costs of applying for better air quality. Already in the theoretical approach of Harris & Todaro (1970), the income differential between regions explains the displacements of the populations. This highlights the importance of income in moving decisions. In each of the theories, it must be understood that the individual is in search of well-being. And the pursuit of well-being is always a concern for the development of nations. Thus, the various movements of populations from one area to another must be integrated into the country's development policy decisions.

Table 4: LOGIT Model Estimation Results of Relocation Decision

| Variables | Coefficients | Probabilities |
|--------------------|--------------|---------------|
| Average Income | 0.00000621* | 0.088 |
| Health expenditure | 0.0000122** | 0.043 |
| Treatment Cost | -2.000005 | 0.541 |
| Housing time | -0.0028527 | 0.701 |
| Smoker | 0.3941388 | 0.143 |
| Age | -0.0043211 | 0.932 |
| Agesquare | -0.0000376 | 0.948 |
| Health Status | 0.5577794*** | 0.006 |
| Troublesome | 0.2957054 | 0.497 |
| Education Level2 | 0.686053*** | 0.001 |
| Education Level3 | 0.6483943** | 0.035 |
| Education Level4 | 0.3910896 | 0.184 |
| Constant | -1.745411 | 0.110 |

Number of observations = 584

LR chi2 (12) = 45.22

Prob> chi2 = 0.0000

*** Significant at 1% ** significant at 5% * significant at 10%

Source: Author, after estimation under STATA

The increase in health expenditures (5% significance) due to morbid episodes increases the probability of moving out of the city. More the people suffer from an annoying disease due to air pollution, more they have a higher probability of moving. Secondary and higher education levels were significant at 1% and 5% respectively. So, the more educated the individual is, the more likely he is to move from the polluted area.

Table 4 presents the marginal effects of the main variables of the estimated model. According to this table, the magnitudes of the coefficients of the variables "average income" and "health expenditure" are relatively low (0.00000150 and 0.0000029). Despite this weakness of size, these variables positively influence the probability of relocation. Thus, for those with higher incomes, the effect would be much more noticeable, confirming from this point of view the work of Chu and al. (2017). Here, the monthly health expenditures made by individuals are linked to the morbid episodes related to air pollution. Indeed, individuals who have high expenses will have a higher probability of moving.

Table 5: Marginal Effects of Major Variables

| Variables | dy/dx | Probabilities |
|-------------------|------------|---------------|
| Average Income | 0.00000150 | 0.088 |
| Healthexpenditure | 0.0000029 | 0.044 |
| Health Status | 0.1304938 | 0.004 |
| Education Level2 | 0.1658963 | 0.001 |
| Education Level3 | 0.1599874 | 0.034 |

Source: Author, after estimation under STATA

In addition, the health status of individuals who have suffered from an embarrassing disease is a determining variable. Indeed, when the individual admits having suffered, the number of chances of relocation decision increases by about 13%. This situation is similar to the case discussed in China by Yazdanparast and al. (2013) on respiratory diseases to which children are exposed. And to do this, the solutions found are to decide to migrate to healthy places rather than pay for better air quality (Renaudand al., 2011). Finally, the individual level of study is very important. Specifically, when the individual has a secondary level, there is an increase of almost 17% in the number of chances to relocate.

Similarly, the probability of the decision to relocate increases by about 16% when individual has a higher level than in the primary level case. The level of education increases the knowledge on pollution; thus, allowing to have a positive effect on the decision to relocate. This result is similar to that obtained by Chu and al. (2017), according to which a high level of knowledge on pollution issues increases the propensity to migrate.

In addition, the fact that the individual sees the pollution as embarrassing (Troublesome) in the city of Cotonou had no effect on the decision to move. This result does not seem surprising because of the significance of the variables "health status" and "health expenditure". Beyond a simple statement on the discomfort felt by individuals, their health expenditure coupled with their healthstatus; indirectly provide information on how pollution is inconvenient.

Overall, the average monthly income, health expenditure, health status and education level fundamentally determine people decision to move from Cotonou due to air pollution.

5. Conclusion

The purpose of the paper is to analyse the determinants of the decision to relocate in a context of air pollution in Cotonou. The analysis was done based on a sample of 584 households. In terms of results, the average monthly income, health expenditures, the health status of individuals and their level of education are the factors that influence the decision to relocate from Cotonou due to air pollution. By the way, this decision theoretically depends on the income of the individual. In this paper, despite the small magnitude of the income effect, it should be noted that it remains an important factor. Indeed, the results confirm the microeconomic theory. As a result of air pollution, the health expenditures made by individuals and the state of their health encourage households to leave the polluted area to a less polluted one. Thus, the health consequences of air pollution partly justify the decision to relocate. In addition, secondary and higher education levels have an important contribution to the decision to relocate.

Overall, the relocation projects reported by the respondents, due to air pollution, are explained by average monthly income, health expenditures, health status and education level. But it is noted that this paper would gain more in analysis if the database had moving costs. This would have made it possible to appreciate the effect of these costs on the probability of moving. This consideration will deepen in future research. Ultimately, it is necessary to reduce health expenditures whilst improving the health status of the population. The improvement of income levels must be considered. The strengthening of secondary and higher education should be continued. All this, to allow a better knowledge of the effects of the air pollution; and a taking into account of the externality in the various policies.

Thus, taking into account the effects of air pollution in policies is still relevant to achieve sustainable development. And as the fundamental concern of the governments is to reduce the air pollution, Montovani and Vergari (2016) specify that the main reason globally recognised is that of the protection of the environment. From this point of view, these authors show the arbitration that must be made between the use of the pollution tax and an environmental awareness campaign in terms of policy instruments.

6. References

- Avoce Viagannou, F. (2018), “Air pollution in Cotonou: An evaluation of the statistical value of life”, *International Journal of Research in Environmental Studies*, Vol. 5(1), pp 1-9
- Avoce Viagannou, F. (2015), “Morbidity due to Air Pollution in Cotonou: An Assessment of the Psychological Cost”, *Int J Econ ManagSci* 4: 268. doi:10.4172/21626359.1000268.
- Barrios, S., Bertinelli, L., Strobl, E., (2006), « Climatic Change and Rural–urban Migration: The Case of Sub-Saharan Africa », *Journal of Urban Economics* 60 (3), 357–371.
- Black, R., (2001), « Environmental refugees: myth or reality? » *New Issues in Refugee Research – UNHCR, Research Paper (34)*.
- Castles, S., (2002), « Environmental change and forced migration: making sense of the debate. », *New Issues in Refugee Research – UNHCR, Research Paper (70)*.
- Chen S., Oliva P. and Zhang P., (2017), « The Effect of Pollution on Migration: Evidence from China. », *NBER Working Papers 24036, National Bureau of Economic Research, Inc.*
- Chu Y., Liu Y., Lu Y., Yu Y., Lu H., Guo Y., Liu F., Wu Y., Mao Z., Ren M., Li N., Chen X., Xiang H., (2017), « Propensity to Migrate and Willingness to Pay Related to Air Pollution among Different Populations in Wuhan, China », *Taiwan Association for Aerosol Research ; Aerosol and Air Quality Research*, 17: 752–760.
- Feng S., Krueger A. B. and Oppenheimer M., (2010), « Linkages among climate change, crop yields and Mexico-US cross-border migration », *Proceedings of the National Academy of Sciences*, vol. 107(32), pages 14257-14262.
- Feng S., Oppenheimer M., and Schlenker W., (2012), « Climate change, crop yields, and internal migration in the United States », *NBER working paper 17734*; DOI: 10.3386/w17734.
- Gemenne, F., (2011), « Migrations et déplacements de populations dans un monde à + 4° C Scénarios d'évolution et options politiques ». *Études*, 6, Tome 414.
- Germani, A. R., Talamo, G. and Scaramozzino, P., (2018), « Air Pollution and Migration in Italy: An Empirical Investigation at Provincial Level. », *Economie*, 16 (1). pp. 26-31.
- Gibbons A. S. J. and Nicholls R. J., (2006), « Island abandonment and sea-level rise: An historical analog from the Chesapeake Bay, USA. », *Global Environmental Change* 16(1): 40-47.
- Gonin, P. and Lassailly-Jacob, V., (2002), « Les Réfugiés de l'environnement », *Revue Européenne des Migrations Internationales*, Vol. 18, N° 2, 139-160.
- Gray C, and Mueller V., (2012), « Natural disaster and population mobility in Bangladesh », *Proceedings of the National Academy of Sciences*, 109:6000–6005.
- Harris, J. and M. P. Todaro, (1970), « Migration, Unemployment and Development: A Two-Sector Analysis. », *American Economic Review* 60(1), 126-142.
- Hsieh, C. and Liu, B. (1983), « The Pursuance of Better Quality of life: In the Long Run, Better Quality of Social Life Is the Most Important Factor in Migration », *The American Journal of Economics and Sociology*, vol. 42(4): 431–440.
- Hunter, L.M., (2005), « Migration and environmental hazards », *Popul Environ*, 26, 273–302.
- Kinnan, Cynthia, Shing-Yi Wang, and Yongxiang Wang., (2016), « Access to Migration for Rural Households », *American Economics Journal: Applied Economics* (Forthcoming).
- Mantovani, A. and Vergari, C. (2016), “Environmental vs hedonic quality: which policy can help in lowering pollution emissions?”, *Environment and Development Economics* 22: 274–304 © Cambridge University Press 2017 doi: 10.1017/S1355770X16000371.
- Mishra, D and P. Goyal (2015), “Analysis of ambient air quality using fuzzy air quality index: a case study of Delhi, India” *International Journal of Environment and Pollution*, Vol.58 No.3, pp. 149-159;
- Mortreux, C., and Barnett, J., (2009), « Climate Change, Migration and Adaptation in Funafuti, Tuvalu », *Global Environmental Change*. 19 (1), 105–112.
- Mueller V., Gray C. and Kosec K., (2014), « Heat Stress Increases Long-term Human Migration in Rural Pakistan », *Nat Clim Chang*. 4: 182–185.
- Naude, W., (2010), « The Determinants of Migration from Sub-Saharan African Countries ». *Journal of African Economies* 19 (3), 330–356.
- Pais J. F. and Elliott J. R., (2008), « Places as Recovery Machines: Vulnerability and Neighborhood Change After Major Hurricanes »; *Social Forces* 86(4): 1415-1453.

- Piguet E., Pecoud A. and De Guchteneire P., (2011), *Migration and Climate Change*, Cambridge: Cambridge University Press and UNESCO Publishing. xix + 442pp. ISBN 978 1 107 66225 4.
- Qin Yu and Zhu Hongjia, (2015), « Run Away? Air Pollution and Emigration Interests in China. », *Journal of Population Economics*, Springer; *European Society for Population Economics*, Vol. 31(1), pages 235-266.
- Ravenstein, E. G., (1889), « The Laws of Migration », *Journal of the Royal Statistical Society* **52**(2): 241-305.
- Renaud, F.G., Dun, O., Warner, K. and Bogardi, J., (2011), « A decision framework for environmentally induced migration. », *Int. Migr.* 49: e5–e29.
- Ruohong C., Feng S., Pytlikov M. and Oppenheimer M., (2014), « Climate Variability and International Migration: The Importance of the Agricultural Link-age », Discussion Paper Series 1418, Centre for Research and Analysis of Migration (CReAM), University College London.
- Tacoli, C., (2011), *The Links Between Environmental Change and Migration: A Livelihoods Approach*. International Institute for Environment and Development, London
- Thiam M. T. et Crowley J., (2014), « Impact des changements environnementaux sur les migrations humaines : cas du Sénégal et Côte d'Ivoire », Rapport d'étude de l'UNESCO Secteur des Sciences Humaines et Sociales (SHS).
- Vos, F., Rodriguez, J., Below, R. and Guha-Sapir, D., (2009), *Annual Disaster Statistical Review 2008 The numbers and trends*. Brussels, Centre for Research on the Epidemiology of Disasters (www.emdat.be).
- World Bank (2002), *Air Quality in the City of Cotonou, Study on Private Sector Development and Infrastructure*, September, www.worldbank.org/afr/findings.
- Wooldridge J. M. (2002). *Econometric analysis of cross section and panel data*. The MIT Press Cambridge, Massachusetts, London, England, 741 p.
- Xu X., Sylwester K., (2016), « Environmental Quality and International Migration », *Kyklos*, Vol. 69-February 2016, N. 1, 157-180.
- Yazdanparast, T., Seyedmehdi, S.M., Khalizadeh, S., Salehpour, S., Boloursaz, M.R., Baghaie, N., Hassanzad, M. and Velayati, A. A., (2013), « Knowledge and practice of asthmatic children's parents about daily air quality », *Tanaffos* 12: 23.