Analysis of climate change adaptation mechanisms in rainfed agriculture in Morocco (1)

Laamari Abdelali[1], Faiz Mourad[2] and Lakhyar Zouhair[3]
(1) Researcher on Agricultural economics. Dryland Research Center Settat Morocco
(2) PhD Student on Economics. LMMCE ,Faculty of Law, Economics and Social Sciences Settat Morocco
(3) Professor of Social Economics. Faculty of Law, Economics and Social Sciences Settat-Morocco

Abstract:
Agricultural development is a very broad concept which depends on professional, natural, social and political issues. In Morocco, precipitation is low and highly variable from one season to another and within the cropping season. Although drought can occur at any time during the growing season, two main periods of drought are more likely; the early one that coincides with seed germination and seedling emergence and the terminal drought that is more frequent and affects grains set and growth. This variability has significant impact on cropping systems and livestock performances. In this research we have conducted a survey on more than 508 households in rainfed region of Meknes. We have tried to study production system vulnerability to climate change. So questions related to farmers perception of climate change events, farming system treats, related risk and adaptation mechanisms developed by the household were addressed. Application principal component for clustering these households and the development of multinomial logit model have demonstrated significant information on local adaptation mechanisms to climate change in the representative rainfed farming systems. The findings are important and can be used in differentiating public interventions according to wealth, education and experience in farming.
Key words: Agriculture, Climate change, Logit model, policy

Introduction

In recent decades, the world has experienced extreme weather events, unusually high temperatures, drought, floods, tsunamis, etc… Analysis of these phenomena has given special importance to the issue of climate change and places it at the center of policy making, economic or social whether regional, national or international concern. Moreover, agriculture is the economic activity that is directly affected by these phenomena especially in marginal areas where natural resources are degraded (mountains, arid and deserts, etc…)[2]. Two forms of adaptation can be distinguished: reactive adaptation and proactive adaptation. Reactive adaptation is an ex-post reaction to the adverse impacts of climate change, when they occur, and anticipatory adaptation, however, is to act before impacts occur (Smit et al, 2000)[3]. In recent years, Morocco has proposed measures and programs for adaptation to climate change particularly in the agricultural sector to combat its effects, reduce agricultural vulnerability to its impacts and mitigate its consequences. But the figures reported by national or international bodies are still in progress. This allows us to ask the question about the achievement of the objectives of these programs.

In seeking to answer this question, probably different factors should be considered. Some of them are related to climate conditions and others are related to economic and social behavior of the households. In this paper we have tried to identify and analyze the main socio-economic factors that influence the individual vulnerability of agriculture to climate change through an econometric model using cross-sectional data from a survey conducted in 2014. The survey ws conducted in three rural communities of Meknes region (Ain Jemaa, Sidi Slimane and Bettit) representing three different ecosystems. The region is part of CRP11

[1] Corresponding author is Laamari Abdelali, Email: laamari@gmail.com
[2] IFAD (2011).Climate change, building the resilience of poor rural communities.
[3] Stéphane Hallegatte , Franck Lecocq ,Christian de Perthuis.(2010). Economics of Adaptation to Climate Change. Economic Council for Sustainable Development , France.

program known as Dryland Systems launched by the CGIAR system in Africa and Asia. The Dryland Systems research program aims to identify and develop resilient, diversified and more productive combinations of mixed crop, vegetables, livestock, rangeland, and tree agro-ecosystems that have the potential to be scaled-out, where water is scarce. It targets the poor and highly vulnerable populations of the dry areas. It aims to develop technology, policy and institutional innovations to improve livelihoods, using an integrated agro-ecosystems approach.

In the case of Morocco, the program aims to develop sound policy, technology and institutional options that can improve production system vulnerability. Climate change, policy and market dynamics are affecting the production system and farmers are trying to develop new mechanisms to be adapted to this dynamic. So, the objective of this paper is to present and discuss the main results of system vulnerability in the region.

Concepts and definitions

The literature on defining the concept vulnerability and adaptation is rich. For vulnerability two definitions can be presented, from a social standpoint, the vulnerability is the degree to which an ecosystem is being negatively affected by climate change and from a technical standpoint, the vulnerability is defined as the measurement of the damage of climatic phenomenon. The analytical approach addresses the vulnerability by nature of its issues, so we have structural vulnerability when damage affects the ecosystem infrastructure, institutional vulnerability is used when institutions that have been involved are affected, human vulnerability if the population of a region which was affected and finally, environmental vulnerability concerns the damage from various components of the natural environment. The systemic approach does not consider the vulnerability of an ecosystem as the simple sum of the different vulnerabilities but vulnerability treated in its entirety as a system whose components are still in describing the interaction and analyzing its complexity.

Adaptation is not a new concept, it is a fact linked to the existence of mankind from the beginning of history. Human beings have always been able to familiarize themselves with their environmental surroundings and find rational solutions to climate or technical requirements, while modifying their behavior (lifestyle, diet, dressing, etc...)[4].

Good local practice adapted to climate change can be defined as a reaction, individually or collectively, to face climate risk. Bandura (1995) argues that the more people have high self-efficacy, the more they tend to engage in collective efforts to change their practices and improve their productivity in hostile changes. Adaptive capacity is a variable that depends on the individual perception, specificities, life context and situation to which adaption is needed. Local adaptation practices to climate shocks should be supported by technological innovations and policy options. According to Perthuis (2009), adaptation to climate change is the set of organizational changes, localization and techniques that communities have to operate to limit the negative impacts of these changes and maximize their benefits.

In general policy makers try to underestimate often local expertise, while seeking to introduce new techniques witch more often not adapted to local knowledge. Local communities have developed Knowledge and practices to face climate change according to their assets and environment. They have their way of point of view and opinions, and then any analysis of vulnerability to climate risks should be based on their knowledge. Local users of the know-how must be normally considered as resource persons and experts in their field. Policy designers and makers are asked to listen carefully while developing their intervention programs. Public policies are often easy to take after any crisis which is not the case in the situation of preventive actions.

[4] James J. McCarthy , Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, Kasey S. White.(2001). Climate change 2001: impacts, adaptation and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change Published for the Intergovernmental Panel on Climate Change. CAMBRIDGE UNIVERSITY PRESS.

The objective of this research is to study the relationship between climate change adaptation mechanisms and some socioeconomic factors. Different questions were addressed such as the effect of education level, the local knowledge or the farm size on the adaptation of local communities to climate change. This research is part of others related research production system dynamics and climate variability, the gendered perception of climate change and others.

Research methodology

1. Farm classification

Research methodology is based on two tools, factor analysis and logit regression model. The factor analysis was conducted in order to classify farmers according to specific variables (structural and production). The Principal Component Analysis (PCA) used in this study, is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance, and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors are an uncorrelated orthogonal basis set. PCA is sensitive to the relative scaling of the original variables.

After a factor analysis and following the nature of the data collected and the type of selected variables on which we worked, this part of the work was approached by econometric modeling by process of a binomial logistic regression. The aim is to verify the relationship between climate change adaptation as a dependent variable on one side and the level of education, experience (know-how), the size of the area used as independent variables on the other side. Indeed, it is to estimate the probability that a farmer adopts or does not adopt a strategy for adapting to climate change while referring to socioeconomic determinants.

So we tried to classify farmers according to their adaptation capacity to climate change in three different areas. The selected areas are Ain Jemaa, Betit and Sidi Slimane as the main communities of CRP-Dryland system.

2. Logit model: Theory and definition [(5)]

a. Basic definition

The model is based on the principle that the studied population is divided into two categories. The first category includes all individuals that concerned by the events and the second category includes where the event is absent. The concept of the logit model is based on probability of occurrence of events. If we consider a sample of n members with indices i= 1, 2… n. For each member we observe the presence or absence of the event. So we set:

$$y_i = \begin{cases} 0 \;\; if\ the\ event\ is\ absent \\ 1 \;\; if\ the\ event\ is\ present \end{cases}$$

So we can define the probability of event occurrence as an expected function of the Y_i as follow:

$$E[y_i] = (\Pr(y_i = 1) \times 1) + (\Pr(y_i = 0) \times 0) = \Pr(y_i = 1) \qquad (1)$$

[5] **Paul D. Allison.(2014).** Measures of Fit for Logistic Regression:Paper 1485-2014.

,

The objective of dichotomous models is then to explain the occurrence of the event considered in terms of observed characteristics X_i for individual i in the sample.

b. Binary logit model

According to equation (1), if we want to explain the values of Y by X, we estimate the probability $Y_i=1$ or $Y_i=0$ given that X_i can be written as:

$$\Pr(Y_i = 1/X_i) = \Pr(\beta X_i = \varepsilon_i \geq 0/X_i) = \Pr(\beta X_i \geq -\varepsilon_i/X_i) = F_{-\varepsilon}(\beta X)$$

Because the law of residues is symmetric, so we can replace $F_{-\varepsilon}(\beta X)$ by $F_{\varepsilon}(\beta X)$. We can introduce the logistic law by using the distribution function Λ, so we can obtain the logistic model called logit and can be written as:

$$F(X_i\beta) = \Lambda(X_i\beta) = \frac{e^{X_i\beta}}{1 + e^{X_i\beta}} = \frac{1}{1 + e^{-X_i\beta}}$$

Where x_i is a vector of covariates and β is a vector of regression coefficients. This defines the systematic structure of the model. The logit model estimation is possible through the estimation of β parameter. According to the logit model formulation, the estimated values of β parameter can give the following explanations:

- If $\beta_i > 0$, so the variable X_i relative to β has a positive effect on the studied event.
- If $\beta_i < 0$, so the variable X_i relative to β has a negative effect on the studied event.

c. Logistic regression

Logistic regression is a method for fitting a regression curve, y = f(x), when y is a categorical variable. The typical use of this model is predicting y given a set of predictors x. The predictors can be continuous, categorical or a mix of both. The categorical variable y, in general, can assume different values. In the simplest case scenario y is binary meaning that it can assume either the value 1 or 0. In this situation we call the model "binomial logistic regression", since the variable to predict is binary, however, logistic regression can also be used to predict a dependent variable which can assume more values (2, 3 or more). In this second case we call the model "multinomial logistic regression. These relations can be written as:

The logistic regression model predicts the probability that event occurred or not by optimizing the regression coefficients.

$$P(Y_i) = \frac{1}{1 + e^{-X_i\beta}}$$

Thus, if the value predicted by the model is greater than 0.5, the event is likely to occur, however if this value is less than 0.5, the event does not occur. The regression coefficients β can be interpreted along the same lines as in linear models, bearing in mind that the left-hand-side is a logit rather than a mean. Thus, β_i represents the change in the logit of the probability associated with a unit change in the i^{th} predictor holding all other predictors constant.

Source of data and analysis

The agriculture activity in the study area is the main source of income for the majority of rural households. Rainfed mixed system is the dominating (crops and livestock). The crops in this system are primarily rainfed, although in some areas supplementary irrigation on wheat and full irrigation for summer cash crops are developing rapidly. There are tree crops (olives and fruit trees) and grapes. Common crops are wheat, chickpeas, lentils, faba bean and fodder crops. Many farms are intensively capitalized with a high level of inputs, and farmers are very sensitive to market opportunities. There are a number of specialized dairy and poultry systems within this ecological zone. These may also include summer crops grown following winter fallow or with some supplementary irrigation. Major production constraints are poor access to quality land by increasing numbers of small farmers, soil erosion on slopes during rainstorms, and erosion by wind on light, over-cultivated, exposed soils.

A random sample of 508 households (1.4% of the total population) was selected in the Meknes and El Hajeb provinces focusing on three locations. The sampling strategy was based on the spatial distribution of villages using topographic map and household's representativeness. This distribution was approached by distances from the district. A multi-stage random sample technique was used. Villages or douars were selected randomly using topographic maps. A subgroup of 28 villages is selected randomly, which represents 49% of total villages in the three locations. The sample distribution among communities is as follow:

- Ain Jemaa community (229 households)
- Sidi Slimane community (136 households); and
- Bettit community (142 households).

After a literature reading in terms of socio-economic factors of agricultural vulnerability, and following a descriptive analysis of the data collected and the individual characteristics of the region, we decided to choose characters directly linked to the farmer and that may affect farmers' behavior and adaptation to climate change. These characteristics are education level, experience in farming and farm size. We present the details of these characters as follow:

- ***The variable representing farm size.*** We have tree classes; Small_Farmed_Area represented by smallholders whose surface is less than 5ha. Average_Farmed_Area represented by farmers whose surface is between 5 and 10 ha. Finally, large_farmed_Area that includes farms with more than 10 ha.
- ***The variable representing farmers' education level.*** We have two categories; Level_Lower_Educ representing farmers with low education level (at least a secondary level). Level_Higher_Educ: a level of education more than the secondary school.
- ***The variable representing farmers' experience in farming.*** In this case we have tree classes; More-exp for farmers with more than 15 years' experience in agriculture. Average-exp representing farmers whose experience is between 5 and 15 years. No-exp for those with less than 5 years' experience in practicing agriculture.
- ***The variable adaptation to climate change.*** Nine categories are identified; STR_DIDNOTHING representing households who didn't adopt any practice. STR_ LEFT represented households who adopt crop rotations. STR SOLD for households who adopt the strategy based on selling animals. STR-BORRO represents households who borrow money from private, bank or relatives. STR-SI for households who adopt deficit irrigation when rain is late. STR-ADOPT for households who adopt drought tolerant varieties. STR-CHANG for households who adapt planting date to rainfall period.

STR-LESS for household who adopt the diet to food availability. STR-ANY concerns other adaptation mechanisms

Results and discussion

1. Principal component analysis

As presented in figure 1, 2 and 3 it's clear that smallholders with low level of education and less experience in agriculture have not adopted diversified mechanisms to be adapted to climate change. They were limited to reduce food consumption quantities (quantities). This mechanism is largely reported in the Moroccan history, particularly in drought of such as 1946 and 1945. This behavior can be accepted and argued for this poor category of households

Figure 1: Sidi Slimane

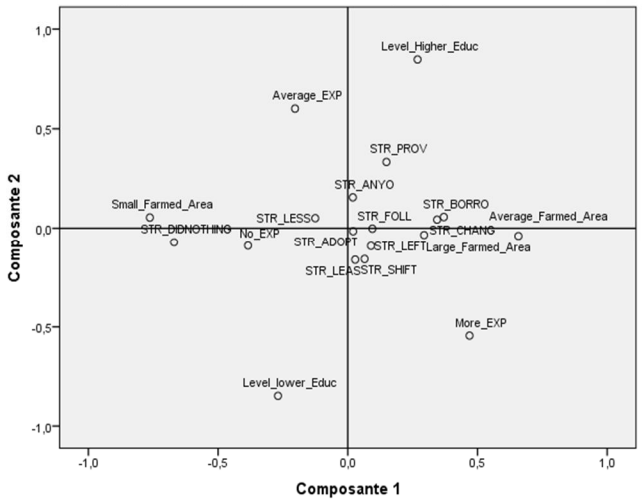


Figure 2: Ain Jemaa

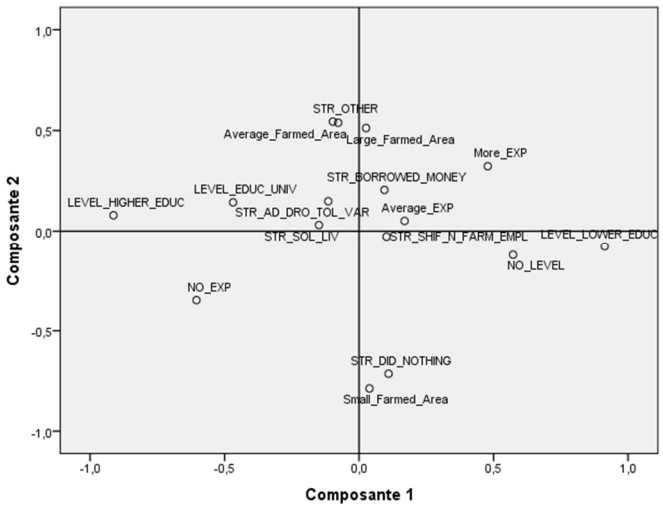
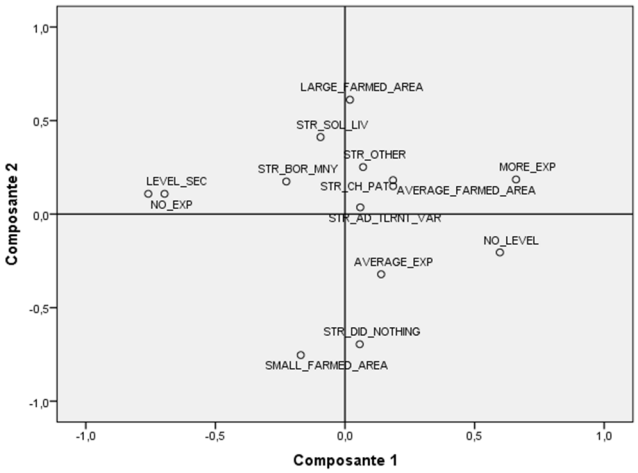


Figure 3: Bettit



On the other hand, large farmers who are well experienced and with a higher level of education practice various production technologies and more choices for adaptation to climate change; they adapt planting date to rainfall, and use drought-tolerant varieties. They are more flexible but more vulnerable to climate change according to the amount of investment and financial practices.

2. **Modeling results**

The tree models have generated interesting outputs. For Sid Slimane (table 1), results show that the three coefficients are positive and significant at level 5%. In table 2; the results indicate that coefficients are positively significant at 5% and 1%. Table 3 shows that coefficients are positively significant at level 5%.

The results indicate that farmers' education level, his experience in agriculture and farm size are determinant factors of farmers' decision in terms of adaptation to climate change. Thus they confirm the findings of factor analysis as presented before. Indeed a well-educated farmer can follow the news on agriculture; it may seek information everywhere and can experiments new knowledge or technologies to behave rationally vis-à-vis climate change impacts. Furthermore a farmer who operates large size of area should have a very important material and may invest more on irrigation system and/or insurance against climatic disasters. Also, it's clear that more experienced farmer is less vulnerable to climate change. He has developed best practices and expertise in terms of adaptation to climate change.

Table 1: Results of logistic regression (of SIDISLIMANE study area)
Variables in the equation

		TO	ES	Wald	ddI	Sig.	Exp (B)
Step a	LEVEL_EDUC	1,172	0, 565	4,299	1	0, 038	3,229
	EXP	0,721	0,317	5,178	1	0, 023	2,056
	Farmed_Area	0,931	0,428	4,738	1	0 , 030	2,537

Table 2: Results of logistic regression (of AINJAMA study area)
Variables in the equation

		TO	ES	Wald	ddI	Sig.	Exp (B)
Step a	LEVEL_EDUC	0, 623	0,299	4,324	1	0 ,038	1,864
	EXP	0,655	0,251	6.803	1	0,009	1,926
	Farmed_Area	0,557	0,279	3,992	1	0,046	1,745

Table 3: Results of logistic regression (of BETTIT study area)
Variables in the equation

		TO	ES	Wald	ddI	Sig.	Exp (B)
Step a	LEVEL_EDUC	0,830	0,397	4,369	1	0,037	2,293
	EXP	0,853	0,334	6,520	1	0,011	2,347
	Farmed_Area	0,945	0,479	3,894	1	0,048	2,573

The important aspect is the integration of crop/livestock is the main characteristics of the production systems in Morocco. Livestock play an important role in supporting crop practices and household needs. Studies on other issues, particularly the on production system vulnerability in rainfed agriculture, it's clear that farmers are conscientious about climate change and their impacts.

Conclusion

Farming systems vulnerability to climate change in the rainfed areas of Morocco is evident. Indeed, under the climate changes are expressed by lower average annual rainfall, more intense and frequent droughts, and significant reduction in the length of growth period, farmers in rainfed agriculture are more vulnerable and familiar with climate variability. They are struggling to adjust and adapt their farming systems' management to these changes. These farming systems based mainly on annual crops like cereals and food legumes make it more vulnerable to climate change particularly under continuous natural resources (soils and rainfall water) degradation. In this study the objective was to understand the adaptation mechanisms to climate change and try to identify the main factor affecting farmers' decision in the context of climate change.

Many studies on household facing climate change or market price variability were usually based on analyzing production side as the main indicator of climate change impact on farmers' strategy and decision. Studies conducted CC impact on farmers' behaviors showed that the household integrate of all components of production, consumption and livelihood in the decision process. It's important to consider production, consumption and livelihood strategies in analyzing farming system adaptation to climate change.

The Meknes and Elhajeb provinces are considered as more favorable regions for agricultural activities. They have an important potential to develop more cereals and will contribute to food security. As part of CRP11 CGIAR program, this research has demonstrated that:

- Drought is the more frequent climate event in the region. So they have developed a local expertise to face climate drought. However the region is also vulnerable to storm and cold. Fruit tree is more vulnerable to these climate events.
- Farmers have developed different strategies to alleviate the impact of climate change such as; crop diversification, adopt new income generating activities and the most important one is emigration.
- Farmer's capacity to climate change adaptation is positively linked to household wealth, education and experience.

Despite technological advances, such as improved varieties, irrigation systems, and natural resource management technologies, weather is still a key factor in agricultural productivity. The effect of climate on agriculture is related to variability in local climates rather than in a national climate patterns. Consequently, agronomists and other scientists consider any assessment has to be individually and consider area specificities. The different studies conducted in Morocco have showed that farmer's reactions to climate change depend on farmer's perception and adaptation capacity. So public policies should consider these specificities in implementing policies. Water policy, and particularly irrigation subsidy, has contributed to extension of irrigated area and crop diversification. Farmers are encouraged to pump more and more water, so the source is now in a critical situation and its rehabilitation is difficult.

Research on climate change impact on agriculture should be conducted using an integrated approach involving policy and social issues to innovation and technology.

Bibliography

Alain Bourque.(2000). Climate change and its impacts: VertigO–Electronic, journal Environmental Science. Volume1. Number 2.

Avraam Louca.(2010). Climate change and sustainable water resources management. IFAD's experiences in the Near East and North Africa and in Eastern and Central Europe Governing Council: IFAD**,** Background Paper.

Balaghi R., H. Benaouda and M. Jlibene.(2011). Report on the project Integration of Climate Change in the Implementation of the Green Morocco Plan (PICCPMV).Study of Environmental Impact and Social Framework (Rapport sur le projet d'Intégration du Changement Climatique dans la Mise en œuvre du Plan Maroc Vert (PICCPMV).Etude Cadre de l'Impact Environnemental et Social): DFC, INRA, Maroc

Barry Smit, Johanna Wandel ,Ana Iglesias, and al. (2007). Adaptation to climate change in the agricultural sector. European Commission DG AGRI: AEA Energy & Environment.

Barry Smit and Johanna Wandel. (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16 (2006) 282 – 292. SCIENCE@ DIRECT

Barry Smit and Mark W. SKINNER.(2002). Adaptation Options In Agriculture To Climate Change: A Typology :Global Change 7: 85–114, 2002)

Bonizella Biagini, Rosina Bierbaum,Missy Stults, Saliha Dobardzic and Shannon Mc Neeley.(2014). A typology of adaptation actions. A global look at climate adaptation actions financed through the Global Environment Facility: Global Environmental Change 25 (2014) 97–108.ELSEVIER.

Boureima.M and al. (2012) . Participatory analysis of Vulnerability and rabilit adaptation to climate change: a methodological guide, Occasional. Paper 19. Nairobi: World Agroforestry Centre.

Céline DubreuiL.(2012). Water and Climate Change: which adaptation strategy for the Mediterranean? :Building the Mediterranean future together. PLAN BLEU, NOTES # 23.

Christopher Bryant. (2007). Vulnerability and adaptation to climate change in Quebec at the farm: lessons learned from risk management and adaptation to climate variability by farmers. (Vulnérabilités et adaptation aux changements climatiques au Québec au niveau de la ferme : leçons tirées de la gestion du risque et de l'adaptation à la variabilité climatique par les agriculteurs), Natural Resources Canada Contract Number: A931.

D.PRUNEAU et al.(2009). Build coping skills to climate change through education on the environment, education and Francophonie .Construire des compétences d'adaptation aux changements climatiques, grâce à l'éducation relative à l'environnement) :Review Volume XXXVII. 2.

Ellen Wall, Barry Smit, and Johanna Wandel. (2007). Farming in a Changing Climate: Agricultural Adaptation in Canada.UBC Press ,vancouver.toronto.

Frédéric Leone and Freddy Vinet.(2006). The vulnerability of societies and territories to natural threats, geographic analysis:Collection. Georisques .No.1.

EUROPEAN COMMISSION.(2013). Communication from the commission to the European. Parliament, the Council, the European Economic and Social committee and the committee of the regions. An EU Strategy on adaptation to climate change Brussels: EUROPEAN COMMISSION.(2013).EN.

European Environment Agency.(2005). Vulnerability and adaptation to climate change in Europe: EEA Technical report No 7/2005.

Francesco Bosello, Carlo Carraro, and Enrica De Cian. (2000). An Analysis of Adaptation as a Response to Climate Change. Copenhagen Consensus on Climate,:DK-2000, Denmark;

Gaspard Dumollard et Alexia Leseur.(2011). the elaboration of a national policy of adaptation to climate change: feedback on five european event:(l'élaboration d'une politique nationale d'adaptation au changement climatique : retour sur cinq cas europeens) : Etude Climat n°27 – CDC. Climat Recherche ISSN 2101-4 663.

Hallegatte, S., F. Henriet, et J. Corfee-Morlot.(2008). The Economics of Climate Change Impacts and Policy Benefits at City Scale: A Conceptual Framework. OECD Environment Working Paper 4, ENV/WKP(2008)3. Paris: OECD.

IFAD.(2011). Climate change. building the resilience of poor rural communities: https://www.ifad.org

Isabelle NIANG-DIOP and Henk BOSCH.(2004). Formulating an Adaptation Strategy :Technical Paper8

James J. McCarthy , Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, Kasey S. White.(2001). Climate change 2001: impacts, adaptation and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change Published for the Intergovernmental Panel on Climate Change. CAMBRIDGE UNIVERSITY PRESS.

Jennifer Frankel-Reed, Barbara Fröde-Thierfelder and Ilona Porsché.(2011). Integrating climate change adaptation into development planning : GIZ Climate Protection Programme, Eschborn, Germany July .2011.

Joel B. Smith, Saleemul Huq, Richard and J. T. Klein. (2003). Climate Change, Adaptive Capacity and Development: Imperial College Press,347 pages.

Marie-Ange BAUDOIN.(2010).Climate change adaptation in Southern Benin: A study comparing international policy and local needs: Geo-Eco-Trop., 2010, 34 : 155 - 169.

Marie-Joëlle Fluet, Luc Vescovi and Amadou Idrissa Bokoye.(2009). Water and Climate Change. Citizen Mobilization, a Source of Solutions: UNESCO 2009 ISBN 978-92-3-104119-8.

M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson.(2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Eds., Cambridge University Press, Cambridge, UK, 976pp.

Paul D. Allison.(2014). Measures of Fit for Logistic Regression Paper 1485-2014

Paul Sayers and al. (2016). Drought risk management a strategic approach: UNESCO 2016.

S. Coleman, Lynn K. Fenstermakerk, Jeffrey R. Seemann & Robert S. Nowak.(2000). Elevated CO2 increases productivity and invasive species success in an arid ecosystem : Letters to Nature,VOL408, 2 NOVEMBER 2000.

Stéphane Hallegatte , Franck Lecocq ,Christian de Perthuis.(2010). Economics of Adaptation to Climate Change. Economic Council for Sustainable Development . France.

Suchitra Sugar, Stephanie Hodge, Morgan Strecker and Changu Mannathoko.(2012). Climate Change and Environmental Education, a companion to the Child Friendly Schools.UNICEF (2012).

Susanna Reid, Barry Smit , Wayne Caldwell and Suzanne Belliveau.(2006). Vulnerability and adaptation to climate risks in Ontario agriculture, Springer Science+Business Media B.V.

United Nations.(2012). Report on the technical workshop on water and climate change impacts and adaptation strategies: FCCC/ SBSTA/2012/4.

United Nations Framework Convention on Climate Change.(2007). Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries : Climate Change Secretariat (UNFCCC) Martin-Luther-King-Strasse 8 53175 Bonn, Germany.

Walthall, C.L., J. Hatfield, and al. (2012). Climate Change and Agriculture in the United States. Effects and Adaptation: USDA Technical Bulletin 1935. Washington, DC. 186 pages.

Yohe, G.W., R.D. Lasco, Q.K. Ahmad, N.W. Arnell, S.J. Cohen, C. Hope, A.C. Janetos and R.T. Perez.(2007). Perspectives on climate change and sustainability. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 811-841