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Factors influencing the adoption of climate change adaptation strategies in the arid Morocco's rangelands

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Abstract. The high plateaus of eastern Morocco (HPEM) have already suffered the adverse impacts of climate change (CC) since it is at the basis of many of socio-economic and environmental transformations observed in this pastoral ecosystem. Moreover, breeder's decision to opt for a particular adaptation strategy among a range of possible choices is dependent on certain factors, which need to be known as they will provide indications of factors that favor or hinder adaptation and they are very useful in developing policies to promote effective and successful adaptation. The objective of this study is to identify the factors influencing the adoption of the main endogenous adaptation strategies. Data obtained through a structured questionnaire from 167 herders selected randomly in the HPEM, were analyzed using binary logistic regression. The main determinants of the adoption of climate change adaptation strategies are perceptual and socio-economic variables. The results of the regressions show that the factors significantly influencing the adoption include perception of long-term change of temperature and rainfall, age of head of pastoral household, education level, training received, size of the flock of sheep, equipment in possession and credit access. Thus, in order to enhance local climate change adaptation, it is suggested to take into consideration these above-mentioned determinants, particularly by setting up some accompanying measures (information, training, financing, equipment).

Keywords. Climate change – Adaptation strategies – Logit regression – Determinants – Morocco.

Facteurs influençant l'adoption par les éleveurs des stratégies d'adaptation au changement climatique dans les parcours arides du Maroc

Résumé. *Les hauts plateaux du Maroc Oriental constituent un écosystème pastoral ayant déjà subi les impacts adverses du changement climatique (CC) puisqu'il est à la base de plusieurs de ses transformations socio-économiques et environnementales. Par ailleurs, la décision d'un éleveur à opter pour une mesure d'adaptation particulière parmi un ensemble de choix possibles est tributaire de certains facteurs, qui ont besoin d'être connus car ils fourniront des indications sur les facteurs qui favorisent ou entravent l'adaptation et ils sont très utiles dans l'élaboration de politiques visant la promotion d'une adaptation efficace et réussie. L'objectif poursuivi est d'identifier les facteurs qui influencent l'adoption des principales stratégies d'adaptation (SA) endogènes. Les données collectées moyennant une enquête structurée auprès de 167 éleveurs, ont été analysées via la régression logistique binaire. Les principaux déterminants de l'adoption des SA sont les variables de perception et socio-économiques. Les résultats des régressions montrent que les facteurs qui influencent significativement l'adoption comprennent la perception d'un changement à long terme de la température et des précipitations, l'âge du chef du ménage pastoral, le niveau d'instruction, la formation reçue, la taille du troupeau d'ovins, l'équipement en possession et l'accès au crédit. Ainsi, afin d'améliorer l'adaptation locale au changement climatique, il est suggéré de prendre en compte les déterminants susmentionnés, notamment en mettant en place certaines mesures d'accompagnement (information, formation, financement, équipement).*

Mots-clés. *Changement climatique – Stratégies d'adaptation – Régression logistique – Déterminants – Maroc.*

I – Introduction

The high plateaus of eastern Morocco are one of the largest pastoral areas in Morocco which have already suffered the adverse effects of climate change (CC). The extensive livestock breeding –main source of income for local populations–, is vulnerable because of its high dependence on the increasingly unfavourable climatic conditions. In order to combat the negative effects of CC, pastoralists in the study area have implemented a range of adaptation strategies. Better understanding of the factors influencing their decision to opt for a particular adaptation strategy, is vital for the identification of the levers of adaptation at the local level. Indeed, the decision of a farmer to opt for an adaptation strategy depends on certain factors such as environmental variables or geographical characteristics, the socio-economic characteristics of households, the characteristics of farms and socio-institutional factors (Below *et al*., 2012; Tiwari *et al*., 2014). These factors whose main determinants need to be studied as they will provide insights into the factors that promote or hinder adaptation (Tiwari *et al*., 2014) and are very useful in developing policies whose purpose is to promote effective adaptation in the agricultural sector (Mabe *et al*., 2014; Berhanu and Beyene, 2015). Thus, the objective of this study is to identify the factors that influence breeders' implementation of endogenous strategies of CC adaptation.

II – Materials and methods

The study was carried out in the high plateaus of eastern Morocco, which are located in the 30S UTM zone. Data collection was done through a structured survey with the heads of pastoral households (a total of 167 herders). The structured questionnaire covered household socio-economic characteristics, perceptions of CC (frequent climate related hazards and risks, changes in rainfall and temperature patterns) and the core endogenous adaptation strategies implemented in response to the perceived climate changes. The household survey was run from September to December in 2015.To identify variables that influence the adoption of the endogenous adaptation strategies, the binary logistic regression was used (Eqn. 1). Giving to Gujarati (2004), the specification of the empirical model of logit regression is as follows: $Y_j = a_0 + a_1x_1 + a_2x_2 + \ldots + a_{35}x_{35} + a_u$ (Eqn. 1). Where: Y_j= the dichotomous dependent variable (breeder practicing any CC adaptation strategy or not, defined as yes=1, 0=otherwise); a_0: the regression constant; $a_1 – a_{35}$: the coefficients of x to be estimated; x_i: the explanatory variables (i: 1,….,35) and a_u: the error term. The explanatory variables used in logistic regression models relating to the adoption of six main endogenous adaptation strategies, include 26 socio-economic variables relating to socio-economic characteristics and assets of households, on and off farm incomes and access to social infrastructure, 2 geographic variables reflecting to the belonging to two different agroecological sub-zones of the HPEM and 7 Perception variables (Perception of: late onset of rains, increased pockets drought, heavy rains, frequent droughts, temperature change, increased violent winds, increased sandstorms). The core adaptation strategies analyzed include: *Herd mobility* in search of favorable rangelands particularly over the droughts of long duration, *Storage of livestock feed* (especially barley) to meet animal needs (essentially food supplementation of lactating ewes), *Regular sale of animals* or decapitalizing strategy which is an anti-risk strategy of the curative type, commonly implemented to overcome the adverse effects of climatic hazards, mainly by small breeders, *breeding of mixed herds* composed largely of sheep and goats, subscription to the *insurance for climatic multi-risks* which has become a common practice, particularly for large livestock producers and to a lesser extent among the medium breeders in order to obtain important financial revenues via compensation in the event of climatic vagaries (drought in particular) and the *Profit of state programs* and interventions such the pastoral improvement actions (fodder shrub planting, tillage), the rangelands' restoration and rehabilitation (resting, seed reserves), the pastoral hydraulics (creation and equipment of facilities of water, micro-dams) and the incentives (Livestock Safeguard Program).

III – Results and discussion

The results of the binary logistic regression analysis are presented in Table 1 which contains only the factors who appeared to play significant role in the decision to adapt to CC. The six logistic regression models obtained have a high quality and strength and allow to classify the observations (herders) successfully since the overall correct percentage prediction rate varies from 78 to 92%. The results show that the breeders' perception to CC affect very significantly the adoption of herd mobility, climate multihazard insurance and profit of state agricultural programs. This suggests that these strategies are targeted responses to CC. Furthermore, since the coefficient of change of temperature perceived is negative and significant for these aforementioned adaptation strategies, thus the breeders' who perceived a change of temperature are less likely to adapt. Debalke (2011) found the same result by showing the negative impact of this factor with respect to the adoption of some adaptation strategies (soil conservation, changing planting dates). Also, the heavy rains perceived is a significative determinant for the adoption of the herd mobility. Berhanu and Beyene (2015) found that this factor is a determinant for pastoral household to adopt the herd mobility as a main adaptation practice.

The results reveal that farmers' who own agricultural equipment and transportation are more likely to adapt to CC. Indeed, the equipment of the farms positively and very significantly affects the adoption of the diversification of livestock species (sheep and goats) and the regular sale of animals to stock up on feed. In line with these findings, Ouédraogo *et al*. (2010) found that ownership of heavy machinery enhances significantly and positively the ability of farmers to adapt in response to CC. Otherwise, the credit access has a positive and very significative effect on the adoption of storage of animal feed but negatively influences the regular sale of animals to stock up on feed. Several authors have pointed out that access to credit is a determining factor in adapting to CC (Obayelu *et al*., 2014; Opiyo *et al*., 2015; Ndamani and Watanabe, 2016). Contrariwise, Piya *et al*. (2013) indicated that the direction of the influence of this factor is negative.

Table 1. Determinants of the adoption of the main endogenous adaptation strategies

Explanatory variables	**Coefficients and signification**					
Adaptation strategies	**Herd mobility**	**Storage**	**Regular sale**	**Herd mixed**	**Insurance**	**State programs**
AAge			-0.07**			-.11***
Education		2.17**		5.67***		
Training	2.43**	-2.78**		-6.12***		2.34*
Sheep Size	0.04**				.024**	
Equipment			1.83**	8.79***		
Credit		4.50***	-1.97***			
Heavy Rain	4.47***					
Temperature					-1.66*	-3.59**
Sandstorm	4.64**				2.88**	
Winds	-3.83*					
Constant	-0.11	-0.08	-0.11	1.26***	-.08	1.33
Correct percentage[1]	88.60	92.20	77.80	91.6	85.6	83.8

Note: Signification: *, ** and ***: Level of significance at 0.1, .05 and .01. [1]: The correct percentage of classification is the number of correct classifications divided by the total number of predictions. it allows to judge the quality and the strength of the model and thus to see if the model successfully classifies the observations (herders).

The results show that the likelihood of older breeders practicing the regular sale of animals and profiting of state agricultural programs is lower than that of younger breeders. Berhanu and Beyene (2015) found that the age is a very significant factor, with negative sign, influencing the pastoral households to prefer herd mobility and diversification of livestock species.

Also, the education level of head of pastoral household positively and very significatively affects the probability that breeders will adopt storage of animal feed and herd mixed in response to CC. In line with these finding, Opiyo *et al*. (2015) consider that this factor is a positive determinant of pastoralist's choices of CC adaptation. In fact, the education level is an important factor influencing the farmers' adaptation to CC (Tiwari *et al*., 2014; Ndamani and Watanabe, 2016). Likewise, the training received by household head has a positive and significant impact on the likelihood of using herd mobility and profit of state programs. However, since the coefficient of training is negative and very significant for the adoption of the storage and the herd mixed, it means that the probability of breeders with training to implement these strategies is lower than that of those without training. Piya *et al*. (2013) and Tiwari *et al*. (2014) emphasize that training improve adaptation to CC. Nevertheless, Yila and Resurreccion (2013) found that the training is a non-significant factor for farmers' adaptation strategies in northeastern of Nigeria.

IV – Conclusions

The main determinants of the adoption of climate change adaptation strategies in the study area are perceptual and socio-economic variables. The access to credit, training, equipment and the education level have a significant effect in the adoption of coping strategies. Public policy aimed to enhance households and pastoral systems' climate resilience should invest in accompanying measures (training, financing) and in the intensification of assets (equipment, incentives), particularly for small-scale herders. Given that these determining factors of adaptation are common to many African countries, it is suggested to consider regional programs implementing similar development strategies focused on improving these factors, particularly in areas where dryland farming is predominant.

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