Adaptive practices of livestock breeders in the face of climate change and factors influencing their adoption in the arid rangelands of eastern Morocco

Snaibi W.[1]

snaibi.wadii@gmail.com

1 : Institut National de la Recherche Agronomique, Centre Régional de la Recherche Agronomique d'Oujda, Maroc

1 : Doctorant à l'Université Mohammed Premier, Faculté des Lettres et Sciences Humaines (Equipe de recherche ETIGGE), Oujda, Maroc

Abstract

Climate change is a determining factor in the dynamics and deregulations observed in the pastoral ecosystem of the high plateaus of eastern Morocco (HPEM). Livestock rearing of small ruminants, which is the driving force for income generation and employment, is vulnerable to this phenomenon because of its strong dependence on climatic conditions. The current climate change adaptation measures practiced in the study area and the determinants of breeders' implementation of these coping actions, are not investigated. Therefore, the objective of this study is to inventory and analyze the main endogenous adaptation practices and the factors that influence decisions on their implementation (adoption) by livestock breeders. The collected data, through a structured survey with a total of 167 herders, were analyzed using descriptive statistics, Chi-square independence test, Kruskal-Wallis test and multiple linear regression.

Although the climate change adaptation measures implemented by breeders in the HPEM are numerous, varied and endogenous originating from their own initiatives, these local adaptation practices are mostly reactive, aiming at a short-term logic and they have a low to medium adequacy in relation with the main or specific objective of adapting to climate change. The results show that there is a high significant relationship between the total count of coping practices adopted and breeders' classes, defined on the basis of the size of the sheep flock in possession (χ^2 = 1009.529, p = 0.000). According to the Kruskal-Wallis test, there are significant differences (Chi square = 39.986, p = 0.000, df = 2) between the three categories of breeders (small, medium and large) in terms of adoption of adaptation practices to climate change and that they are due to a very significant difference ($p < 0.001$) between small herders on the one hand and large and medium breeders on the other. In addition, the regression model revealed a positive relationship between the dependent variable (the total number of adaptation measures adopted) and predictor variables (R=.876, R^2 = .767, F = 11.878). Thus, the adoption of endogenous adaptation actions was significantly and positively influenced by size of sheep flock (β= .005), secondary occupation is the commercial activity (β=2.246), possession of tanks (β=1.592), possession of motor pump (β=1.439), the main occupation of household head (β=4.766), Intermediate agroecological zone (β=1.648) but was reduced by type of household habitat is the tent (β=-1.257) and perception of temperature change (β=-1.440). Therefore, it is rather the socioeconomic factors that are the most determinants and which influence on the total count of coping measures adopted.

Climate change public policy aimed at strengthening the adaptive capacity of breeders in the study area should take into account these above-mentioned determinants, focus its intervention on more environmentally and sustainable actions, while paying particular attention to small-scale herders, who constitute the most vulnerable group with regard to climate change.

Key words : *climate change, adaptation practices, regression model, determinants, Morocco.*

Pratiques adaptatives des éleveurs face au changement climatique et facteurs influençant leur adoption dans les parcours arides du Maroc oriental

Résumé

Le changement climatique (CC) est un facteur déterminant dans la dynamique et les changements qu'a connu l'écosystème pastoral des hauts plateaux du Maroc Oriental. L'élevage de petits ruminants est vulnérable à ce phénomène en raison de sa forte dépendance aux conditions climatiques. L'objectif de cette étude est d'inventorier et analyser les principales pratiques d'adaptation endogènes ainsi que les facteurs qui influencent les décisions de leur mise en œuvre (adoption) par les éleveurs. Les données collectées ont été analysées à l'aide du test d'indépendance du Khi-carré, du test de Kruskal-Wallis et d'une régression linéaire multiple. Bien que les mesures d'adaptation au CC recensées soient nombreuses, variées et endogènes, elles sont pour la plupart réactives, visant une logique à court terme et elles ont une adéquation faible à moyenne par rapport à l'objectif spécifique d'adaptation au CC. Les résultats montrent qu'il existe une relation significative élevée entre le nombre total de mesures d'adaptation adoptées et les classes d'éleveurs, définies sur la base de la taille du troupeau d'ovins en possession (χ^2 = 1009.529, p = 0.000). En outre, il existe des différences significatives (Chi carré = 39.98, p = 0.000) entre les catégories d'éleveurs en termes d'adoption de pratiques d'adaptation au CC, dues à une différence très significative entre les petits éleveurs et les deux autres classes. Aussi, le modèle de régression a révélé une relation positive entre le nombre total de mesures d'adaptation adoptées et les variables prédictives (R = .876, R^2 = .767, F = 11.878) dont les facteurs socio-économiques qui sont les plus déterminants.

Mots clés : Changement climatique, pratiques d'adaptation, modèle de régression, déterminants, Maroc

الممارسات التكيفية لمربي الماشية في مواجهة تغير المناخ والعوامل التي تؤثر على تبنيها في المراعي الجافة للمغرب الشرقي

وديع الصنيبي

ملخص

يعتبر التغير المناخي أحد العوامل الرئيسية التي أسهمت في الدينامية والتحولات التي عرفها النظام البيئي الرعوي في منطقة النجود العليا للمغرب الشرقي .تتأثر تربية الماشية من المجترات الصغيرة ، والتي هي المصدر الأساسي للدخل والشغل بالنسبة للساكنة المحلية ، سلبا بهذه الظاهرة بسبب ارتباطها القوي بالظروف المناخية .الهدف من هذه الدراسة هو جرد وتحليل ممارسات التكيف المحلية والعوامل التي تؤثر في قرارات تنفيذها (إعتمادها)من قبل مربي الماشية .تم تحليل البيانات، التي تم جمعها من خلال بحث ميداني هم 167 مربي الماشية،عن طرية إحصاأت وصفية ، اختبار كاي تربيع للاستقلالية ، اختبار خروسكال واليس والإنحدار الخطي المتعدد

على الرغم من أن تدابير التكيف مع تغير المناخ التي ينفذها المربون في منطقة الدراسة هي متعددة ومتنوعة وذات منشأ داخلي أي ناتجة من مبادراتهم الخاصة ، إلا أنها في معظمها تفاعلية ، ترتكز على منطق قصير الأجل ولديها ملاءمة منخفضة إلى متوسطة فيما يتعلق بالهدف الرئيسي أو المحدد للتكيف مع تغير المناخ .أظهرت النتائج أن هناك علاقة كبيرة ذات دلالة إحصائية بين العدد الإجمالي لممارسات التكيف المتبعة و فئات المربين ، المحددة على أساس حجم قطيع الأغنام الموجود في الحيازة .وفقًا لاختبار خروسكال واليس توجد فروق ذات دلالة إحصائية بين فئات المربين الثلاثة(الصغار، المتوسطون والكبار)من حيث اعتماد تدابير التكيف مع تغير المناخ، و ذلك راجع إلى اختلاف كبير بين صغار المربيين من جهة والمربيين الكبار والمتوسطون من جهة أخرى وهكذا، يتأثر تبني أو إعتماد ممارسات التكيف بشكل كبير وإيجابي بحجم قطيع الأغنام، المهنة الثانوية لمربي الماشية هي النشاط التجاري، حيازة خزانات المياه، حيازة مضخة المياه، المهنة الرئيسية، تخصص المنطقة الجغرافية في النشاط الرعوي، و في المقابل ينخفض تبني إجراءات التكيف المحلية بنوع السكن الرئيسي هو الخيمة و وتصور التغير في درجة الحرارة .لذلك ، فإن العوامل الاقتصادية والاجتماعية هي المحددة والأكثر تأثيرا على العدد الإجمالي لممارسات المواجهة المعتمدة

ينبغي للسياسة العامة المرتبطة بتغير المناخ الرامية إلى تعزيز القدرات التكيفية لمربي الماشية في منطقة الدراسة أن تأخذ في الاعتبار هذه المحددات المذكورة أعلاه ، مع إيلاء اهتمام خاص لصغار المربيين ، الذين يشكلون الفئة الأكثر هشاشة فيما يتعلق بالتغير المناخي

الكلمات المفتاح التغير المناخي، الممارسات التكيفية، نموذج الإنحدار الخطي المتعدد، المحددات، المغرب:

Introduction

Morocco is considered the country of North Africa, which presents the greatest vulnerability to climate change (CC), due to its high sensitivity and low generic adaptive capacity (Yohe et al., 2006; Schilling et al., 2012). Historical climatic trends show that since the late 1970s, Morocco has experienced a decrease in annual precipitation (Schilling et al., 2012), an increase in temperatures (Hulme et al., 2001) and a rise in the frequency of droughts (NIC, 2009). These negative climatic changes are likely to continue in the 21st century, resulting in warmer and drier conditions (Schilling et al., 2012). The agricultural sector, the main driver of the national economy and job purveyor, is most negatively affected by the effects of CC (Maroc, 2016). Consequently, rural population whose agriculture is the major source of income, is certainly the greatest impacted by the harmful consequences of this climatic phenomenon (Maroc, 2011). Located in eastern Morocco, the study area, namely the high plateaus of eastern Morocco (HPEM), is one of the largest pastoral areas on a national scale, and which has already suffered the adverse effects of climate change. Indeed, from the mid-1970s, this area experienced a significant drop in precipitation (Fink et al., 2010), an accentuation of drier weather conditions (Born et al., 2008), in addition to a pronounced increase in the frequency and the intensity of droughts (Maroc, 2001). Likewise, François et al. (2016) emphasized that in the Eastern Morocco, since the early 80's, average annual rainfall has decreased by 29%, the temperature has increased, especially the minimum temperature during the autumn season, and the frequency of occurrence of drought has raised (7 years out of 10). Based on a rainfall series from 1935 to 2015, Melhaoui et al. (2018) reported a significant downward trend in the pluviometric regime in the study area. Also, they added that the drought frequency increased since 1980 reaching 33 and even 51%. In addition, breeding of small ruminants on rangelands, which is the main source of income for the local population, is low productive and especially vulnerable to CC because of its high dependence on increasingly erratic climatic conditions marked by more and more irregular rainfall and poorly distributed in time and space, with increased occurrence of droughts (El Harizi et al., 2005; Bechchari et al., 2014). These unfavourable climatic trends in the HPEM seriously threaten the sustainability of pastoral livestock rearing, accentuate the precariousness of the poorest rural households and increase the flow of potential claimants to emigration.

Regarding extreme climatic events, long dry spells in the HPEM, cause generally scarcity of water resources and pasture leading to higher competition for available natural resources and to sometimes brutal pastoral conflicts. The increase in the occurrence and intensity of droughts and their prolongation over time aggravate social inequalities among local breeders (Schilling et al., 2012). Indeed, in this time of crisis (drought), small-scale livestock owners face both increased pressure on available pastoral resources and an inability to purchase higher-priced livestock feeds. After drought, the size of their herds decreases considerably, while large breeders, their strategy of decapitalisation seems to be well under control and their ability to replenish herds is much greater. In fact, better-off herders are slightly less vulnerable because they are not exclusively or largely dependent on natural resources, have the financial resources to buy livestock feed and can even take advantage of this opportunity created by the decapitalisation of the poorest livestock owners (Kuhn et al., 2010). Public intervention (subsidy of animal feed) and remittances from emigrants have contributed to the increase in overgrazing as they have served to maintain or even increase the number of livestock during the drought.

While this extreme event (drought) allowed in the past the natural load shedding of the rangelands. This increase in animal load on the rangelands, despite the decrease in rainfall and increased droughts' frequency, has led to an advanced degradation of rangelands in the HPEM, which has also been caused by plowing and anarchic cultivation of marginal areas and uncontrolled land clearing (Mahyou et al., 2010; Maâtougui et al., 2011; Schilling et al., 2012).

To cope with or circumvent the adverse effects of climate variability and change, breeders of the HPEM have implemented a diverse set of adaptation measures such as mobility of herds (transhumance) with reciprocal grazing agreements with distant pastoral tribes, rearing of mixed species herds, social network and intra-community solidarity to cushion income shocks (Bourbouze, 2000; Bourbouze and El Aich, 2000; Schilling et al., 2012). In addition to these traditional coping measures, new adaptation practices have appeared in recent decades. They include: association of agriculture and livestock farming, breeding of mixed herds of sheep and goats, new form of mobility based on motorization, income diversification and use of emigrants' remittances, commercializing of livestock, constitution of different stocks: livestock feed, livestock and money, using subsidized livestock feed and programs to combat drought' effects and sale of animals to purchase supplementary livestock feed (Bourbouze, 2000; Bourbouze and El Aich, 2000; Schilling et al., 2012). Recently, a new adaptation measure was adopted by a large part of the breeders in the study area. This is the subscription to insurance climatic multi-risks which covers land cultivated with cereals and not mobile or sedentary livestock rearing. However, these adaptation practices or climate anti-risk measures are mostly curative, low efficient and their sustainability is questionable on the socio-economic and environmental levels (Bourbouze, 2000; Bourbouze and El Aich, 2000). In addition, some of these adaptive practices show a low to medium adequacy in relation to the specific objective of adapting to climate change, as they are considered as alternative options implemented by some breeders in order to secure or diversify their livelihoods, e.g. casual work, emigration and the practice of income-generating activities in addition to animal husbandry. Bechchari et al. (2014) pointed out that the adaptive capacity of the breeders in the HPEM's area to climate variability and hazards depends on the size of the livestock held and the financial and material resources available. In fact, their adaptive behaviors are closely linked to their respective socioeconomic status. Thereby, small-scale herders have less options for adaptation, are more severely affected by the observed adverse climatic trends and are more threatened by the abandonment of livestock rearing. More globally, Lazarev (2008) stressed that the main criteria for differentiating between categories of breeders in terms of modes of using pastoral lands are the size of the herd exploited and the capital available. In addition, public policy has established several measures to support breeders in pastoral areas against the harmful effects of climatic vagaries, such as the subsidy of livestock feed, facilities for watering livestock, the planting of fodder shrubs, water and soil conservation actions and the insurance climatic multi-risks. However, these public interventions, in particular financial incentives, have been inappropriate to these pastoral lands, and have generated some negative side effects such as sedentarisation and overgrazing (Schilling et al., 2012).

Furthermore, a thorough understanding of the factors affecting the decision of farmers to undertake one or a wide range of coping practices is essential to identify the levers for adaptation to climate change at the local level and thus develop an effective and appropriate adaptation of the agricultural sector to this climatic

phenomenon (Mabe et al., 2014; Tiwari et al., 2014; Berhanu and Beyene, 2015). Indeed, a set of factors of environmental, socioeconomic or socio-institutional type, influence the farmer's decision to undertake or adopt CC adaptation practices (Below et al., 2012; Tiwari et al., 2014; Taruvinga et al., 2016). In view of all the above, the specific objectives of this study are: i) to inventory and describe the herders' adaptation practices to climate variability and change in the study area; ii) to identify the factors that influence breeders' implementation (adoption) of these adaptive measures. The hypotheses underlying our research are the following:

- The breeders' implementation of adaptation measures to climate variability and change is closely linked to their households' socioeconomic characteristics, the characteristics of their farms, their institutional environment and to their perceptions of CC.
- The larger the size of the sheep herd in the breeder's possession, the greater the total number of CC adaptation practices adopted (implemented).
- Public policy has put in place a set of support and accompaniment measures for breeders to help them adapt to CC, but it has generated some counterproductive side effects.

Methodology

Study Area

Located in the east of the country, the high plateaus of eastern Morocco (HPEM) are one of the largest pastoral areas in Morocco, covering about 3.5 million hectares (Figure 1). Their soils are generally shallow, low in organic matter and therefore susceptible to wind and water erosion. Water resources are very limited. The HPEM have two gradients going from north to south: the altitude increases regularly from 900 to 1,400 m and the climate fluctuates from semi-arid to lower arid and pre-Saharan. Indeed, the climate is of Mediterranean type, but under of a great influence of the Sahara. Average annual rainfall is highly variable, ranging from 143 mm in the south to 201 mm in the north, with respective coefficients of variation of 45 and 34% (Melhaoui et al., 2018). Dry and hot winds that can cause real sandstorms, especially in summer, are frequent. The rangelands of the HPEM are dominated by specific steppe vegetation consisting of steppes at *Stipa tenacissima*, chamemic steppes at *Artemisia herba alba* and steppes at Chenopodiaceae (*Artrophytum scoparium*). The rural population of the study area is 51,805 inhabitants, spread over 9,003 households (HCP, 2018), the vast majority of which derive most of their income from livestock farming, in particular sheep breeding. The herds in the possession of the breeders in the study area are made up of more than 2 million heads of small ruminants, usually conducted according to an extensive to semi-extensive rearing system. Finally, the combination of climatic (recurrence of droughts and decrease in rainfall amounts) and anthropogenic (overgrazing, cantonment of collective rangelands, rangelands cultivation, sedentarisation of pastoralists) factors, has generated an acceleration of the degradation and desertification of this pastoral ecosystem (Maâtougui et al., 2011), coupled with a tendency of weakening of livelihoods of the local population, particularly small livestock breeders (El Harizi et al., 2005). All these elements provide information on increasing biophysical and social vulnerability related to climate change in the study area, thus requiring the urgent implementation of appropriate and sustainable adaptation measures.

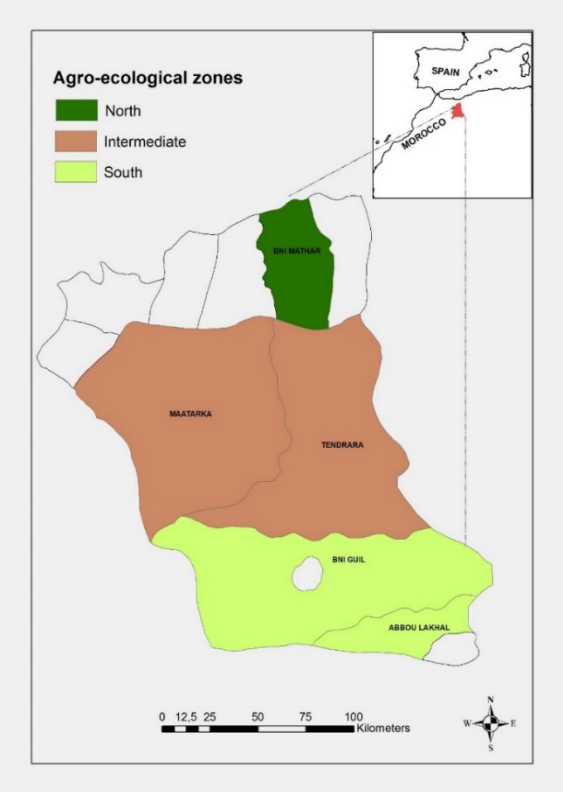

Figure 1: Location map of the study area

Data collection

Data collection method consisted of a literature review and a survey of 167 breeders, heads of pastoralist households. Relevant literature available from local extension and agricultural development agencies was consulted to acquire a complete and clear overview about the CC issue in the HPEM's area, mainly with regard to livestock practices and main endogenous adaptation measures implemented by the breeders in response to climate variability and changes. The survey of herders focused on the demographic, socioeconomic and institutional characteristics of households, perceptions regarding CC (changes in precipitation and temperature regimes, frequent climatic risks) and the adaptation practices embraced to reduce the effects of perceived CC. The basic study unit is the pastoralist household, as at this level, decisions relating to adaptation to climate variability and change are taken (Below et al., 2012).

Sampling: In order to select herders surveyed, a multi-step sampling procedure was employed by including purposive and random sampling methods. At first stage, since the HPEM's zone is a very large area encompassing distinct agroecological sub-zones, which exhibit contrasting socio-economic and biophysical conditions, three differentiated study sites, were selected to take into account this agroecological and social heterogeneity. The main criteria for this differentiation are: climate type (decreasing bioclimatic gradient ranging from arid in the north to hyperarid or pre-Saharan in the south), extent of rangelands (the rangelands are more extensive in the intermediate and southern zones compared to the northern part), water potential (water resources are more abundant in the north zone in comparison to the other areas), altitude (an increasing altitude gradient from north to south) and type of dominant livestock breeding system (more extensive in the intermediate and southern zones than to the north). Thereby, five rural communes were purposively

selected, namely Bni Guil, Abbou Lakhal (south zone), Tendrara, Maâtarka (intermediate zone) and Bni Mathar (north zone). At the second stage of selection, given that the size of the sheep flock in ownership was chosen as the criterion of discrimination between herders, three classes of livestock breeders have been identified and this in agreement with local agricultural extension agencies. Large breeders are those with a sheep herd exceeding 300 heads, medium breeders with own sheep flocks of between 101 and 300 heads, and finally the small breeders with the number of sheep owned is less than or equal to 100 heads. Lastly, based on the respective representativeness of these three breeders' categories in the study sites, respondent herders were randomly selected. The distribution of herders surveyed by class is as follows: 96 small, 47 medium and 24 large breeders.

Empirical model and explanatory variables

To ascertain variables influencing farmers' adaptation to climate change and to estimate the relationship between their adaptation practices implemented and a set of socio-economic, institutional and biophysical variables, many statistical methods have been used. They include: binary logistic regression (Nabikolo et al., 2012; Mabe et al., 2014; Tiwari et al., 2014), multi-nominal logit model (Balew et al., 2014; Obayelu et al., 2014, Atinkut and Mebrat, 2016) and generalised linear regression model (Yila and Resurreccion, 2013; Arimi, 2014; Taruvinga et al., 2016). Thus, since our dependent variable (the total number of adaptation practices implemented by each breeder) is measured by counting and thereby it is treated as a continuous variable, a multiple linear regression model (Eqn. 1) was used to identify the factors that influence the adoption (implementation) of adaptation measures to climate variability and change by the breeders in the study area. According to Confais and Le Guen (2006), the equation for the linear multiple regression model is as follows:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon \qquad (1)$$

This equation is linear but its parameters are unknown, they are estimated by minimizing the criterion of ordinary least squares. This criterion corresponds to the minimization of the sum of the squares of the difference between the observed and predicted values of the response variable Y. Y estimated is noted $\hat{Y}$ and takes the form: $\hat{Y} = b_0 + b_1 x_{1i} + \ldots + b_p x_{pi}$ (2)

Where: Y= the dependent variable indicating the total number of adaptation practices embraced by each breeder ; b_0: the regression constant ; b_1- b_{35}: the coefficients of x or the vector of parameters ; xj: the p explanatory variables (j: 1, …., p=35); i: breeder number (current observation), i=1, …, n ; n: total number of breeders surveyed (n=167). The values which minimize the criterion of ordinary least squares are estimates b_0, b_1, ..., b_p of the unknown parameters β_0, β_1, …, β_p. The factors (explanatory variables) that can influence the adaptation practices of breeders have been identified from the literature and our field experience. The table 1 presents the explanatory variables, their description and their expected sign. The effect of these regressors on the adoption of coping practices varies according to the measure adopted.

Table 1. List of explanatory variables affecting the total number of adaptation measures practiced

Explanatory variables (Type)	Description and Measurement	Expected effect
Socio-economic variables		
Age of household head (Dummy)	Age groups of heads of HH (0: <50 years; 1: >= 50 years)	±
Educational level (Dummy)	Level of schooling of HH head (0: Otherwise; 1: Literate)	+
Main occupation (Dummy)	Main occupation (0: Livestock; 1: Agriculture-Livestock)	+
Practice of official activity (Dummy)	Secondary activity is functionary (0: No; 1: Yes)	+
Practice of commercial activity (Dummy)	Secondary activity is commercial activity (0: No; 1: Yes)	+
Number of wives of HH head (Continuous)	Number of wives of HH head	+
Household size (Continuous)	Total number of household members	+
Agricultural labor force in the HH (Continuous)	HH labor force involved in agriculture (Number/HH)	+
Use of hired labor (Continuous)	Number of hired labor employed (Number/HH)	+
Out migration of labor (Continuous)	Number of HH labor force occasionally migrated away (Number/HH)	±
Concrete house_ Habitat type (Dummy)	Type of HH habitat is concrete house (0: No; 1: Yes)	+
Tent _ Habitat type (Dummy)	Type of HH habitat is the tent (0: No; 1: Yes)	-
Farm size (Continuous)	Size of farm owned by a household in Hectares (Ha)	+
Possession of truck (Dummy)	Truck owned by the head of HH (0: No; 1: Yes)	+
Possession of tractor (Dummy)	Tractor owned by the head of HH (0: No; 1: Yes)	+
Possession of cart (Dummy)	Cart owned by the head of HH (0: No; 1: Yes)	+
Possession of tank (Dummy)	Tank owned by the head of HH (0: No; 1: Yes)	+
Possession of motor pump (Dummy)	Motor pump owned by the head of HH (0: No; 1: Yes)	+
Size of sheep flock (Continuous)	Total number of sheep owned by a breeder	+
Size of cattle flock (Continuous)	Total number of cattle owned by a breeder	+
Employment of shepherds (Dummy)	Use of shepherds (0: No; 1: Yes)	+
Total consumption expenditure (Continuous)	Annual total consumption expenditure (Amount in Morocco Dirhams: DH)	±
Access to formal credit (Dummy)	Access to formal credit (0: Otherwise; 1: if Access)	+
Electricity access (Dummy)	Access to electricity network (0: Otherwise; 1: if Access)	+
Market distance (Continuous)	Distance to the nearest market in Kilometers (Km)	-
Distance to livestock watering source (Continuous)	Distance to the nearest livestock watering source in Kilometers (Km)	-
Geographic variables		
Northern agroecological zone (Dummy)	Agro-ecological site is Northern zone (0: Other zones; 1: Northern zone)	+
Intermediate agroecological zone (Dummy)	Agro-ecological site is Intermediate zone (0: Other zones; 1: Intermediate zone)	±
Perception variables		
Perception of late onset of rains (Dummy)	0: Otherwise; 1: if perceived	+
Perception of increased pockets drought (Dummy)	0: Otherwise; 1: if perceived	+
Perception of heavy rains (Dummy)	0: Otherwise; 1: if perceived	+
Perception of more frequent droughts (Dummy)	0: Otherwise; 1: if perceived	+
Perception of temperature change (Dummy)	0: Otherwise; 1: if perceived	+
Perception of increased violent winds (Dummy)	0: Otherwise; 1: if perceived	+
Perception of increased sandstorms (Dummy)	0: Otherwise; 1: if perceived	+

Data analysis

The collected data were analyzed using: Descriptive statistics, Chi-square independence test, Kruskal-Wallis test and Multiple Linear Regression. The Chi-square independence test aimed to highlight the relationship that may exist between the breeders' categories and the total number of adaptation measures adopted. As mentioned above, breeder classes are based on the size of the flock of sheep in possession. The Kruskal-Wallis test was carried out to test the difference in terms of the total number of adaptation measures adopted among the three categories of breeders identified. Indeed, this test is an appropriate nonparametric test for comparing more than two independent samples and which can be used to look whether such samples come from the same distribution (Ostertagova et al., 2014). All populations have the same median or no significant difference between groups (samples) is the null hypothesis of this rank-based test. When the Kruskal-Wallis statistic is significant, the nonparametric multiple comparison method is employed to highlight which classes of breeders are different from the others. Finally, multiple linear regression was used to determine the factors influencing the adoption (implementation) of adaptation practices to climate variability and change by the breeders in the study area.

Results and discussion

List and analyze of the breeders' adaptation practices to CC in the study area

There are diversity and richness in terms of adaptation measures implemented by livestock breeders in the HPEM (Figure 2). In fact, most of these coping practices have an endogenous origin since they emanate from their own initiatives, attesting of their great ability and their accumulated experience to permanently anticipate or cope with the negative effects of climate variability and change. Nevertheless, these adaptation practices can be described, in their majority, as reactive and they are part of a short-term logic. In addition, they show a low to medium adequacy in relation to the main or specific objective of adapting to CC. In fact, these current adaptation actions are practiced by local breeders either on the one hand to improve the productivity or the performance of their breeding thus making it possible to reduce the vulnerability of this economic activity to CC (medium adequacy) or to improve their incomes and to meet the financial needs of their farms (low adequacy) on the other hand. The only adaptation measures implemented whose purpose is a specific response to CC and thus having a high degree of relevance by report to this climatic phenomenon are the herd mobility, storage of livestock feeds, subscription to climate insurance and the integration of livestock breeding and irrigated agriculture. However, the latter actions depend on the socioeconomic level of the breeder (mostly practiced by large herders) or they are localized in space like irrigated agriculture.

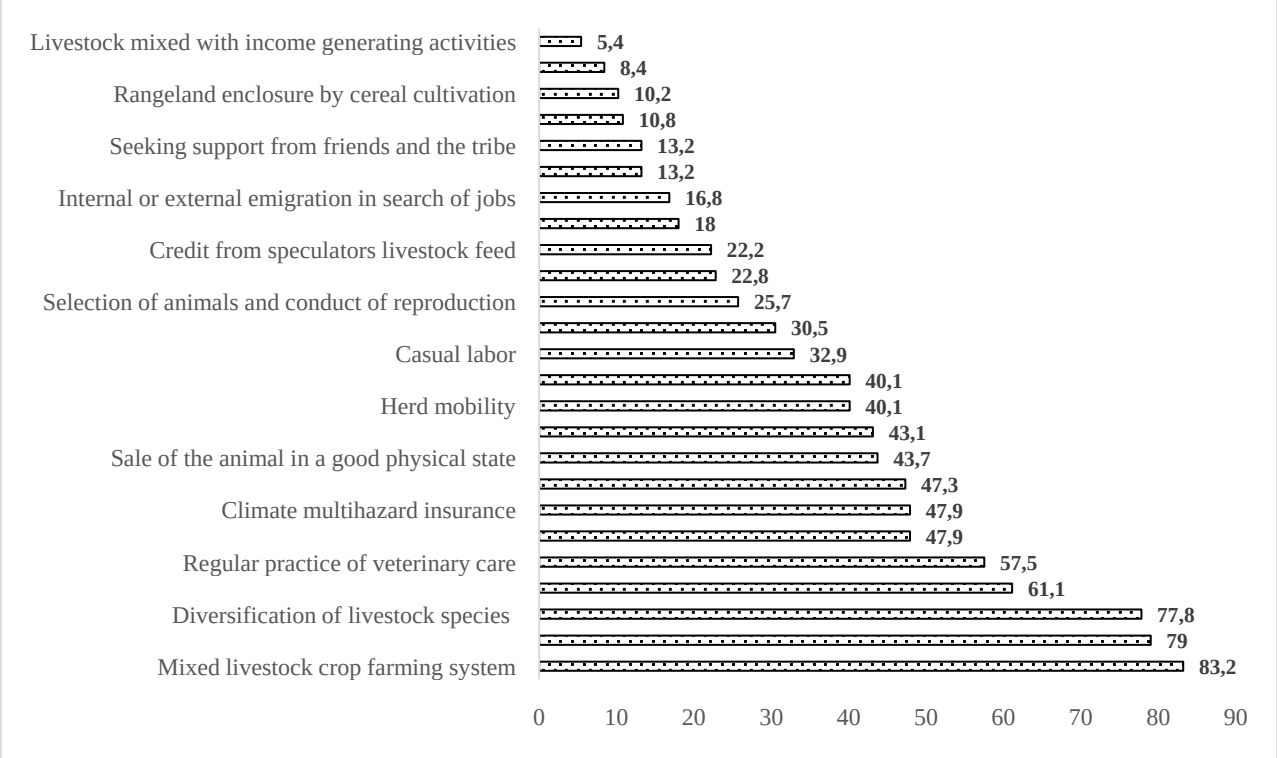

Figure 2: Inventory or portfolio of local adaptation measures (in %)

In line with our findings, Bourbouze (2000) and Bourbouze and El Aich (2000) pointed that most adaptive practices or climate anti-risk practices implemented by the breeders in the HPEM are curative and low efficient particularly in the event of climatic hazards (drought) prolonged in duration. Bechchari et al. (2014) underlined that the adaptive capacity of breeders in the HPEM's area with regard to climate variability and risks, largely depends on their respective socioeconomic status.

Hereafter a description of some examples of adaptation practices in response to the adverse effects of variability and climate change, that are widely adopted (implemented) by the herders in the study area.

Association of livestock and agriculture

It is a long-term preventive adaptation practice. It is essentially aimed at diversifying the production of the farm and providing breeders with complementary food resources of agricultural origin, such as stubble, straw and grain (Bourbouze, 2000). Indeed, this coping action is a traditional adaptation measure that has developed due to demographic pressure and which was initiated by sharing in the 60s within the local pastoral communities, favorable lands to agriculture. However, extensions of cereal farming outside of the old areas of cultures relatively favorable, such as depressions and lowland, called "Mharet" habitually and traditionally recognized by community users, towards less favorable pastoral lands, are increasingly observed. The result is a gradual but accelerated conversion of the pastoral system into a production system combining livestock farming and cereal cultivation (notably barley), which is visibly widespread (Bourbouze and El Aich, 2000). This practice (cultivation of rangelands) is often accompanied by two other phenomena, namely the sedentarisation and the construction of permanent habitats on the rangelands. This reflects a profound change in the behaviors and habits of pastoralists in the study

area, formerly based on mobility, nomadic lifestyle, rangelands exchange agreements and pastoral pacts. In fact, the sedentarisation of breeders is not necessarily a deliberate choice on their part, but it is the consequence of a public policy initiated during the protectorate period and which was followed after independence. Also, a risk of erosion, in particular of water, is more and more to be feared as a result of the succession of plowing on open sites (shallows lands) corresponding to watercourses (Mahyou et al., 2010) combined with the worsening of rangelands degradation processes (Bechchari et al., 2014). Despite the low productivity of cultivated cereals, this mixed system allows local breeders to better free themselves from the effects and climatic and economic uncertainties.. And this by: various combinations of sheep and cereals, taking into account fluctuations in the climate and prices of animals and livestock feed, complementarity/integration between livestock and agriculture and profit from the time lag between animal and plant production (Pluvinage, 1995). In case of a favorable season initiated by early autumn rains, the breeder will collect barley in green (depressed or "Ksil"), plus a few quintals of grains (rarely exceeding 5 Qx ha-1) and stubble. In addition to the aforementioned reasons, this livestock- agriculture farming association continues to attract adopters since it allows relative independence of the livestock farmer from the vagaries of the market and a certain personal satisfaction (consumption of cereals grown on place, animal grazing on stubble produced and constitution of stocks of own grain in case of a rainy year). Finally, this cultivation of rangelands even in dry years, knowing its low productivity and the random nature of precipitation in the HPEM, can only be justified by the desire to appropriate the collective pastoral lands or at least the assertion of their annexation (Bourbouze, 2000; Maâtougui et al., 2011). Thus, a dynamic of appropriation of the collective pastoral areas by cultivation is widely observed. This illegal appropriation is due to the gradual substitution of administrative and elected structures for customary community organizations, which has hampered community rules governing access and use of rangelands for the benefit of rules based on private property (Narjisse, 2006) and to the legal ambiguity governing collective rangelands where traditional law, Muslim land law and modern state law intermingle (Bourbouze, 2000; Lazarev, 2008). In order to combat this unfavourable trend, the new Law 113-13 relating to pastoral transhumance, planning and management of pastoral and sylvopastoral lands, which entered into force in 2016, has as main objective to secure national pastoral lands through their delimitation, their development and their management by multi-party and territorialised institutions, and where the breeders' representatives are constituent members of these management commissions.

Food complementation of herds

It is a curative practice in the short term that was notably developed at the end of the years 70 and is currently widespread or even generalized to all categories of breeders (Bourbouze, 2000; Maâtougui et al., 2011; Bechchari et al., 2014). This complementation, which essentially concerns the fattening of lambs and the supplementation of full or lactating ewes, especially during drought years, aims to keep animals in good physical condition. The corollary objective is thus to maintain the high prices of the livestock market and also to benefit from the interesting prices offered on the occasion of the sacrifice feast "Aïd Al Adha". This adaptation allows large livestock producers to have good animal products that can be easily finished. Supplementation or even fattening of animals purchased and / or emaned from the flock in possession are strongly practiced in these large farms. Medium and small

livestock owners purchase livestock feed at weekly rhythm, often with supply credits from speculators or resellers of food, the amount of which is refundable on the sale of the products animals. In fact, this resort to informal credit could be an indication of the difficulty of access to formal credit, mainly among small breeders, and the unsuitability of conventional modes of financing in relation to the activity of mobile or sedentary livestock farming. Public policy should pay more attention to this lever for adaptation and development. Finally, this dependence of breeding over food supplementation (and therefore on livestock feed market) is also observed in rangelands of the North-Atlas plateaus and of the plains of Morocco (Chattou, 2014).

Decapitalizing strategy or regular sale of animals

It is an anti-risk measure of the curative type, widely practiced to overcome the adverse effects of changes and climatic hazards (Bourbouze, 2000; Bourbouze and El Aich, 2000). In fact, small breeders and, to a lesser extent, medium herders are the most vulnerable categories since they are the first and most affected by these phenomena. Medium-sized livestock breeders are opting for a reduction in herd numbers, as a result of the narrowing of rangeland feed offers and rising livestock feed prices, particularly during drought years. The latter are accompanied by a downward trend in the selling prices of animals to local markets, ultimately leading to a significant reduction in the profit margins of breeders during these periods of crisis. With regard to the small-scale livestock producers, after the gradual sale of part of their livestock for the purpose of supplying animal feed necessary to maintain the remaining herd, they end up selling their entire animal capital. They subsequently abandon livestock production and migrate in search of casual employment in nearby urban centers usually occupying the peripheral areas of these centers or, at worst, settling near permanent water facilities. Afterward, some of these former small herders face serious difficulties in rebuilding their herds and resuming pastoral activity, while others manage to procure flocks to very small size but without being able to renounce their new mode of life. Nevertheless, even if this change of activity is made, the small herders who have become without herds, converting themselves into wage-earners on site (day laborers, shepherds, agricultural workers), they do not abandon their lands of crops situated in the shallows in the hope of leasing them to third parties (transfer of the right). By contrast to small breeders, who are greatly influenced by the duration and intensity of climatic hazard and therefore their capacity to reconstitute the herd is generally limited (Bechchari et al., 2014), the practice of decapitalisation, among large herders and part of the medium breeders, seems well controlled because the herds are obviously in good condition. They are engaged in regular sheep sales, despite lower prices than usual, but the revenues generated are generally sufficient to mitigate the negative effects of climatic vagaries with a prospect of a rapid recovery in terms of replenishment of flocks once the climatic conditions are improving. This capacity for the reconstitution of the herd is dependent on several factors: the financial resources of the breeder (savings, income from speculation actions and non-agricultural activities), State aid and transfers of money from the emigration.

Motorization / Mechanization

The emergence and then the diffusion of the use of means of locomotion (trucks, pick-up) and also of the tractor in the steppe ecosystems of Eastern Morocco, led to the modification in particular of the way to practice the livestock breeding and, above all, the way in which the pastoral lands is used. Thanks to the mechanization of the

production system, in particular among large breeders, movements of herds are organized more rapidly and probably using more distant pastures, the transport of livestock feeds and water to the flocks and not the other way around, and finally, sales of animals become easier or more flexible (Bourbouze 2000; Bourbouze and El Aich 2000). Nevertheless, the negative consequences of this motorization have sometimes given rise to serious conflicts, since big breeders have been able to concentrate large flocks, with an annexation of vast expanses of collective lands (similar to the system of ranching) and mining of available natural resources (Bechchari et al., 2014). The use of means of locomotion has favored overgrazing (Bourbouze and El Aich 2000) and has undermined the principles that control the social relationships of yesteryear and the norms that governed them in the context of nomadism camps (Mahdi, 2007).

Mobility and transhumance

The mobility of herds in search of favorable rangelands constitutes a traditional and ancestral strategy for adapting pastoral livestock farming, particularly to the droughts of long duration. It ensured a rational use of the pastoral resources of the ecosystem studied, taking into account the availability and quality of these resources, thus allowing a better distribution of the animal load on the vegetation cover. Currently, the practice of herd mobility, pursued in terms of nomadism and transhumance, is greatly reduced and it is limited to the large breeders in the majority of cases (Bourbouze, 2000; Bourbouze and El Aich, 2000, Mahdi, 2007). About two-thirds of large breeders interviewed continue to practice this mobility against 27% among small breeders who opt for low amplitude movements. It is mainly the herders of the rural communes of Tendrara and Maâtarka (intermediate zone) who use transhumance even more, that is 61%, against respectively 30 and 9% for those of the southern and northern zones of the HPEM. This is probably due to the fact that they hold large numbers of livestock exceeding 450,000 heads of small ruminants and who have been able to keep socio-cultural values specific to pastoral societies (social cohesion and solidarity, habits of the nomadic way of life, receptivity, socio-cultural value of livestock and breeding, pastoral pacts with distant communities). The regression of transhumance is attributed to several factors. Indeed, the population growth combined with a public policy that has favored the sedentarisation of pastoralists, have led to a significant increase in the pressure on the land and the narrowing of the crossing areas and pastures for transhumant herds. The increasing costs of moving livestock are another significant cause. In fact, herd movements over long-distance "Attarhal" were replaced by an exceptional transhumance with a mode of use based on sedentarisation and a breeding activity that is increasingly dependent on the distribution of complementary livestock feed on the rangelands. Despite the reduction in herd mobility, in terms of frequency and distance traveled, this practice is still an important CC adaptation measure, even it is currently pursued as short term or curative-type action, by about 40% of herders surveyed. Law N° 113-13 provides for the regulation of transhumance activity through the obligation to have a transhumance authorization, issued by the competent authorities and which takes into account the fodder possibilities and optimal animal load capacity of receiving pastoral areas.

Storage of livestock feed

The constitution of livestock feed stocks is generally considered as a curative adaptation action (Bourbouze, 2000), but it may be a strategic option, particularly for

large livestock farmers and for some emigrant practicing the fattening (Bechchari et al., 2014). The recourse to the livestock feed storage, especially barley, is observed among almost half of the herders questioned. This practice is currently widespread among large breeders (over 62% of them) compared to small herders (just over a third of them) in order to meet animal needs (essentially the complement of lactating ewes) for a period ranging from 3 to 6 months. In addition, the storage of barley is prevalent in the northern zone (90% of the breeders surveyed) compared to the intermediate and southern zones, which exhibit an adoption rate of 29 and 53% respectively. This is probably due to the availability of water resources in the first site, which encouraged local breeders to practice massively forage crops. After the exhaustion of the feed stock, and in the event of the persistence of the drought in particular, the breeder is forced to sell the fattened lamb and to explore transhumance sites. Furthermore, a large proportion of the small and medium-sized livestock breeders engage in weekly purchases of livestock feeds, thus being able to constitute feed stocks only infrequently and for a period not exceeding one month.

Emigration/rural exodus

The emigration is a practice anti-risks preventive pursued to the long term. It can be internal (at local, regional and national level) or external (abroad) looking for jobs and better living conditions. In fact, it represents an alternative livelihood, rather than a measure of adaptation to climate change proper. Nevertheless, in the case of climatic vagaries (drought) particularly, this practice (emigration) played, in the past, a very important role in the funding of the activity of the livestock breeding (Bourbouze, 2000; Mahdi, 2007) primarily for the maintenance of animals in good physical conditions -without being obliged to sell them-, for the replenishment of the flocks and for better finishing of herds outside the rangelands by investing in the fattening. Mahdi (2007) found that in 2002, half of 4,064 pastoralist households investigated in the HPEM's area have at least one emigrant member (nationally or internationally). In fact, the acceleration of external emigration (to Western Europe, especially Spain) in the mid-1990s, concerned in particular the sons of medium and large breeders, and allowed on several occasions to manage the risks run by animal production. Moreover, the recurrence and prolongation of the drought episodes in the HPEM forced a large proportion of small breeders to abandon livestock farming, and ultimately to the rural exodus for the search for work in the nearest cities. This form of adaptation (rural exodus) has become their preferred choice in order to find alternatives to the crisis situation that threatened their economic activity based on pastoral rearing and whose vulnerability to change and vagaries in climate and fluctuations in prices of feed and livestock are important causes. Emigration is more widespread in the northern zone (27%) compared to the intermediate and southern areas which show respective lower rates of 13 and 16%. This indicates that emigration in particular to foreign countries is dependent on the relative wealth of each area and that its weakness in the southern part provides information on a higher degree of poverty and a weakness within it of emigration abroad networks (Mahdi, 2007). It should be noted that, at present, this preventive adaptation action (emigration) has largely lost of magnitude, since only 17% of the households interviewed have at least one emigrant member. It could be due to the economic crisis and the hardening of immigration measures at the host countries level. Money transfers from abroad have shrunk considerably, with sometimes of inverse shipments of money. Recently, increasingly frequent return of emigrant persons to the HPEM's area is observed, may be to take advantage of the new opportunities

offered as part of the INDH (National Human Development Initiative) and “Plan Maroc Vert” programs.

Profit of the State support

The range of adaptation options cited above, which are described as endogenous or emanating from the own initiatives of the breeders in the HPEM, has been reinforced by the contribution of the public authorities through various interventions. The latter mainly include pastoral improvement actions (fodder shrub planting, tillage), restoration and rehabilitation of rangelands (resting areas, seed reserves) and finally, pastoral hydraulics (creation and equipment of facilities of water, micro-dams). Further encouragements and incentives were provided by the State, as part of the program to combat the effects of drought and the Livestock Safeguard Program (LSP). The action of benefiting by the breeders in the study area from this public support is considered as a form of curative adaptation in the short term. The majority of breeders surveyed (almost 80%) declared having benefited from these development and support actions. Note that there is a significant difference in terms of profit from these public measures between the agroecological sub-zones studied (χ^2 = 7.192, p <0.05) where the northern zone seems to benefit more (97%) compared to the other intermediate and southern areas, which record respective relative frequencies of 77 and 73%. However, with regard to the breeder classes, no significant difference was found (χ^2 = 2,423, p = .298), even if the large and medium-sized herders show a slightly higher frequency, i.e. 85%, in comparison with small-scale breeders (73%). In addition, in spite of its salutary character and its great socio-economic interest, the LSP (mainly of subsidized livestock feed and livestock watering) has led to some results counterproductive, if not negative such as decline in the practice of usual load shedding of rangelands due to the maintenance or even the increase in the number of heads (Maâtougui et al., 2011; Schilling et al., 2012) and the problem of social equity in the distribution of subsidized barley, benefiting, in general, more to large and medium-sized breeders who have of the instant cash money. A revision of the latter aid programs, in particular as regards their design and their modalities of implementation, is therefore necessary.

Relationship between the total number of adaptation practices implemented and the size of the flock of sheep in possession by the breeder

The Chi-square independence test showed that, at the α= 0.05 level of significance, there exists very strong evidence to conclude that there is a statistically significant relationship between the total count of adaptation practices adopted and breeders’ classes (χ^2 = 1009.529, p = 0.000). Also, the Cramer's V. coefficient measuring the strength of this statistical relationship has high value either 0.657. Thus, this association is of high magnitude. This is an indication that the larger the size of the sheep flock in ownership, the higher the total number of adaptation practices adopted (implemented).

The Kruskal-Wallis test was conducted to examine the differences in the total number of climate change adaptation measures implemented according to the classes of breeders that are defined on the basis of the size of the owned sheep flock. Since p-value = 0.000 ≤ 0.05 = α, we reject the null hypothesis (the distribution of the total number of adaptation practices is identical across classes of breeders). Indeed, significant differences (Chi square = 39.986, p = 0.000, df = 2) were found between the three categories of breeders (small, medium and large). After the Kruskal-Wallis

test led us to reject the null hypothesis of similarity between breeders' categories in terms of total number of coping measures practiced, we performed multiples comparisons using Dunn's pairwise tests to determine which classes of breeders are different. The results show that there is a highly significant difference ($p < 0.001$, adjusted using the Bonferroni correction) between small breeders on the one hand and large and medium herders on the other hand in adopting climate change adaptation practices. The mean rank is of 65.10 for small breeders, 100.32 and 127.63 respectively, for medium and better-off herders. In addition, the large breeders have the highest median (and, hence, the mean of the total count of adaptive measures practiced) either 12 compared to small (6) and medium herders (8). There was no evidence of a difference between medium and large breeders. In line with our results, Bechchari et al. (2014) underlined that HPEM' breeders exhibit variable behaviors in response to the effects of CC (droughts), which clearly depend on the socioeconomic status of the herder. A wider range of adaptation practices is implemented by large breeders in comparison with the other categories of breeders. Similarly, Mahdi (2007) and Lazarev (2008) highlighted that the social stratification of the breeders in the study area, based on the size of the herd in possession, influences their measures as for the use of the pastoral lands, the management of the livestock rearing and the reaction regarding the climatic vagaries such as the drought.

Factors influencing the adoption of adaptation practices in the study area

In this section, we have tried to determine the factors that influence the total number of adaptation measures adopted by the breeders in the study area regarding to the climatic variability and change. The table 2 shows the estimated multiple regression coefficients for the determinants of adaptation methods. The regression model of determinants of climate change adaptation practices' adoption revealed a positive relationship between predictor variables and the dependent variable ($R=.876$, $R^2 = .767$, $F = 11.878$). The model has a good fit and significant at 1% ($p=.000$). The value of the multiple correlation (R) of 0.876 suggests that the data are very satisfactorily adjusted to the regression model. Also, the R^2 obtained means that the predictors explain for a significant proportion (nearly 77%) of the variability of the dependent variable (the total number of adaptation measures adopted). The evaluation of the parameters of the model shows that from the 35 variables that were included in the model, only eight were significant. The latter are mainly of socioeconomic type. In line with this finding, several authors have found that the determinants of farmers' adaptation to climate change are socioeconomic variables at the household level, and this in many countries such as Uganda (Nabikolo et al., 2012), Nigeria (Obayelu et al., 2014), Ethiopia (Balew et a., 2014; Berhanu and Beyene, 2015), South Africa (Taruvinga et a., 2016), Ghana (Ndamani and Watanabe, 2015), Tanzania (Below et al., 2012) and Nepal (Tiwari et al., 2014). By contrast, Ouédraogo et al. (2010) pointed out that the main factors influencing the adoption of climate change adaptation practices are the perception variables, even if other socio-institutional factors like access to supervision / extension, credit and education have a significant effect on the implementation (adoption) of these coping measures.

Table 2. Multiple regression presenting determinants of adoption of climate change adaptation measures practiced by the breeders in the high plateaus of eastern Morocco

Variables	**β**	**Std. E**	**t-values**
Constant	2.978	2.940	1.013
Intermediate agroecological zone	1.648	.697	2.364*
Main occupation	4.766	1.978	2.409*
Secondary activity as commercial activity	2.246	.695	3.231**
Type of habitat is the tent	-1.257	.391	-3.217**
Possession of tanks	1.592	.505	3.155**
Possession of motor pump	1.439	.512	2.812**
Size of sheep flock	.005	.002	3.384**
Temperature change	-1.440	.624	-2.309*
No. of observations			167
F.			11.878
Sig. F.			.000
R^2			.767

Note: * and ** denote level of significance, respectively, at .05 and .01.

Discussion of determinants identified by multiple regression

Size of sheep flock

The results of the regression model, which analyses factors affecting the adoption of coping practices, show that a one standard deviation positive change in the size of sheep herd, holding other explanatory variables constant, provides an increase of .005 standard deviation for adopting of CC adaptation measures. There is a high and very significant positive relationship between the dependent variable (the total number of adaptation measures adopted) and the size of sheep flock (Pearson correlation = .613, p = .000). This suggests that the size of the sheep herd in possession positively affects the likelihood that breeders will adopt adaptation practices in response to CC. In addition to the supply of animal products (meat, milk, wool, manure), the possession of large livestock herds represents an economic power or a sign of wealth of breeders (Watson and van Binsbergen, 2008; Deressa et al., 2009) and an important socio-cultural value (Yirga, 2007; Opiyo al., 2015). Also, it assigns them a particular social status in relation to their pairs. It is widely recognized that the implementation of adaptive techniques requires the provision of substantial financial resources such as large herds of livestock (Opiyo al., 2015). In line with our findings, livestock ownership (Bryan et al., 2009; Balew et al., 2014) or herd size (Berhanu and Beyene, 2015; Opiyo et al., 2015) have a positive and significant effect on the likelihood that farmers adapt to CC. For their part, Obayelu et al. (2014) reported a contradictory effect of this factor. Indeed, the larger livestock number improved the farmers' choices for the practice of soil and water conservation measures but reduced their likelihood of diversification to non-farm activities. On the other hand, Deressa et al. (2009) and Nabikolo et al. (2012) have found that

possession of animals is not a significant factor in the adoption of adaptation methods, respectively in the Nile basin of Ethiopia and Eastern Uganda.

Secondary occupation is the commercial activity

The slope of secondary occupation (commercial activity) of household head is 2.246. This means that for every one unit increase in this factor, after controlling for all other predictors, the adoption of coping practices increases by 2.246. The practice of a secondary activity, in this case small trade, in addition to the main occupation (livestock rearing) provides some breeders with additional income that may be used to implement measures to adapt to variability and climate change. Previous studies have shown a significant and positive effect of the additional income from non-farm activities, on increasing the likelihood of implementing adaptive practices, such as mixed farming (Obayelu et al., 2014), destocking (Mabe et al., 2014), planting trees, changing planting dates and using irrigation (Bryan et al., 2009; Deressa et al., 2009). On the other hand, Debalke (2011) emphasizes the contradictory effect of this determinant. Indeed, the latter increases households' choices for the soil conservation and changing planting dates as coping techniques, but decreases the probability of undertaken of multiple cropping, irrigation and livestock. In contrast, Yila and Resurreccion (2013), Tiwari et al. (2014) and Opiyo et al. (2015), highlight that off-farm income is a non-significant factor in relation to the implementation of adaptation practices. It probably because the off-farm occupation encroaches on the available time for farming activities (McNamara et al., 1991).

Possession of the tanks and motor pump

For a one standard deviation positive change in both ownership of tanks and motor pump, holding other predictor variables constant, the results reveal an increase in the adoption of coping practices by 1.592 and 1.439 standard deviations respectively. Thus, we can conclude that breeders' who own agricultural equipment are more likely to adapt to CC. Similarly, other authors had found that ownership of heavy machinery or in general agricultural equipment enhances significantly and positively the ability of farmers to adapt in response to climate change (Hassan and Nhemachena, 2008; Ouédraogo et al., 2010). Nevertheless, the acquisition of agricultural machinery necessary to the implementation of adaptation measures represents a major constraint because of the combined effect of a rural context marked by poverty and the lack of financial instruments adapted to small farmers (Ouédraogo et al., 2010).

Main occupation

The slope of main activity (breeding and agriculture) is 4.766. This means that for every one unit increase in this factor, the adoption of coping practices rises by 4.766 in comparison with the other households which their main occupation is only livestock breeding. In line with this result, Balew et al. (2014) found that the main occupation (only farming) is a non-significative factor that can influence the adoption of adaptation techniques. However, the farmers with livestock holding had more probability to adapt to CC. Also, other authors (Bryan et al., 2009; Berhanu and Beyene, 2015; Opiyo et al., 2015) have mentioned that livestock ownership in addition to agriculture had a positive impact on the probability to implement adaptation measures. On the other hand, some authors (Ouédraogo et al., 2010; Nabikolo et al., 2012) have reported that the possession of livestock herds alone is not a significant factor in the adoption of adaptation practices. In fact, the breeders with a production system combining livestock holding and agriculture are less

affected by the climatic and economic effects and uncertainties. This thanks to the integration between livestock breeding and agriculture (complementary food resources of agricultural origin, constitution of stocks of animal feed, manure).

Agro ecological zone

The slope of intermediate agroecological zone is 1.648. This means that for every one unit increase in this factor, the adoption of coping practices rises by 1.648. As expected, living in different agro-ecological zones, influences the decision and the farmers' choices regarding the implementation of adaptation measures (Ouédraogo et al., 2010; Piya et al., 2013; Tiwari et al., 2014; Atinkut and Mebrat, 2016). These actions vary mainly according to the local biophysical and socioeconomic conditions (Deressa et al., 2009; Below et al., 2012; Atinkut and Mebrat, 2016). In our case, belonging to the intermediate agroecological zone (rural communes of Tendrara and Maâtarka) increases the probability of undertaking adaptation practices in comparison with the southern zone. Indeed, climatic conditions are more favorable, rangelands are largely more extended, livestock flocks are greater and social traditions (transhumance, nomadic lifestyle, social cohesion) are even more affirmed in the first locality than in the South.

In accordance with our previous results, several authors have highlighted the effect of climatic conditions linked to the "agroecological area" factor on the adoption (implementation) of adaptation measures. Below et al. (2012) showed that the differences in the frequencies of adaptation practices between two wards in Tanzania namely Mlali (Sub-humid climate with average annual precipitation of 890 mm) and Gairo (Semi-arid climate with average annual precipitation of 499 mm) are significant and the distribution of most adaptation practices also differs significantly between the two wards and this in favor of the first site. Ouédraogo et al. (2010) emphasized the positive effect of this factor, mentioned above, on the adoption of water and soil conservation techniques and organic fertilization in the Sahelian zone (rainfall between 300 and 600 mm) and a negative effect in the Sudanian zone (precipitation between 900 and 1200 mm). Contrariwise, in line with Gutu (2012) who pointed out that more sites receive less precipitation, their farmers are more likely to implement adaptation measures, Deressa et al. (2009) underlined that decreasing precipitation significantly rises the probability of adopting soil conservation, changing crop varieties, changing planting dates and irrigating. On the other hand, Berhanu and Beyene (2015) have claimed that traditional pastoralism is seen as the unique resilient system in terms of adapting to harmful and unpredictable CC in arid areas.

Type of household is the tent

The slope of tent as main habitat of household is -1.257. This means that for every one unit increase in this factor, the adoption of coping practices decreases by 1.257. The tent or "Kheima" is still an essential tool during the movements of livestock breeders in the study area (Bourbouze, 2000), although its use is more and more less frequent. In addition, the decline of this traditional habitat can also be explained by the fact that the wives of breeders find it increasingly difficult to carry out their domestic activities in the tents. The study showed that breeders who do not live in tents are more likely to implement adaptation practices. This may be due to the fact that herders residing in the "urban" areas bordering the steppes are more aware of the phenomenon of climate change (availability of means of communication and

possible contacts with local agricultural extension agencies) compared to those rarely leaving the rangelands.

Long term change of temperature

With reference to the regression model, the obtained results show that breeders' perception to climate change is one of the factors that affect the adoption of adaptation practices. The slope of temperature change is -1.440. This means that for every one unit increase in this factor, the adoption of coping practices decreases by 1.440. Thus, this study found that breeders' who perceived a change of temperature are less likely to adapt to this climatic phenomenon. Debalke (2011) found the same result by showing the negative impact of this factor with respect to the adoption of some adaptation measures (soil conservation, irrigation, changing planting dates). On the other hand, other authors have stressed the significant and positive effect of perception of temperature change in relation to the implementation of these same adaptation practices (Deressa et al., 2009; Atinkut and Mebrat, 2016), or of other coping measures such as multiple cropping or crop-diversification (Debalke, 2011; Atinkut and Mebrat, 2016), destocking, fallowing and planting of trees (Mabe et al., 2014). Other previous studies have reported that perception of temperature change is a non-significant factor with respect to the use of adaptation measures in response to CC (Yila and Resurreccion, 2013; Tiwari et al., 2014; Ndamani and Watanabe, 2016). In our study area (steppic rangelands with an arid to hyperarid climate) where extensive livestock breeding is the major activity of households, it is mainly the precipitation parameter which is a determining climatic factor in the eyes of breeders because it conditions in particular the forage supply of rangelands in quantity and quality and the watering of herds.

Conclusions

This study showed that breeders in the high plateaus of eastern Morocco have adopted a large and varied range of climate change adaptation practices, the most common of which are: association of livestock and agriculture, profit from public interventions (fodder shrub plantations, pastoral hydraulics, water and soil conservation actions), mixed sheep-goats breeding, climate multihazard insurance, livestock feed storage, regular sale of animals to stock up on livestock feed and transhumance. However, the implementation (adoption) of these adaptation measures is influenced mainly by the socioeconomic attributes of the breeders. Therefore, small-scale herders are the most vulnerable group that can only implement a small or limited number of adaptation actions to cope with the adverse effects of CC. Given that extreme climatic events (droughts) have increased in the recent past and will likely rise in the future, there is a risk that current and future climate change seriously threaten the livelihoods of this precarious segment of the local population and could exacerbate social inequalities among breeders, by accentuating the impoverishment of small livestock owners while the better-off breeders could become more wealthy.

References

Arimi K. (2014). Determinants of climate change adaptation strategies used by rice farmers in Southwestern, Nigeria. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 115 (2). p. 91-99.

Atinkut B., Mebrat A. (2016). Determinants of farmers choice of adaptation to climate variability in Dera woreda, south Gondar zone, Ethiopia. Environ Syst Res 5. p.6. doi : 10.1186/s40068-015-0046-x

Balew S., Agwata J., Anyango S. (2014). Determinants of Adoption Choices of Climate Change Adaptation Strategies in Crop Production by Small Scale Farmers in Some Regions of Central Ethiopia. Journal of Natural Sciences Research. 4 (4). p. 78-93.

Bechchari A., El Aich A., Mahyou H., Baghdad B., Bendaou M. (2014). Analyse de l'évolution du système pastoral du Maroc oriental. Revue d'élevage et de médecine vétérinaire des pays tropicaux 67 (4). p. 151-162.

Below T. B., Mutabazi K. D., Kirschke D., Franke C., Sieber S., Siebert R., Tscherning K. (2012). Can farmers' adaptation to climate change be explained by socioeconomic household-level variables? Global Environmental Change, 22(1). p. 223-235. http://dx.doi.org/10.1016/j.gloenvcha.2011.11.012.

Berhanu W., Beyene F. (2015). Climate Variability and Household Adaptation Strategies in Southern Ethiopia. Sustainability 2015 (7). p. 6353-6375. doi :10.3390/su7066353

Born K., Fink A., Paeth H. (2008). Dry and wet periods in the northwestern Maghreb for present day and future climate conditions. Meterologische Zeitschrift, 17. p. 533-551.

Bourbouze A. (2000). Pastoralisme au Maghreb : la révolution silencieuse. Fourrages, 161. p. 3-21.

Bourbouze A., El Aich A. (2000). Gestion des parcours et des troupeaux en régions steppiques et réponse à l'aléa climatique. Dans: Livestock Production and Climatic Uncertainty in the Mediterranean, Guessous F., Rihani N. et Ilham A. (Eds.). EAAP Publication No. 94. Wageningen Pers, Wageningen. p. 307-319.

Bryan E., Deressa T. T., Gbetibouo G. A. Ringler C. (2009). Determinants of Adaptation to Climate Change in Ethiopia and South Africa. South African Centre for Environmental Economics and Policy, International Food Policy Research Institute.

Chattou Z. (2014). Mutations des pratiques d'élevage et des structures sociales, cas des parcours des plateaux et plaines nord-atlasiques. Alternatives rurales, 2. p. 1-11.

Confais J., Le Guen M. (2006). Premiers pas en Régression Linéaire. La Revue Modulad, 35. p. 220-363.

https://www.rocq.inria.fr/axis/modulad/numero-35/Tutoriel-confais-35/confais-35.pdf

Debalke N. M. (2011). Determinants of farmers' preference for adaptation strategies to climate change: evidence from north shoa zone of Amhara region Ethiopia. MPRA Paper No. 48753.Ambo University, Addis Ababa University.

Deressa T. T., Hassan R. M., Ringler C., Alemu T., Yesuf M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change, 19. p. 248-255.

El Harizi K., Narjisse H., Herzenni A., Tozy M., et al. (2005). L'autonomisation des ruraux pauvres et la volatilité des politiques en Afrique du Nord et au Moyen Orient. Étude de cas Maroc. Rapport de restitution.

http://webagris.inra.org.ma:120/agris/doc/ouvrages/autonomisationruraux.pdf

Fink A., Christoph M., Born K., et al. (2010). Climate. In: Speth, P., Christoph, M., Diekkrüger, B. (Eds.), Impacts of Global Change on the Hydrological Cycle in West and Northwest Africa. Springer, Heidelberg. p. 54-58.

François A., Gauché E., Génin A. (2016). L'adaptation des territoires aux changements climatiques dans l'Oriental marocain : la vulnérabilité entre action et perceptions. Vertigo 16 (1). http://journals.openedition.org/vertigo/17177. doi: 10.4000/vertigo.17177.

Gutu T., Bezabih E., Mengistu K. (2012). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. Int Res J Agric Sci Soil Sci, 2(8). p. 347-363.

Hassan R. M. (2010). Implications of Climate Change for Agricultural Sector Performance in Africa: Policy Challenges and Research Agenda. J. Afr. Econ, 19. p. 77-105. https://doi.org/10.1093/jae/ejp026.

Hassan R. M., Nhemachena C. (2008). Determinants of African farmers strategies for adapting to climate change: Multinomial choice analysis. African Journal of Agricultural and Resource Economics, 2(1). p. 83-104.

Haut-Commissariat au Plan (HCP) (2018). Recensement Général de la Population et de l'Habitat (RGPH). http://www.hcp.ma/downloads/RGPH-2014_t17441.html.

Hulme M., Doherty R., Ngara T., New M., Lister D. (2001). African Climate Change: 1900-2100. Climate Research 17 (2). p. 145-168.

Kuhn A., Heidecke C., Roth A. et al. (2010). Importance of resource management for livelihood security under Climate Change in Southern Morocco, in Impacts of Global Change on the Hydro-logical Cycle in West and Northwest Africa. Springer, P. Speth, M. Christoph and B. Diekkrüger, (Eds.), Heidelberg, Germany. p. 566-591.

Lazarev G. (2008). L'élevage pastoral dans les Hauts Plateaux de l'Oriental du Maroc, Les notes d'analyse du CIHEAM (37). p.16.

Maâtougui A., Acherkouk M., El Fadili M., Elhoumaizi M. A. (2011). Les pâturages steppiques de l'Oriental marocain. L'essentiel sur l'état de dégradation et les voies d'amélioration. Division de l'information et de la communication, INRA-Edition, Rabat, Maroc. p. 1-57.

Mabe F. N., Sienso1 G., Donkoh S. (2014). Determinants of Choice of Climate Change Adaptation Strategies in Northern Ghana. Research in Applied Economics 6 (4). p. 75-94

McNamara K. T, Wetzstein M. E., Douce G. K. (1991). Factors affecting peanut producer adoption of integrated pest management. Review of agricultural economics, 13. p. 129-139.

Mano R., Nhemachena C. (2007). Assessment of the economic impacts of climate change on agriculture in Zimbabwe: A Ricardian approach. The World Bank, Policy Research Working Paper 4292.

http://documents.worldbank.org/curated/en/584431468168844535/pdf/Wps4292.pdf

Mahdi M. (2007). Pastoralism and Institutional Change in the Oriental, In J. Gertel and I. Breuer (Eds.) Pastoral Morocco: globalizing scapes of mobility and insecurity, Reichert, Wiesbaden. p. 93-105.

Mahyou H., Mimouni J. Hadria R. (2010). Mise en place d'un système d'alerte précoce à la sécheresse. Hilalpress, Oujda, Maroc. p. 29.

Maroc (2001). Communication Nationale Initiale à la Convention Cadre des Nations Unies sur les Changements Climatiques. Ministère de l'Aménagement du Territoire, de l'Urbanisme, de l'Habitat et de l'Environnement, 2001.

https://www.unfccc.int/resource/docs/natc/mornc1e.pdf

Maroc (2011). Projet d'intégration du changement climatique dans la mise en œuvre du plan Maroc vert. Ministère de l'agriculture et de la pêche maritime and Agence pour le développement agricole. http://www.ada.gov.ma/ uplds/pars/ECIES PICCPMV.pdf

Maroc (2016). 3ème Communication Nationale du Maroc à la Convention Cadre des Nations Unies sur les changements climatiques. Ministère Délégué auprès du Ministre de l'Energie, des Mines, de l'Eau et de l'Environnement Chargé de l'Environnement, Maroc.

Melhaoui M., Mezrhab A. Mimouni J. (2018). Evaluation et cartographie de la sécheresse météorologique dans les hauts plateaux de l'Oriental du Maroc. Rev. Microbiol. Ind. San et Environn., 12 (1). p.71-92.

Nabikolo D., Bashaasha B., Mangheni M. N., Majaliwa J. G. M. (2012). Determinants of climate change adaptation among male and female headed farm households in eastern Uganda. African Crop Science Journal, 20 (s2). p. 203- 212.

Narjisse H. (2006). Les écosystèmes agricoles et pastoraux : état des lieux et voies d'évolution. Cinquante ans de développement humain au Maroc et perspectives 2025. p. 349-391.

National Intelligence Council (NIC) (2009). North Africa: The Impact of CC to 2030 (Selected Countries). A Commissioned Research Report NIC 2009-007D, 2009. https://www.dni.gov/files/documents/climate2030_north_africa.pdf

Ndamani F., Watanabe T. (2016). Determinants of farmers' adaptation to climate change: A micro level analysis in Ghana. Sci. Agric., 73 (3). p. 201-208.

Obayelu O. A., Adepoju A. O., Idowu T. (2014). Factors influencing farmers' choices of adaptation to climate change in Ekiti State, Nigeria. Journal of Agriculture and Environment for International Development, 108 (1). p. 3-16.

doi: 10.12895/jaeid.20141.140

Ostertagova E., Ostertag O., Kováč J. (2014). Methodology and Application of the Kruskal-Wallis Test. Applied Mechanics and Materials, 611. p. 115-120.

Opiyo F., Wasonga O. V., Nyangito M. M., Mureithi S. M., Obando J., Munang R. (2015). Determinants of perceptions of climate change and adaptation among Turkana pastoralists in northwestern Kenya, Climate and Development.

doi:10.1080/17565529.2015.1034231

Ouédraogo M., Dembélé Y., Somé L. (2010). Perceptions et stratégies d'adaptation aux changements des précipitations : cas des paysans du Burkina Faso. Sécheresse, 21 (2). p. 87-96.

Piya L., Maharjan K. L., Joshi N. P. (2013). Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal. Reg Environ Change, 13. p.437-447. doi : 10.1007/s10113-012-0359-5

Pluvinage J. (1995). Les systèmes de production céréales-élevage et la gestion du risque dans les zones sèches méditerranéennes, thèse de doctorat en Sciences économiques, INRA-ENSAM. 377 p.

Schilling J., Freier K.P., Hertig E., Scheffran J. (2012). Climate change, vulnerability and adaptation in North Africa with focus on Morocco. Agriculture, Ecosystems and Environment, 156. p. 12-26.

Seo N., Mendelsohn R. (2006). Climate change impacts on animal husbandry in Africa: A Ricardian analysis. CEEPA Discussion Paper no. 9. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Taruvinga A., Visser M., Zhou L. (2016). Determinants of Rural Farmers' Adoption of Climate Change Adaptation Strategies: Evidence from the Amathole District Municipality, Eastern Cape Province, South Africa. International Journal of Environmental Science and Development, 7(9). p. 687-692.

doi: 10.18178/ijesd.2016.7.9.863

Tiwari K. R., Rayamajhi S., Pokharel R. K., Balla M. K. (2014). Determinants of the climate change adaptation in rural farming in Nepal Himalaya. International Journal of Multidisciplinary and Current Research, 2. p. 234-240.

Watson D. J., Binsbergen J. V. (2008). Livestock market access and opportunities in Turkana, Kenya. ILRI Research Report. no. 3. Nairobi, Kenya, 2008. 106p. https://cgspace.cgiar.org/bitstream/handle/10568/238/Res_report_no3.pdf?sequence=1&isAllowed=y.

Yila J. O., Resurreccion B. P. (2013). Determinants of smallholder farmers' adaptation strategies to climate change in the semi-arid Nguru Local Government Area, Northeastern Nigeria. Management of Environmental Quality: An International Journal, 24 (3). p. 341-364.

Yirga C. T. (2007). The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. Ph.D. Thesis. Department of Agricultural Economics, Extension, and Rural Development, University of Pretoria, South Africa.

Yohe G., Malone E., Brenkert A., et al. (2006). Global distributions of vulnerability to climate change. Integrated Assessment, 6. p. 35-44.