A Choice Experiment Approach to inform the Design of a PES for Watershed Protection in a Collective Pasture System

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Abstract. This paper suggests the use of the choice experiment approach to inform the design of a payment for environmental services (PES) to foster collective rangeland management. The empirical implementation was conducted in the M'goun watershed located in South-East of Morocco. Individual acceptability of various conservation measures and incentives is analysed. The results show that the combination of individual and collective conservation measures under individual subscription, and incentives in the form of technical assistance to improve production performances are ways that can facilitate the implementation of PES and encourage collective action for the conservation of pastures as a common good.

1 Introduction

Efficiency and effectiveness of natural resources conservation policies in developed or developing countries largely depends on their acceptability by the people who directly use these resources or affect their condition through their activities. Thus, in many countries, past and present soil and water conservation policies, of « *command & control* » type, have met with the resistance of rural populations who directly derive substantial benefits from the exploitation of resources targeted by preservation measures, or from the activities which contribute to degrade them. Moreover, the weakness of natural resources governing institutions often makes difficult the control over uses and practices and the respect of regulations (Baland and Platteau, 1996).

From the beginning of 2000's, payments for environmental services (PES) have emerged as innovative instruments for environment conservation policy. Indeed, they allow translating non market values of ecosystems into financial incentives for local stakeholders who produce these services, thus increasing the acceptability of conservation policies. PES are voluntary agreements, under which direct beneficiaries of environmental services are willing to pay (incentive) the service suppliers, under the conditionality of effective service

delivery. PES have been especially implemented for watershed protection to reduce erosion, regulate water flows, enhance groundwater recharge, mitigate floods and improve water quality (sometimes at the instigation of international funding agencies, such as the World Bank) (FAO, 2004 ; Smith *et al.*, 2006; Bennett *et al.*, 2013).

The increasing interest arisen by this type of instrument can be explained by the possibility to negotiate the contractual terms and the choice of conservation measures, the voluntary and free character of the subscription and the opportunity to adapt contractual terms and conservation measures to the local context (type of ecosystems and services providers) (Wunder, 2013 ; Pirard and Billé, 2010). Moreover, in developing countries, PES may contribute to poverty reduction through the provision of additional income to vulnerable rural people (Pagiola *et al.*, 2005; Tschakert, 2007; Pagiola *et al.*, 2008; Wunder, 2008).

To date, the majority of PES experiences have occurred in a private property context. Indeed, potential environmental services providers are theoretically those who hold property rights, or at least user rights, on the ecosystems generating the services (Engel *et al.*, 2008). Private landholders having full rights on their lands can more easily freely subscribe to a PES program. In the case of ecosystems under common property, the right-holding community, in its whole, can be considered as the environmental service provider, but then arise the usual issues of potential heterogeneity of individual contributions to service provision and of payment distribution within the community. Thus, the rare documented cases of PES in a common-property context imply the collective enrolment of private smallholders in Costa-Rica (Pagiola, 2008) or the subscription of small communities such as the *ejidos* to the PSA-H National Program in Mexico (Muñoz-Piña *et al.*, 2008 ; Balderas Torres *et al.*, 2013). In most cases prior organization of individuals or communities is deemed necessary to reduce transaction costs related to collective PES negotiation, implementation and management (Ledant, 2008). These transaction costs can prove to be particularly high in the case of large common-property ecosystems, where user rights are shared within large groups (Fisher *et al.*, 2010).

In Maghreb and sub-Saharan Africa, the implementation of PES would be particularly interesting to improve collective pastures management. Indeed, common rangelands occupy very large areas of degraded and fragile lands in these regions (le Polain de Waroux and Lambin, 2012). They also play an important economic role through incomes from livestock rearing and conservation of increasingly rare water resources (MAPM, 2014). The failure of standard conservation policies to preserve these ecosystems should be noticed and PES, which have not been used and seldom studied so far in this part of the world, could be an interesting policy alternative (El Mokaddem *et al.*, 2014).

In this paper, we propose to explore the possibility and the interest to implement PES program targeting individual users of collective goods, through the analysis of their preferences for different types of actions: participation to a collective action or implementation of individual actions for watershed protection. We assume that prior collective organization, superimposed on pre-existing institutions, is not necessary for applying a PES to a common-pool system, and that the success of such a program depends on its acceptation by the relevant populations, as long as its design is adapted to individual preferences.

To do this, we propose to assess *ex ante* the preferences of targeted rural populations, using a choice experiment approach (CE). This method, based on the use of a hypothetical market, has largely been used to analyse the preferences of ecosystem services beneficiaries and evaluate their willingness to pay for their preservation. More recently, it has started to be used to inform the design of PES. Indeed, it allows anticipating the acceptance and adapting the modalities of new environmental management policies (Hanley *et al.*, 2001 ; Hensher, 2010). In developed countries, it was applied for the improvement of water quality through an adaptation of agricultural practices in different production systems (Beharry-Borg *et al.*, 2013 ; Kuhfuss *et al.*, 2014 ; Christensen *et al.*, 2011 ; Espinosa-Goded *et al.*, 2010), or for assessing land management alternatives for watershed conservation (García-Llorente *et al.*, 2012), or forest protection by farmers (Broch *et al.*, 2013). In developing countries, CE has mostly been applied to design PES for forestry or agro-forestry systems (see for example Kaczan *et al.*, 2013 ; Cranford and Mourato, 2014; Mulatu *et al.*, 2014). Applications of this method to rangeland system are rare and relatively recent: Greiner *et al.*, 2014 proposed a framework to assess the participation to rangeland conservation contracts in Australia. Tesfaye and Brouwer, 2012 studied the design of measures to encourage the adoption of soil conservation practices in Gedeben watershed in Ethiopia. In particular, they used the CE approach to identify the key institutional and economic conditions underpinning farmers' PES membership.

The objective of this paper is thus to demonstrate that CE can help framing the design of a PES for collective rangelands, through the identification of appropriate conservation and incentive measures and the assessment of their individual acceptability by the targeted rural populations. The empirical application concerns the collective rangelands of M'goun watershed, south-east of Morocco. Its originality lies in the application of PES in a common-pool ecosystem. Moreover, it is one of the first applications of the CE approach to the design of an incentive-based environmental policy instrument in Maghreb.

The remainder of the paper is structured as follows: The case study is described in section 2. Section 3 gives a general presentation of the CE

approach and specifies the experimental design, data collection method and econometric model specification. Results are presented in section 4 and discussed in section 5. The last section is dedicated to the conclusion.

2 Study site: the M'goun watershed

The M'goun watershed is located in the south-east of Morocco (**Fig. 1**) and submitted to a semi-arid to arid climate characterized by an annual mean rainfall of 130 mm. It belongs to the Oued Draa basin, upstream of the *El Mansour Eddahbi* dam and spreads out over an area of 1240 km² , among which 46 290 ha are collective rangelands .

The watershed rural population (2509 households) derives its main income from sheep and goat rearing. The upstream part of the catchment, with steeper slopes, corresponds to rangelands, used mainly by the *Imgoun* tribe, and in some places by other migratory neighbouring tribes. The degradation of pastures, resulting from drought and an increasing competition between livestock breeders, has led to the settlement of numerous migrant breeders. These recently settled farmers have taken over and developed collective lands in the downstream part of the catchment, where they complement livestock breeding with subsistence farming.

Use and access rules governing collective rangelands were voluntarily defined by the tribe several decades ago. All tribe members hold joint and inalienable ownership rights on lands. However, individual appropriation is tolerated with the agreement of a tribe representative and of the Ministry of Home Affairs. Appropriated lands are rightfully managed as private lands.

Oued M'goun is the main tributary of Oued *Dadès,* which supplies *El Mansour Eddahbi* dam. Water abstractions amounting to 30 to 40 million cubic meters per year (for an annual volume of 250 Mm^3) are shared downstream between six irrigated palm oases and the domestic water supply to Ouarzazate city and its surrounding area.

Overexploitation of rangelands and decreasing forest cover, associated with the uneven topography of upstream lands, are leading to an accelerating soil erosion and consequently important sediment loads during flooding periods, impairing water quality and dam storage capacity. This is threatening the availability and quality of water, while domestic water demand is expected to increase, and irrigation water deficit might jeopardize the future of oasis farming in the coming years (Choukr-Allah, 2005; Laouina, 2007). Consequently, pastoral and agro-pastoral ecosystems' conservation appears to be necessary to reduce and prevent these problems, through an improvement of hydrological regulation services.
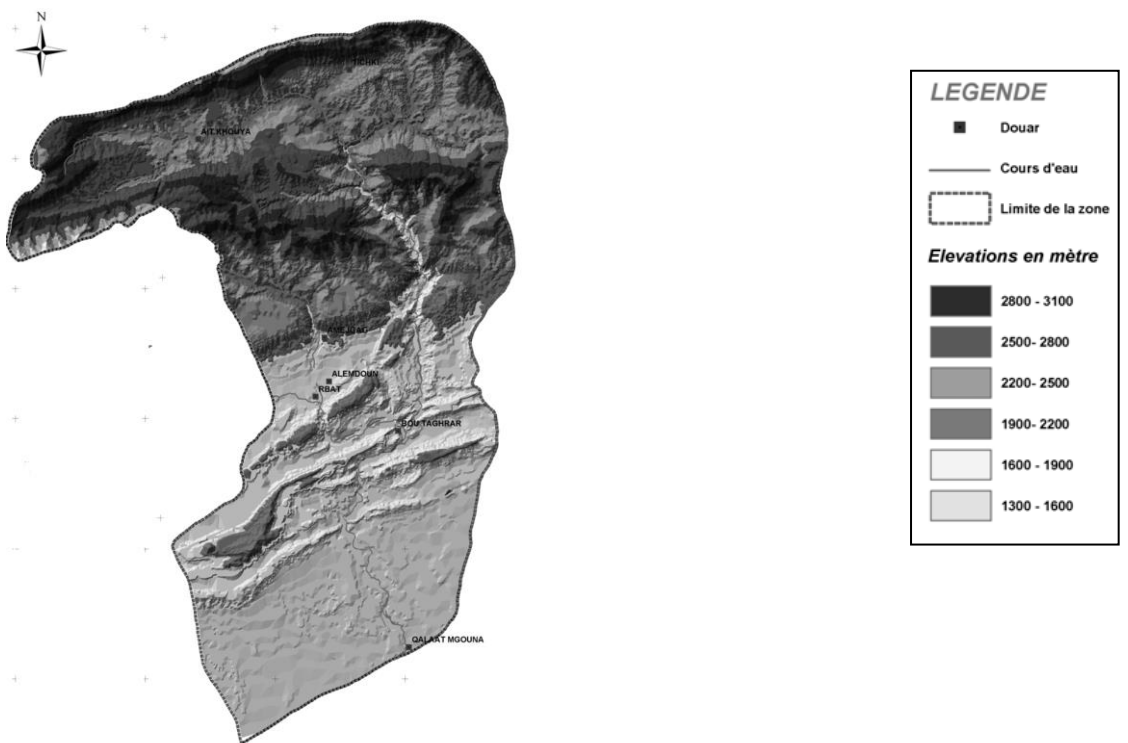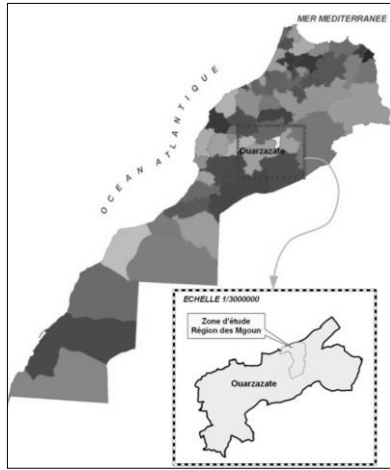
Fig. 1: Location of the M'goun catchment (scale: 1/3000000) and elevation map
(scale: 1/175000) (Source: CBTHA, 2003)

3 Method

The choice experiment approach chosen for this research, is based on stated preferences, and aims at understanding the determinants of individual choices. Individuals are placed in a hypothetical choice situation, as close as possible to reality where they are asked to compare several alternatives (in this case, PES alternatives to improve water quality and availability by way of collective rangelands conservation). Each alternative is described with attributes, with varying level or intensity, which are assumed to influence individual choices (Louviere *et al.*, 2000) and, consequently, the utility associated with the attributes by individuals. Alternatives are selected and paired according to an experimental design and utility variations are assessed using an empirical model specified according to the random utility theory (Adamowicz *et al.*, 1998).

3.1 Experimental design

The first step in CE consists in choosing the attributes to describe the hypothetical PES, and in defining the number and value of attributes' levels. In our case study, the chosen attributes are related to, on one hand, conservation measures to improve hydrological regulation of surface water (both in terms of quality and availability) and to limit soil erosion, and on the other hand, incentive measures aiming at encouraging rural households to join the PES program.

Attributes were chosen on the basis of the relevance and technical feasibility of conservation measures they describe, as well as their understanding by the local population, following a three-steps process: (i) taking up of technical proposals from development study realized by Daali, 2003 ; (ii) discussion of attributes, their levels and feasibility of selected measures with local technical services of the Ministry of Agriculture (Office de la Mise en Valeur Agricole de Ouarzazate) ; and (iii) organization of focus groups to discuss the chosen attributes and test local people familiarity with them.

Selected measures comprise (see Table 1): anti-erosive physical works to be implemented in collective pastures, intended to slow down water flows during flooding events (attribute #1); deferred grazing of collective pastures to improve soil vegetation cover to reduce erosion and enhance the quality of surface water flowing to the dam (attribute #2) ; and finally planting fruit trees on private property lands (attribute #3).

The two first attributes correspond to collective actions. A marked preference for these attributes can be interpreted as an agreement to participate to the requested conservation measures together with the other community members. They are expected to have a negative effect on utility.

Indeed, anti-erosive physical structures require a labour contribution from households. Moreover, deferred grazing, by decreasing the availability of forage resources, may negatively affect incomes from livestock.

The third attribute, on the contrary, is related to individual decision upon private property lands. The measure consists in planting fruit trees, which is a known practice in the region, but currently limited due to the limited size of farming properties. The expected effect of this attribute on utility is ambiguous: it could be negative if tree planting is perceived as a constraint or positive if it is considered as an opportunity of additional income.

The last two attributes represent two types of incentives: a monetary incentive (attribute #4) and an in-kind benefit in the form of technical assistance (attribute #5). The interest to associate financial incentive and technical assistance has been emphasized by several authors, in particular when the contract implies the implementation of complex agricultural practices for which targeted populations do not necessarily have the requested capacities (Pagiola *et al.*, 2005) or when the application of environmental friendly practices also provide private benefits to farmers (Garbach *et al.*, 2012 ;Wynn *et al.*, 2001). The levels chosen for the selected attributes are specified in Table 1.

To conceive the choice sets to be submitted to interviewees, all the possible combinations of the levels of all attributes have been generated. The choice sets chosen for the experiment comprise two alternatives in addition to the *status quo* (possibility to opt out). The selection of choice sets among all possible combinations[1] was based on a reduced and orthogonal factorial design of 16 alternatives, which have been distributed into two blocks, respecting orthogonality within and between blocks[2]. Each respondent was faced with eight different choice sets (**Fig. 2** gives an example of choice set).

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[1]Each alternative is described by 5 attributes with 4 levels each, that is to say a full factorial plan $4^5 = 4096$ alternatives which can be combined into sets of two alternatives in $4^5*(4^5-1)=1.047.552$ different ways.

[2]Orthogonality is satisfied when the levels of each attribute vary independently from one another.

Table 1. Selected attributes, definition and levels

Attributes	Definition	Levels
Anti-erosive physical structures	Development of sloping collective lands (digging half-moon terraces and building of stone dykes in the main gullies) (in hectares of developed area)	0 ha 1000 ha 3000 ha 5000 ha
Deferred grazing of collective pastures	Banning of grazing on a part of collective pastures, to be sown with white wormwood (*artemisia herba alba*),which has a high nutritional value for sheep (in percentage of the area under collective pastures)	None 1/4 of the area 1/3 of the area 1/2 of the area
Planting fruit trees	Planting of fruit trees to stabilize soils on cultivated lands prone to erosion within the limits of lands in property or recently appropriated (in number of planted trees)	10 trees 20 trees 50 trees 100 trees
Payment	Annual payment per household	200 MAD[3] 400 MAD 500 MAD 600 MAD
Technical assistance	Technical assistance (7 days/year) to improve animal or crop production techniques and production system management (type of assistance)	None Crop production Animal production Mixt

3.2 Data collection

A face-to-face survey was administrated to 144 household heads (5.74% of all households) randomly selected among the collective pastures right holders in the M'goun catchment. The survey was not limited only to livestock breeders, as all right holders, whatever their main activity, have a decision power and can choose to use or not the rangelands and to provide the environmental services. Two experienced interviewers, speaking the local language, were trained in three stages to conduct the survey: (i) an in-door session to explain the questionnaire, the survey objective and its mode of administration; (ii) a second field session, to test the questionnaire; and (iii) a third, in-door, session to correct anomalies observed during the test survey.

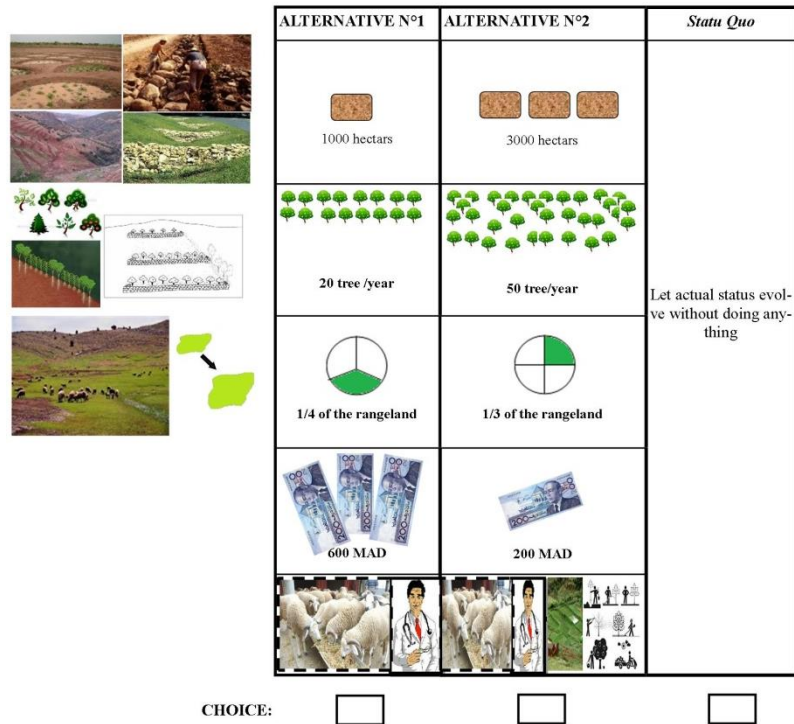[3]One euro is equivalent to 11,047 MAD (rate of 29/11/2014).

Fig. 2. Example of a choice set used in the survey

To avoid a possible "interviewer" bias, each interviewer alternated the choice sets blocks from one respondent to another and systematically and randomly changed the order of presentation of the choice sets to the respondents.

In addition to the eight choice sets, interviewees were also asked about their perception of the present state of the environment in the studied area, as well as their activities and their socio-economic and demographic characteristics.

3.3 Model specification

Choice experiment has its theoretical foundations in Lancaster's new consumer demand theory (Lancaster, 1966) and its econometrical basis in the Random Utility Theory (Adamowicz *et al.*, 1998). According to the latter, choices aim at maximising the utility or satisfaction associated with the subject of choice. An individual i derives a utility U_{ij} when choosing an alternative j within a choice set C. U_{ij} is assumed to depend upon, on one

hand, the attribute vector Z_j describing the alternative j and, on the other hand, the vector of socio-economic characteristics S_i specific to the person making the choice. This assumes that it is possible to observe the variation of utility that an individual associates to the different choices he makes. However, the difficulty to define all the individual-specific factors (psychological, sociocultural, historical, etc.) that may have an impact on the choices made, leads to assume that utility U_{ij} is composed of an observable part V_{ij} describing the variation of preferences in terms of the alternative attributes, and a non-observable part ε_{ij}. Thus, it derives that:

$$U_{ij} = V_{ij}(Z_j) + \varepsilon_{ij} \qquad (1)$$

Respondent i chooses alternative h over j if and only if the utility associated with h is greater than the utility provided by alternative j ($U_{ih} > U_{ij}$). Thus, the probability for an individual i to choose alternative h over j can be written as follows:

$$P_{ih} = \Pr ob(U_{ih} > U_{ij}) \ \forall j \in C \text{ with } j \neq h$$
$$= \Pr ob(V_{ih} - V_{ij} > \varepsilon_{ij} - \varepsilon_{ih}) \qquad (2)$$

Residuals ε_{ij}, for every alternative j in the choice set C, are assumed to be independently and identically distributed (IID) following an extreme value distribution (*Gumbel* distribution). This assumption corresponds to the standard conditional *logit* model (McFadden, 1974) for discrete choice modelling:

$$P_{ih} = \frac{\exp[V_{ih}(Z_{ih})]}{\sum_{j \in C} \exp[V_{ij}(Z_{ij})]} \qquad (3)$$

The indirect utility function V_{ij} for the alternative j is assumed to be a linear function of the attributes that can be specified under a vector form as follows:

$$V_{ij} = \beta_0 + \sum_k \beta_k . Z_{jk} \qquad (4)$$

Where β_0 is a *Status Quo* specific constant, that allows to capture, in an aggregate way, the effect of all the variables not considered in the choice (Hanley *et al.*, 1998)[4]. The parameter β_k is related to the kth attribute (Z_{jk}) describing the chosen alternative j.

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[4]In the case of choice cards with 3 scenarios, when alternatives are « unlabelled », which is the case here, it is recommended to use only one *status quo* specific constant (Hoyos, 2010 ; Hensher *et al.,* 2005).

The willingness to accept (WTA) for a marginal change of a given attribute is measured by the ratio of two parameters statistically significant (Hensher *et al.*, 2005): the parameter of the given attribute ($\beta_{attribute}$) and the payment parameter ($\beta_{payment}$).

$$WTA_{attribute} = - \left(\beta_{attribute} \middle/ \beta_{payment} \right) \quad (5)$$

WTA confidence interval is estimated using the « Delta » method proposed by Hole, 2007. When the parameter of the attribute or of the payment is not significant, WTA measure has no sense.

4 Results

4.1. Respondents' characteristics

Age structure of interviewees is heterogeneous with a slight dominance of household heads aged between 41 and 56 years old. Younger household heads (less than 40) represent only 21% of the sample. Most respondents are illiterate (91%) and only 9% have reached a primary education level. Household size varies from 3 to 12 persons with equal proportions of men and women. Cropping land area varies from 0.2 ha to 2.4 ha and livestock population numbers from 10 to 2000 heads for sheep, with a mean of 183 heads and from 10 to 1000 heads for goats, with a mean of 114 heads.

The right-holders' dominant combination of activities is livestock breeding as a main activity, complemented by cropping (47.6% of households). Livestock trading is a recent complementary activity, undertaken by 13% of interviewees. Only 11% of right-holders are still living only from livestock breeding. Interviewees fully converted to crop production are a minority (2%), and 5.5% of converted farmers still keep livestock as a complementary activity.

Incomes are generally low[5] with little variation among individual households, except for few isolated cases (Table 2).

64% of right-holders have no income outside livestock and cropping. On the other hand, 19.3% of right-holders derive additional income from paid jobs, trading or other sources, between 5,000 MAD and 15,000 MAD per year.

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[5]As a comparison, minimum wage in Morocco (SMIC) is around 2000 MAD/month.

Table 2 : Distribution of respondents according to the class of annual income from livestock breeding and cropping

Income classes	Livestock breeding		Cropping	
	frequence	*%*	*frequence*	*%*
None	2	1.4	25	17.4
Less than 10,000 MAD/year	28	19.4	90	62.5
Between 10 et 30,000 MAD/ year	87	60.4	25	17.4
Between 30 and 50,000 MAD/ year	21	14.6	1	0.7
Between 50 et 80,000 MAD/ year	2	1.4	0	0
More than 80,000 MAD/ year	4	2.8	3	2
Total	144	100.0	144	100.0

All the interviewees perceived the degradation of the main natural resources of the *Imgoun* tribe as important. However, the perception of its origin differs: for example, 62% of respondents explained that pastures degradation is caused by drought and 28.3% by land clearing around the villages.

Water quality is considered as degraded by 22% of interviewees and soils are perceived as highly degraded by water erosion by 73% of respondents. Only 13% of interviewees think that soil status is normal.

Almost half of the right-holders (44.13%) think that a financial incentive could be a solution to improve natural resources conservation, a little above one third have an opposite opinion (36.6%) and finally 18.6% have no opinion on the matter.

Globally, perception of environmental problems and of linkages between agro-pastoral ecosystems and water quality is high among the population. The link between water quality and physical structure developments is acknowledged by a largest part of interviewees than the link between water quality and cropping and rangeland management practices.

4.2. Empirical model estimation

The estimated model is a conditional *logit* which represents the observed indirect utility function. The linearity of the latter was tested and the null hypothesis of non-linearity was rejected. Estimated results are reported in Table 3.

Utility function estimation is limited to main effects of attributes[6]. The first and third attributes, respectively related to physical structures developments on collective pastures and plating fruit trees on private lands are modelled as continuous variables, reflecting the variation of utility with a unit change of developed area. The second attribute related to deferred grazing is modelled as three discrete variables each corresponding to a level of area under deferred grazing. The same type of specification was also adopted for the attribute describing technical assistance, with three modalities. Finally, the payment attribute was modelled as a continuous variable (to limit scale effects, values used in the model correspond to one hundredth of those used in the experiment). The estimated model is thus composed of nine variables in addition to the *Status Quo* specific constant (ASC).

The model is globally significant (p<0,001). The overall quality of the model measured by the McFadden's pseudo R^2 of 0.35, is good by conventional standards (Ben-Akiva and Lehrman, 1985). Moreover, results reveal that all variables have a very significant effect, except the two parameters that represent the two extreme modalities of the deferred grazing attribute. Model coefficients cannot be directly interpreted in terms of importance of these effects on the probability of acceptance of PES alternatives. One then uses *Odds Ratios*[7], which allows capturing the effect of each variable on the probability of choosing the observed alternatives.

Status Quo was chosen in only 1.04% of choice situations and only 15.28% of respondents chose *Status Quo* systematically. The negative sign of the ASC indicates the interviewees' preference for the implementation of a PES program. The *Status Quo* situation thus decreases right-holders' satisfaction and reduces the choice probability by 58.4% (Exp(β)=0.416) relatively to the implementation of a PES program.

Physical structures development on collective rangelands have, contrary to expectations, a positive effect on individuals' utility and increases the probability of joining a PES by 8.4% (Exp(β) = 1.084). This can be explained, on one hand by a low opportunity cost of family labour or by the important

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[6]A number of models with interactions between the attributes and individual characteristics of respondents have been estimated but none of these interactions proved to be statistically significant.

[7]Some authors called them « ratios of relative risk ». They correspond to the ratios of relative choice and no choice probabilities.

household size, which represents a stock of manpower, often under used[8], and, on the other hand, by the interest of these developments to protect crops located along the M'goun valley against floods during high flow periods. Thus participation to these collective developments is positively perceived by interviewed households.

The attribute related to fruit tree planting on private lands has, as expected, a positive effect on utility and increases the probability of joining the PES program by 53%. This can be explained by the additional income provided by selling fruits in the midterm. The hypothesis of a negative effect of planting linked to the land constraint (small cropping areas) is therefore rejected. In fact, cropping intensification on limited areas is a practice largely adopted by *Imgoun* people. Moreover, the maximum density of trees proposed in the experiment allows for intercropping with the crops currently grown by farmers.

Table 3 : Estimation results of the conditional logit model

Types of attributes	Attribute	β, significance[1] (standard-deviation)		Odds ratios (Exp(β))
Constant	ASC	-0.883***	(0.293)	0,416
Collective measure	Physical structures	0.081***	(0.031)	1,084
Collective measure	Deferred grazing			
	1/4 of pastures	0.079^{NS}	(0.142)	1,082
	1/3 of pastures	-0.395**	(0.171)	0,674
	1/2 of pastures	-0.252^{NS}	(0.192)	0,778
Individual measure	Planting on private lands	0.426***	(0.131)	1,53
Monetary incentive	Payment	0.117***	(0.036)	1,124
In-kind incentive	Cropping technical assistance :	0.882***	(0.14)	2,416
	Livestock technical assistance	1.89***	(0.2)	6,616
	Mixed technical assistance	1.712***	(0.143)	5,542
Model statistics:				
Log-Likelihood		-817.041		
Pseudo R^2		0,35		
Prob> chi2		0.0000		
LR chi2(10)		897,12		
% of correctly predicted answers		67,25		
Number of observations		3456		

[1] significant at 1% (***), 5% (**) levels, not significant (NS)

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[8] Discussions with livestock breeders revealed that some of them even think to specifically contract workers to replace them in the implementation of this collective commitment.

Deferred grazing attribute coefficients indicate that its effect on individual satisfaction depends on the area. Conservation of less than a quarter or more than half, of the accessible pastures has no effect on choices. For an intermediary area of one third of collective rangelands, deferred grazing significantly decreases individuals' satisfaction, as expected, because of its negative effect on forage availability.

Technical assistance has, as expected, a highly significant positive effect on PES choice. Whatever its form (for crop production, animal production or both), it largely improves individuals' utility and would encourage them to join the PES program. However, the interest of the assistance varies with its object: the positive effect decreases from livestock oriented assistance to mixed assistance, and then to crop-oriented assistance (increase in choice probability is respectively 562%, 454% and 142%). Relative preferences between the three modalities of assistance reflect the hierarchy of income sources observed in the region. Indeed, despite a recent trend in land appropriation to develop cropping, livestock breeding remains the most important source of livelihoods, and improving its performances is highly desired by the population. One can also assume that respondents hope to improve production performances of their herds with technical assistance, thus compensating the decrease in collective pastures area associated with deferred grazing.

Financial incentive has, as expected, a significant positive effect on utility and on PSE adherence. However, this effect is markedly lower than effect of technical assistance effect (it only increases the probability of choice by 12.35%).

4.3. Willingness to accept

Willingness to accept (WTA) can be estimated only for the second level of deferred grazing, as the coefficients are not significant for the other two levels. Thus, WTA amounts to 338.9 MAD (with a large confidence interval at 5% from 81.3 MAD to 596.5 MAD) for deferred grazing on one third of collective pastures (i.e. an area of 15,430 ha). This marginal value, if reported to the total area of rangelands under conservation, corresponds to a mean payment of 55 MAD per hectare under conservation, which is largely less than the compensation payment currently applied in Morocco for deferred grazing in forests (250 MAD per hectare[9]).

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[9] Decree N° 2-99-626 of 30th of June 1999 and its implementation text available from 2002, ruling deferred grazing in the forestry domain.

5. Discussion

Choice experiment conducted at the design stage of policy making can inform on the respective effects of PES attributes on the probability for the targeted population to join the program. This allows informing public decision-makers both on the characteristics of the contract likely to induce efficient conservation and on the necessary adaptations to the local context to maximize the acceptance of the proposed conservation measures.

The research results show that expected effects are not always confirmed. Some unexpected impacts of an attribute or an attribute level can be specified with the experiment, which enables a wiser choice of conservation measures. In particular, the methodological choice of combining individual commitments on private lands with the participation to a collective action on common pastures to preserve soil and water resources, opens new perspectives for the implementation of PES in the case of collective rangelands. The design possibilities and lessons learnt in the case of Morocco and more globally for the application of PES in common-pool resources contexts are discussed in the following sections.

5.1 Choosing practical modalities for conditionality and incentive

5.1.1 *Impact of conservation measures on fostering new collective action*

The results of our experiment indicate that voluntary participation to the two collective measures of physical anti-erosive structures and deferred grazing of common pastures is not systematically rejected, which may reflect a particular position of right-holders towards intra-community cooperation. However, model results show that engagement in collective action varies, at individual scale, along with its object, according to the nature of requested effort and implied direct and opportunity costs. Thus, in the case of physical structures where the requested effort takes the form of labour, the effect on PES adoption is positive, whereas, in the case of deferred grazing, the effect is significantly negative for only one level (one third of common pastures area). On the other hand, responses to the questionnaire do not give a satisfying explanation to the non-significant effect of the other two levels of deferred grazing. Further investigations would be necessary to understand the right-holders' motivations.

Despite some necessary clarification, CE results indicate that respondents' behaviour is not fundamentally different in a common property regime that it would be in a private property context: reject or acceptance of measures is largely dependent on individual costs and benefits of proposed measures. However, in the case of the collective property under study, it appears that additional utility provided by the realization of collective anti-erosive structures could be explained by sociocultural or psychosocial factors

arousing the will to reinforce traditional cooperation mechanisms, which have decreased over the past decades (Bourbouze, 1999). Respondents do not hesitate to express their nostalgia for these traditions, illustrated by the persistence, up to now, of *Agdals*[10], an efficient system of pastoral management (Dominguez *et al.*, 2012 ; Ilahiane, 1999).

However that may be, the validation of these hypotheses requires further investigations to explore the detailed motivations of these preferences.

5.1.2   *Superiority of technical assistance over financial incentive*

Results suggest that, in all likelihood, PES implementation in the M'goun context cannot only rely on payments to improve hydrological regulation and rangeland conservation. In a context where technical advice is not much accessible, technical assistance, be it targeted on crop production or animal production, provides a much stronger incentive to subscribe to a PES, so much that it is the most decisive attribute of choices. Tesfaye and Brouwer, 2012, also demonstrated the positive effect of technical assistance on PES acceptance for similar livestock production systems in Ethiopia, although, in their case, securing land rights had a more important incentive power than technical assistance. Livestock oriented technical assistance would allow compensating partly the reduction of available forage by improving livestock genetic performances, animal health and herd management. Livestock owners are conscious of this loss of earnings, and have thus expressed in the choice experiment a high information and supervision need to enhance their production. To a lesser extent, agricultural technical assistance is also more appreciated than direct payments. This can be explained by a need for technical advice to mitigate impacts of droughts and improve the productivity of crops recently introduced in the region such as fruit growing The recent settlement of the population increases the need for improving production techniques and know-how, all the more since the small size of landholdings and the limited possibilities of extension incite farmers to intensify their productions.

5.1.3   *Incentive and collective action*

In accordance with theoretical predictions, the financial incentive increases the propensity of individuals to contract a PES. However, its low incidence suggests that it would not be sufficient, in itself, to trigger PES subscription of most right-holders in the community. In a collective property context, if only a minority of individuals subscribe to PES, the additional advantage in terms of environmental services is very likely to be reduced or even cancelled out

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[10] Les *Agdals* sont des espaces pastoraux soumis à une mise en défens volontaire traditionnelle et très ancienne chez les populations Amazigh du Haut et du Moyen Atlas marocains.

by congestion externalities (for example, right-holders who do not currently use the rangelands could be encouraged to do so in order , either to benefit from the PES or to claim their right in fear that PES implementation might exclude them) or technological externalities (dues to differences of technological packages used to exploit resources) that non-contractors may exert in this type of context (Agrawal, 2001; Ostrom *et al.*, 1994). This could be particularly influential when payments are provided by private beneficiaries located downstream. In such a situation, while payments, as they were defined in the experiment, are based on committed means and not on results, the difficulty to produce visible and satisfying outcomes in terms of environmental services provision might deter beneficiaries to pay. Furthermore, even if the PES program was state-funded, it would not be efficient. This suggests that PES instrument efficiency relies on the maximization of subscription, which is also a necessary condition for collective action.

Several works in behavioural economics and social psychology have emphasized the risk for individual monetary incentives of crowding out individuals' intrinsic (or non-economic) motivations for collective action (Bowles and Polanía-Reyes, 2012 ; Vatn, 2009). In our case study, this risk can probably be discarded because monetary incentive was not the main incentive chosen by rural households, and the traditions of collective action appeared to be sufficiently rooted in behaviours such that including anti-erosive works in the PES would have a positive effect on its subscription. However, this issue would certainly deserve further consideration.

5.2 Lessons for PES implementation on collective lands

5.2.1 Lessons for conservation policies in Morocco

In Morocco, the use of PES for watershed protection represents an important opportunity for enhancing the funding and efficiency of conservation of the 51 million hectares of collective rangelands located in the major catchments of the country (El Mokaddem et *al.*, 2014). Several lessons can be drawn from the results obtained in the M'goun catchment for designing conservation policies in Morocco.

First, right-holders have expressed a marked interest for PES targeted to rangelands. However, results related to the level of deferred grazing demonstrate the interest of a prior assessment of people preferences. To ensure PES program efficiency, proposed conservation measures cannot be arbitrarily defined on the basis of intuition or purely technical choices. For example, the principle to limit deferred grazing to one fifth of the forested rangelands, presently in force in Morocco, could be revised by investing in the understanding of local population preferences.

Second, monetary compensation, presently under study in Morocco, would not be sufficient. Technique assistance to improve production performances, both in animal and crop productions would probably be a more effective alternative to encourage deferred grazing. It has the advantage to be strongly desired by the population and offers prospects of multiplier effect on local economy in the midterm. It therefore seems better to invest in strengthening information level through technical assistance instead of increasing financial compensation for deferred grazing. Such a measure would be in line with the present strategy of the Ministry of Agriculture to implement an agricultural extension service at local level through an institutional reform, translated into regional action plans (Dugué *et al.*, 2014). Nonetheless, coordination between the various administrations in charge of agriculture, extension service, water, forest and environment management would be necessary to ensure effective rangelands and watershed conservation.

The third lesson is related to the possibility to support collective action within common property rangelands. The experiment reported in this paper suggests that PES are likely to meet this challenge. Collective action can occur when proposed conservation measures get support from local community. In order to achieve this, compensation of opportunity costs of proposed measures can be combined with the joint benefits right-holders derive from conservation options. Choice experiment allows for anticipating local people's reactions and adjusting the PES design such that proposed incentives are harmonized with proposed conservation measures. Financial compensation might be useless for some measures because of their very low opportunity cost (for example some types of anti-erosive physical structures) or because of their high desirability, which contributes to lessen the costs of conservation for public decision-makers.

Finally, the M'goun study case provides original and valuable perspectives given the scarcity of researches addressing PES application to collective resources. The similarities of this catchment with most of the semi-arid rangelands in Morocco open the floor for an implementation of such instruments in other regions in the country, and beyond to other countries with similar situations in Maghreb.

5.2.2   *Lessons for the implementation of PES in common property settings*

In the case of PES targeting collective subscription from the community, one can observe a posteriori a gap between preferences of the community representatives, who had decided to subscribe, and those of individuals who are supposed to implement conservation options (Kerr *et al.*, 2014). This gap is described in the literature as likely to alter cooperation in a common-pool resources context (Bornstein, 2003; Willer, 2009). Asking individuals about their preferences regarding conservation measures, prior to PES implementation can help preventing these gaps. Experience of compensation

of collective deferred grazing in Morocco has demonstrated that collective compensation through tribal or community institutions leads to an equal distribution of incentives, independent of real effort, which is highly contested by resources users who stand up against a lack of fairness (El Mokaddem et *al.*, 2014). On contrary, a PES program targeting individual right-holders would allow directing payments to households really committed to conservation, instead of generalizing it to all community members. This is particularly important in the case of deferred grazing as selective targeting reduces the inefficiency associated with the absence of distinction between right-holders who do not use their right and real rangeland users (El Alaoui, 2002).

Furthermore, the association of individual and collective conservation measures in the same contract, under the condition of a minimum engagement in the individual measure, would possibly reduce the risk of free-riding on collective action (Fischbacher and Gächter, 2010). This method of right-holders selection has not been tested yet for collective rangeland management and needs to be studied further, especially when collective action requires the acceptance of all right-holders, as in the case of deferred grazing.

6. Conclusion

The main objective of this paper was to analyse the possibility and the conditions of implementation of a PES scheme targeting individual users of collective rangelands for soil and water resources conservation, in a watershed located in the South of Morocco. In particular, the research aimed at identifying which conservation and incentive measures were the most likely to get support from the rural population concerned. To achieve this, a choice experiment was conducted with a sample of rural households holding rights on collective rangelands in the upstream part of the M'goun catchment.

Results of the conditional *logit* model estimated from the survey provide new perspectives on household preferences in terms of conservation measures (conditionality) and incentives. In particular, they brought to light the possibility to combine in the same contract collective measures (physical structures or deferred grazing) and individual measures (tree planting on private lands). Including collective physical structures or fruit tree planting in the PES scheme would have a positive impact on household acceptance of the contract. At the opposite, imposing deferred grazing on collective rangelands, beyond what is traditionally practiced by the community, would require a financial compensation. The determination of the most appropriate level for deferred grazing requires, however, further investigations, because of the non-significance of the most extreme modalities proposed in this experiment. Regarding incentives, the analysis confirmed the high importance awarded to

technical assistance by rural households, who value it even more than financial compensation, in a context of difficult access to technical information. Econometric analysis showed no evidence of major preference heterogeneity within the studied population, but the validity of this result in other regions of Morocco, or more generally in Maghreb, needs to be confirmed.

Finally, this research contributes to enrich the yet limited literature on the application of PES to common-pool natural resources, especially to collective rangelands. By identifying unexpected effects of some attributes on the acceptance of this incentive instrument in complex contexts such as collective rangelands, the choice experiment approach provides valuable insights for designing policies to protect these vulnerable ecosystems, spreading over large areas. Given the limited number of attributes that can be incorporated in choice experiment, there is first, a need for further research to specify the most appropriate modalities of this type of instruments in this context (monetary or non-monetary incentive, collective or individual payment, institutional arrangements), and second, for discussing the research results with interviewed households to improve their interpretation.

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