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Willingness to Pay for Index-Based Livestock Insurance by Pastoralists and Agro-Pastoralists: Evidence from Senegal

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Abstract:- This work uses a contingent valuation and a factor analysis to respectively measure pastoralists' willingness to pay (WTP) and characterize their profile in the context of Senegal. Using primary data on 300 pastoralists, our results show that 50% of the respondents are ready to pay at least 3000 CFA (around 6 USD) to insure against forage shortage due to drought, no matter the animal considered (cattle, sheep or goat) or the type of contract proposed to them (coverage of 1 animal, 5 most important animals or the entire herd). Pastoralists who declared higher level of WTP are not the wealthiest or the most exposed to shocks among the pastoralists in our sample.

Keywords:- *WTP, Contingent Valuation, Index-Based Livestock Insurance, Factor Analysis, Pastoralists.*

I. INTRODUCTION

In Senegal, the livestock sector provides more than one third of agricultural GDP and the majority of rural households are engaged in livestock rearing. As per recent data from the National Agency of Statistics and Demography (Agence National de la Statistique et de la Démographie – ANSD), the livestock sector contributed 38% of agricultural GDP and 3.6% of national GDP in 2018. According to data from the national Ministry of Livestock and Animal Production (Ministère de l'Élevage et des Productions Animales – MEPA), the Total Livestock Unit (TLU[1]) available in the country in 2018 was estimated at 4992152 units.

The Government of Senegal, through MEPA, recently demonstrated a strong political will for sustainable management of the risks that slow down the development of the sector. The Senegalese National Agricultural Insurance Company (Compagnie Nationale d'Assurance Agricole du Sénégal – CNAAS) currently offers a wide range of specific insurance products to cover the risks faced by farmers. However, for livestock breeders, these products currently exist in the form of conventional indemnity insurance and provide per capita coverage with operational costs that limit accessibility for pastoralists with mobile herds.

[1] Tropical livestock units (TLUs) allow comparison of the nutritional requirements across livestock species.

The traditional insurance model does not adapt easily to the extensive farming method which is very mobile and especially practiced in the pastoral zones. In addition, it does not efficiently take into account the coverage of covariate risks linked to climate variability such as off-season rains and the lack of pasture linked to the rainfall deficit. Recently, CNAAS embarked on a project to develop Index-Based Livestock Insurance (IBLI) against drought risks which to date appears to be one of the best possible responses to help cover the risks associated with climate variability, in particular rainfall variability.

IBLI is based on satellite indicators of forage condition elaborated to derive an index of forage production in a given area and to calculate payouts using a pre-defined payout function and trigger mechanism. IBLI is developed for anticipatory action and livestock asset protection in times of severe drought leading to forage scarcity. The forage-deficit estimated by the satellite indices is used as an early sign that drought conditions are going to negatively impact forage and hence trigger payouts that could be used to better cope with the shock, by protecting livestock assets through timely purchase of fodder and animal feed supplements to keep core breeding animals alive.

This paper investigates the nomadic-pastoralists' willingness to pay for IBLI in the context of Senegal. We use original representative survey data in the pastoral areas where the IBLI product is the most relevant, to measure pastoralists' willingness to pay for the product using a contingent valuation method. In addition, on the basis of a factor analysis, we characterize pastoralists who are willing to pay for the insurance coverage of their animals. This work contributes to the weak literature on the demand for livestock index insurance in West Africa and particularly in Senegal in a context where feasibility studies are underway for the implementation of a pilot IBLI in West Africa [1] [2].

II. LITERATURE REVIEW

In a context of high production risk, rural producers choose low-risk levels of investment in various activities rather than profitable but risky investments. This allows them to have a lower but more stable income stream [3]. A study in Kenya, found a positive correlation between the purchase of livestock insurance, the level of investments as

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well as the level of income. Regarding the level of investments, results show that insured producers invested more in animal health services. The logical result that follows with regard to savings is that insured producers tend to reduce their precautionary savings. Also in terms of income, the finding is that milk production as well as income from different activities are higher for farmers who take out insurance [4].

Results has shown that when agricultural insurance is offered to producers, the less poor buy it more than the poorest [[5] [6]]. Moreover, when those who buy it reach a level of wealth that allows them to self-insure, they stop buying [[5] [7]]. In other words, the richest who are able to insure themselves against the risks that insurance offers them to cover prefer to self-insure rather than take out insurance [6]. This observation implies that the richest producers (with a very large herd size, for example) and the poorest producers (with a smaller herd size) are those who insure the least, compared to producers with middle level of income.

Using livestock stock as a measure of producer wealth, authors showed in a work in Ethiopia that producers who had a high stock of livestock and those who had a low stock of livestock did not assure [8]. It was producers with an intermediate stock of livestock who were most interested in insurance. However, other findings suggest a linear relationship according to which the purchase of insurance declines with wealth. This is the case of results obtained from Kenyan breeders to whom index livestock insurance was offered in Kenya, and which shows that the richest breeders did not subscribe to the insurance [9]. From this point of view, wealth is seen as a way to be less vulnerable and therefore more resilient to shocks.

Basis risk is the Achilles heel of all index insurance products. Almost all of the work that has addressed the subject has shown that the demand for insurance decreases with it [10]. The same goes for the premium or the price of insurance. Results suggest, for example, that when the insurance premium is unfavorable (increased by management costs, which made it more expensive for pastoralists), underwriting becomes low even though this exposed livestock to higher levels of covariate risks [11].

Analysis of the relationship between WTP and access to credit based on a study of pastoralist households located in northern Kenya showed that households that did not have access to credit were willing to pay for higher coverage rates than the coverage rates of households that had access to credit [9]. However, several other results show that access to credit can have a positive effect on the demand for insurance [8] [12]. For example, in a study conducted in Senegal it has been shown that access to credit could increases WTP for crop insurance by small farmers, [13].

An idea that is generally held in the microinsurance community is that when producers who apply for microcredit insure, microfinance institutions are more likely to respond favorably to their demand because the insurance plays the role of de-risking the portfolios in the offer side of the market. A study carried out on the basis of a livestock insurance product in Mongolia, provides empirical evidence for this result and shows that in this country it has increased the amount of loans and at the same time revised interest rates downwards, making credit less expensive [14].

III. METHOD & DATA

A. Contingent valuation to measure the willingness to pay

To measure the willingness to pay of breeders, we used the contingent valuation (CV) approach. CV principle simply consists in asking a question of consent to pay (or receive) to a representative sample of the population studied to access or (renounce) the good to be valued. In the context of our study, the valuation method we adopted is that of the payment card. It consists in defining values initially prepared on the basis of the values that can reasonably be assumed by the good or the service for which the consent to pay is requested. Thus, to choose the values to be considered for the choice of payment cards, we used as reference prices that were already proposed by the CNAAS for a similar product as part of a pilot. These values were 500 FCFA (1 USD) for a small ruminant (sheep and goat) and 4000 FCFA for cattle for a period of coverage of 1 year. However, we wanted to test the offering of three, namely for each animal in the herd, or for the five most important cattle in the herd or for the entire herd. The following table 1 gives the payment cards we offered as the value participants could use to purchase the insurance products offered. Finally, to complete the information on the insurance products offered, we explained that the insured risk was drought leading to lack of enough pasture for the herd. We also specified that all the products offered annual coverage (as with current CNAAS policies) and that they would reimburse based on the extent of the risk up to at 100% of the insured value.

Table 1: Values of the payment cards chosen to measure willingness to pay according to different livestock insurance offers

For your herd how much are you willing to pay to have insurance that pays back in case of drought risk for?								
One animal			The 5 most important animals of the herd			The whole herd		
Cattle	Sheep	goats	Cattle	Sheep	goats	Cattle	Sheep	goats
PAYMENT CARD FOR EACH PRODUCT in FCFA (USD) 500 (1 USD); 1000 (2 USD); 3000 (6 USD); 5000 (10 USD); 7500 (15 USD); 10000 (20 USD)								

The willingness to pay analysis is performed by putting pastoralists in a context where they should choose to purchase a drought risk insurance product. The question of the amount of willingness to pay is asked of each breeder for cattle, sheep and goats. In addition, for each type of livestock, we ask for the willingness to pay for (1) a single animal, (2) the 5 most important animal and (3) all the herd.

B. Factor analysis with loads rotated

To reach the objective of characterisation of the pastoralists who are willing to pay for the insurance of their animals, we perform a factor analysis with factor loads rotated to get a clearer pattern between them. The varimax rotation has been used to get factors which are not correlated between them as they are orthogonal. Since the components obtained are not inter-correlated, it is possible to define them based on the variables which contribute the most to their loadings. Only factors with eigenvalues greater than 1 were considered to identify the different categories of pastoralists. This approach of factor analysis is exploratory as we do not have a pre-defined assumption of how many categories could be generated.

The variables considered in the analysis to explain the factors are presented in table 2 below. In total they are 10 socio-economic variables which adds to 3 variables of pastoralists' willingness to pay for the drought IBLI to cover either (1) one animal in the herd, (2) the 5 most important animals of the herd or (3) all the herd.

Table 2: description of the variables considered in the factor analysis

Variables	Description of the variables
Gender	Reports the gender of the pastoralist: 1=male; 2=female
Age	Reports the age of the pastoralists in years
WTP for 1 animal	Willingness to pay (as defined above) for the insurance of each animal
WTP for 5 animals	Willingness to pay (as defined above) for the insurance of 5 most important
WTP for all the herd	Willingness to pay (as defined above) for the insurance of the entire herd
Dwelling floor material	Characteristics of the house floor (main room(s): 1= bamboo/palm/clay/sand; 2 = cement; 3 = tiles.
Dwelling roof material	Characteristics of the roof (main room(s)): 1 = thatch/palm leaves; 2 = wood/metal; 3 = zinc/slates, value ; 4=cement/terrace
Dwelling wall material	Characteristics of the wall (main room(s)): 1 = wood/stone/zinc/banco; 2 = simple cement bricks; 3 = cement and tiles and marbles
Water source	Gives insights on the household primary water source: 1 = well/river/creek/backwaters; 2 = tap/borehole
Financial shocks	Rise of agricultural input prices, rise of fodder prices, rise of deworming prices, and rise of food prices, decline in sales prices for livestock and decline in other sales prices.
Non-financial shocks	Death/accident of a family member, illness of a family member, insect attack of plants, plant disease, livestock theft, livestock disease, livestock accident, drought (poor rain, dry spell), off-season rains flooding, conflict, insecurity, livestock accident, livestock theft.
Access to credit	Whether the respondent has received a formal loan from a bank or a microfinance institution in the last 12 months: 1=Yes; 0 = No.
Household's assets	Asked whether the household own a certain number of goods (e.g. fridge, TV, car, smartphone etc.). Household assets index is generated using a principal component analysis. The component is predicted and transformed into a 4 quartiles variables to rank households based on their assets level.
Tropical Livestock Unit	Indicator built by affecting weights to the different animal species based on their nutritional requirements. All animals' scores (weightings considered) are then summed. The weights are: horses/donkeys/camel=1.4 ; adult cow =1; goats/sheep = 0.1; poultry = 0.01

This above described factor analysis was performed for each of the three animal species (goats, sheep and cattle) for which we have asked the pastoralists' willingness to pay for an insurance. That resulted in three different table of results.

C. Data

We use primary data which regards a sample of 300 livestock breeders interviewed in the pastoral areas of Senegal. To make the sample representative, we considered the 5 departments (second administrative level of decomposition of the Senegalese territory) where the livestock rearing is mostly practiced in Senegal and where the IBLI product is pertinent because of the level of exposition to drought. These are the departments of Podor, Dagana, Ranérou, Linguère and Koumpentoum. Stratifying at departmental level, we proceeded to a random selection of 60 villages in which 5 pastoral breeders, each in different pastoral households, have been interviewed.

IV. RESULTS

A. Sociodemographic characteristics of the respondents

The pastoralists in our sample are mainly composed of men (91%). The average age is 51.6 with minimum of 21 and median of 50. It is hence a population of adult pastoralists. As the criteria to choose the respondents included to identify someone who is responsible of the herd, it was expected that participants would be adults who are mainly the head of the households. 88% of the respondents are head of their household. In terms of wealth, the household's asset indicator shows a quite symmetrical repartition of the participants as 50% of them are below the second quartile of the indicator and hence 50% are above. However, there is a gap between households with large assets and households with less assets because the assets of the former are large enough to pull the mean above the median. Regarding the dwelling, for each of the three indicators considered (floor material, roof material and wall material of the dwelling), it is noticed that the medians are low (1 out of 4). As the medians are lower than means as in the case of household's assets, households with "better" dwelling materials present scores which are high enough to to pull the mean above the median. The sources of water also divide the population in two equal groups with pastoralists who mostly have access to "better" water source (tap or borehole) and those who mainly use well, creek or river as main source of water. However, the low mean compare to the median means that respondents with low ranked source of water do have really low score compared to those with high ranked source. For the level of exposition to financial and non-financial shocks, we remark a symmetrical distribution as the median is the second quartile of the indicators but the pastoralists with high level of exposition to risks also pull the means up. The overall level of exposition to shocks (financial and non-financial) is, without surprise, high in the population considered. Access to credit is low in the sample, with a mean of 0.477 and a median of 0. For the tropical livestock unit, a high variability is observed amongst the respondents with 50% of the population declaring only 34.5 TLU or less while the mean is almost two times higher (57.66). There is hence an important heterogeneity in the size of the herd of the pastoralists interviewed. The variability is indeed very high (62.63), higher than the means and also almost two times higher than the median.

Table 3: Summary statistics on the Socio-demographic characteristics

	Mean	Median	Std. Dev.	min	max	N
Household's assets	2.467	2	1.11	1	4	300
Tropical Livestock Unit	57.657	34.5	62.63	1	423	300
Financial shocks	2.39	2	1.167	1	4	300
Non-financial shocks	2.473	2	1.137	1	4	300
Access to credit	.477	0	.5	0	1	298
Dwelling floor material	1.809	1	1.019	1	4	298
Dwelling roof material	2.01	1	1.102	1	4	300
Dwelling wall material	1.502	1	1.122	1	4	227
Water source	1.607	2	.489	1	2	300
Age	51.6	50	15.523	21	99	300
Gender	1.127	1	.333	1	2	300

B. Values of the willingness to pay

Table 4 represents summary statistics of willingness to pay for each of the three types of insurance product offered and each of the three animal species considered. The statistics are computed for only the pastoralists who declared a WTP > 0 in the total sample of 300 pastoralists because they are the potential applicants for the IBLI insurance. We noticed that WTP are mostly comprised between 1000 CFA (~ 2 USD) and 10000 CFA (~ 20 USD) for the insurance of the cattle and between 1000 CFA (~ 2 USD) and 5000 CFA (~ 20 USD) for sheep and goats. For all type of animals and all type of contracts, the median is 3000 CFA (~ 6 USD). It is at the third quartile that we observe differences between the WTP. Based on that quartile, we remark that 25% of the pastoralists who accept to purchase the insurance product are willing to pay 10 000 CFA (~ 20 USD) or more for the insurance of 1 animal or the 5 most important animals in their cattle herd. However, their WTP for the insurance of the entire herd of cattle is lower (7 500 CFA (~ 15 USD)). It seems hence that the pastoralists are less interested in the insurance of the entire cattle herd and value more specific animals for which they would pay higher insurance premiums. The mean willingness to pay for the herd of

cattle is higher when it comes to insure the 5 most important animals. For the herds of sheep and goats, as in the case of the first and second quartiles, the third quartile reveal that 25% of the pastoralists are willing to pay 5000 CFA (~ 10 USD) or more to insure their animals, no matter the type of contract considered.

Table 4: Summary statistics of the willingness to pay for the IBLI by pastoralists

	Mean	Std. Dev.	p25	Median	p75	N
CATTLE						
WTP for 1 animal	4922	3699	1000	3000	10000	161
WTP for 5 animals	4956	3683	1000	3000	10000	159
WTP for all the herd	4385	3631	1000	3000	7500	157
SHEEP						
WTP for 1 animal	3531	3019	1000	3000	5000	211
WTP for 5 animals	3507	2974	1000	3000	5000	213
WTP for all the herd	3009	2734	1000	3000	5000	210
GOATS						
WTP for 1 animal	3860	3210	1000	3000	5000	221
WTP for 5 animals	3947	3215	1000	3000	5000	225
WTP for all the herd	3316	2705	1000	3000	5000	217

C. Profiles of the potential clients for IBLI

Table 5 below presents the results of the factor analyses considering WTP for IBLI of the cattle, the sheep and the goats. Only factors with eigenvalues equal or higher than 1, the first three eigenvalues were considered as combined they account for at least 80% of the total variance (see the Appendix). The table provides the factor loads greater than or equal to 0.40 only.

Table 5: Factor loadings and unique variances of variables

	VARIABLES	Factor 1	Factor 2	Factor 3	Uniqueness
CATTLE	Willingness to insure 1 animal	0.9368			0.1218
	Willingness to insure 5 animals	0.9515			0.0944
	Willingness to insure all the herd	0.954			0.0892
	Total livestock unit				0.8885
	Financial shocks			0.7431	0.4479
	Non financial shocks			0.4974	0.7132
	Access to credit			0.5865	0.6269
	Dwelling floor material		0.833		0.2764
	Dwellin roof material		0.7689		0.3684
	Dwelling wall material		0.662		0.5433
	Source of water		0.6565		0.4861
	Household assets		0.7035		0.467
	Age				0.9908
	Gender				0.7464
SHEEP	Willingness to insure 1 animal	0.9494			0.0985
	Willingness to insure 5 animals	0.9589			0.0766
	Willingness to insure all the herd	0.9139			0.161
	Total livestock unit				0.9454
	Financial shocks			0.6297	0.5907
	Non-financial shocks			0.7225	0.4767
	Access to credit				0.9169
	Household assets		0.6725		0.4967
	Dwelling floor material		0.864		0.244
	Dwellin roof material		0.8191		0.2904
	Dwelling wall material				0.6191
	Source of water		0.4595		0.6571
	Age				0.938

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	Gender	-0.4583			0.7737
GOATS	Willingness to insure 1 animal	0.9372			0.1215
	Willingness to insure 5 animals	0.956			0.0851
	Willingness to insure all the herd	0.9371			0.1168
	Total livestock unit				0.9462
	Financial shocks			0.4996	0.7047
	Access to credit			0.7425	0.4325
	Non financial shocks				0.9046
	Household assets		0.6373		0.5195
	Dwelling floor material		0.8592		0.2279
	Dwellin roof material		0.8164		0.2837
	Dwelling wall material				0.6707
	Source of water		0.4139		0.6988
	Age				0.9208
	Gender				0.9163

The results of the factor analysis show three categories of pastoralists. Those with a high willingness to purchase the drought IBLI defines the factor 1. That factor could hence be renamed as the group of potential "purchasers" of the livestock insurance product. The factor 2 is composed of the group of pastoralists who have the highest number of household assets, "better" dwelling characteristics (floor roof and wall materials) and the "better" source of water. It could hence be considered as the group of the "wealthiest" Finally, in factor 3, pastoralists are the ones with the highest level of exposition to risks (both financial and non-financial risks) and who have access to credit (in the case of the cattle table). They could be named the most "vulnerable". Based on these findings, pastoralists who are willing to pay to insure their animals no matter the type of coverage (individual animal coverage, 5 most important animal coverage or coverage for all the herd) are different from pastoralists who would not decide to insure essentially on their level of wealth and level of exposition to risks. Wealthiest pastoralists and pastoralists who are the most exposed to risks are not willing to purchase the drought IBLI insurance. On the contrary, potential purchasers would be pastoralists who are less rich than the wealthiest and less exposed to risks than the most vulnerable group.

V. CONCLUSION

In our analysis, we looked at willingness to pay for IBLI and characteristics of pastoralists with the highest WTP. For that we gave respondents the opportunity to comment on different insurance policy offers. These offers concerned insurance for (1) a single animal in their herd, (2) the 5 most important animals in their herd, (3) the whole herd. For each offer, the pastoralists declared an amount they were willing to pay. Coming out of this analysis, we notice that there emerge more or less clear guidelines on the characteristics of the insurance product which interests pastoralists and which could therefore work for this type of breeding. Likewise, the profile of the pastoral breeder ready to pay to obtain an IBLI which covers his animals against the shortage of fodder in the event of drought is clearly emerging.

Results indicate that pastoralists who are willing to purchase IBLI would pay for most of them 3000 CFA or more, no matter the animal considered (cattle, sheep and goat) and no matter the type of contract proposed to them (coverage of 1 animal, 5 most important animals of the herd or the entire herd). However, the highest average WTP is declared for the coverage of the 5 most important animals in the herd. Regarding the profile of the potential purchasers of a drought IBLI product with the highest WTP, results of the factor analysis reveal that they are not the wealthiest pastoralists and are not also the most exposed to risk. Those with higher level of exposition to risks and those who are the wealthiest did not declare the highest level of WTP.

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APPENDIX:

Table A: Factor correlation (Cattle)

Factor analysis/correlation — Number of obs = 137
Method: principal factors — Retained factors = 3
Rotation: orthogonal varimax (Kaiser off) — Number of params = 39

Factor	Variance	Difference	Proportion	Cumulative
Factor1	2.92887	0.12811	0.3088	0.3088
Factor2	2.80076	1.39075	0.2953	0.6041
Factor3	1.41001	.	0.1487	0.7528

LR test: independent vs. saturated: chi2(91) = 1214.65 Prob>chi2 = 0.0000

Table B: Factor correlation (Sheep)

Factor analysis/correlation — Number of obs = 196
Method: principal factors — Retained factors = 3
Rotation: orthogonal varimax (Kaiser off) — Number of params = 39

Factor	Variance	Difference	Proportion	Cumulative
Factor1	3.19501	0.92925	0.4247	0.4247
Factor2	2.26576	1.01133	0.3012	0.7259
Factor3	1.25443	.	0.1667	0.8926

LR test: independent vs. saturated: chi2(91) = 1483.03 Prob>chi2 = 0.0000

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Table C: Factor correlation (Goats)

Factor analysis/correlation — Number of obs = 185
Method: principal factors — Retained factors = 3
Rotation: orthogonal varimax (Kaiser off) — Number of params = 39

Factor	Variance	Difference	Proportion	Cumulative
Factor1	3.07404	0.85067	0.4021	0.4021
Factor2	2.22337	1.06994	0.2908	0.6929
Factor3	1.15343	.	0.1509	0.8438

LR test: independent vs. saturated: chi2(91) = 1388.58 Prob>chi2 = 0.0000