Population Mobility and Adaptation to Droughts in the Brazilian Semi-Arid

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Abstract. We discuss how population perceptions about impacts of droughts affect mobility responses as a livelihood adaptation response in the Seridó region in the Brazilian Northeast semi-arid, which historically faces severe droughts and water supply shortages and where *ex-situ* livelihood adaptation strategies (mainly mobility and governmental transfers) are particularly relevant. We use a unique urban household survey (n=1,064) conducted in 2017, bivariate descriptive analysis with significance tests, multiple multinomial regression framework and Probit Heckman selection model. We show that migration and commuting have an inverse relationship when controlled by exposure to droughts. Migration is a more common strategy in events not related to droughts, while the probability of commuting increases when experiences with droughts increase. Receiving a social benefit increases the probability of adopting commuting and thus reduces immobility. The results reinforce the male preference for commuting in harsh times, but preference for migration when environmental conditions are attenuated.

Keywords. Mobility, livelihoods, droughts, Brazilian semi-arid Northeast.

Introduction

Regardless of the impacts of climate changes, the occurrence of disasters related to climate hazards such as droughts and flooding tends to become even more important due to the intensification of hydrological and climatic events, the increasing population exposed to risks (due for example to the precarious urban settlements) and the lack of institutional capacity and investments in risk management (Alvala and Barbieri, 2017; Barbieri, 2018). Alvala and Barbieri (2017) show that 68% of the natural disasters in Brazil are associated with flooding or landslides and 8.4% to droughts, and between 1999 and 2008 happened at least catastrophic episodes of these disasters, with 5.2 million affected, 1,168 deaths, epidemics (especially water-borne diseases) and U$3.5 billion in economic damages.

The Brazilian semi-arid Northeast has been historically the most affected region by droughts in Brazil. In the Northeast, poor socioeconomic indicators associated with periods of drought and demographic pressures have motivated peaks of out-migration and labor circulation – with these migrants being known as *retirantes* – from the Northeast region to richer areas in southeast Brazil until the late 1970s (Leighton, 2006; Barbieri et al., 2011). Periods of droughts can cause around 80% decrease in agricultural outputs in the Northeast (Khan and Campus, 1992) and intensify migration (Franke et al., 2002; Barbieri, 2011. During the 1960s and 1970sthe Northeast’s Net Migration (given by the difference between total number of immigrants and total number of emigrants in the Northeast) was -2,166,258 and -3,049,459 individuals, corresponding to Net Migration Rates – NMR (ratio of the NM to the total population in a given year) of approximately -7,6% and -8,7%, respectively (Barbieri et al. 2011).

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The intensity of migration flow from the Northeast has shown a dramatic decrease since the late 1980s and 1990s due especially to slower rates of economic growth in the Southeast, and the largest cities in the Northeast (particularly the state capitals) have increasingly attracted migrants from rural or smaller urban areas in the region. Nonetheless, droughts have still be linked to population mobility as in the past. Franke et al. 2002) show, for example, that the El Niño oscillations at the beginning of the 1980s and 1990s induced migration from rural areas to São Luís and Teresina (capitals of the states of Maranhão and Piauí, respectively),and El Niño oscillations in 1982-1983 are also linked to migration peaks from the state of Maranhão to the state of Pará (in the Brazilian Amazon) in the period 1983-1984.

We discuss in this paper how population perception about the impacts of droughts affect *in-situ* and ex-*situ* livelihood adaptation responses. Our analysis take into account an urban household survey on mobility, socioeconomic and demographic characteristics and perceptions on climate hazards conducted in the Seridó region in the Brazilian semi-arid Northeast. We predicate the importance of this paper in three aspects. First, to the extent of our knowledge this is the first statistically representative survey in the Brazilian semi-arid for the purposes mentioned above. Second, while most of the literature has focused on the impact of droughts on rural livelihoods, we focus on a region where urban – rural articulations are particularly strong (most of active population in the labor market is involved in agricultural-related activities). Given that the study population is urban, our focus is on *ex-situ* livelihoods adaptation strategies, particularly those which have been mentioned in the literature as critical components of income and welfare among the most vulnerable: the adoption of mobility strategies such as migration and commuting, and access to Social Protection programs such as governmental cash transfers. Finally, and following Gray and Muller (2012), we aim to show the usefulness of multivariate multinomial statistics analysis of survey data to unveil the linkages between climate hazards and population mobility in the context of developing countries.

Droughts and population mobility

As in other spaces such as in the Amazon, the strong linkages between rural and urban livelihoods in the Brazilian semiarid has produced new socio-spatial configurations that cannot be easily defined as urban or rural (Barbieri et al., 2009). These rural – urban livelihood strategies are indeed an adaptation mechanism to cope with environmental and developmental shortcomings – particularly due to its suffering since 2010 of one of the most severe droughts in history – in regions that are still economically dependent on rural activities.

The articulation between rural and urban spaces can open the array of livelihoods diversification from strictly *in situ* adaptation strategies (e.g., irrigation and culture rotation in rural areas) to *ex situ* adaptation strategies such as mobility and cash transfer programs (Berkes and Jolly, 2001; IPCC, 2012; 2013; Peterson et al., 2001; Peterson and Manton, 2008) or a combination of both (Bilsborrow, 1987; Davis, 1963; Barbieri, 2011). For example, cash transfer programs such as *Bolsa Familia* and rural retirement pensions have had an important impact on livelihoods in the poorest areas of Brazil, such as in the Amazon and in the Brazilian Northeast. These impacts are not only in terms of reducing vulnerability and increasing food security, but also in terms of decisions towards *in-situ* livelihoods strategies such as land management towards more profitable and less labor-demanding land uses (see Guedes et al., 2014; Barbieri et al., 2016 on the Amazon). They also impact other *ex-situ* strategies such as increasing off farm employment and rural – urban mobility strategies, including out-migration of family members (Ojima, 2013; Guedes et al., 2014; Barbieri et al., 2016).

Both *in-situ* and *ex-situ* strategies are nonetheless highly dependent on contextual and institutional arrangements (Adger and Adams, 2013; Black et al., 2011). Population mobility is a key *ex-situ* livelihood adaptation strategy whose drivers range from multiple dimensions (environmental, socioeconomic, institutional etc) and contextual factors which shape family and household mobility decisions (Black et al., 2011). In this same vein, Warner et al (2011) suggest that environmental impacts such as droughts, land degradation and desertification are not usually the only cause of population mobility as a livelihood adaptation strategy, and Lilleor and Van Den Broeck, 2011) consider impossible to separate economic from environmental motivations to migrate. Leighton (2011) suggests that the relationship between drought and mobility is highly contextual (or site-specific) given the diversity of variables (confounding factors) affecting it, what makes explicit the need to overcome the limitation in the literature on study cases on drought-related migration.

Overall, mobility as a livelihoods adaptation response to droughts may be theorized upon the conceptual framework proposed by Black et al. (2011) as well as other theoretical frameworks, such as the theory of multiphasic responses (Davis, 1963; Bilsborrow, 1987), the livelihoods and capabilities approaches (Ellis, 1993; Bebbington, 1999) and the New Rurality approach (Key, 2008) which investigate household or individual responses to reduce their vulnerability and threats to livelihoods given external constrains or opportunities (Barbieri, 2006; Barbieri and Ojima, 2018). Some studies have in fact discussed how mobility may act as a livelihood adaptation response to climate changes or variations (see, e.g., McLeman and Smith, 2006 and Pearch Nielsen et al., 2008). One common feature in these approaches is the key role of mobility and articulation between rural and urban areas as adaptation strategies and a as key component of household livelihoods (Barbieri et al., 2009b; Barbieri and Confalonieri, 2011). Warner et al. (2011) discuss several cases studies in Africa showing the impact of drought on rural-urban mobility, such as temporary mobility to coastal and urban agglomerations in the Sahel, intra-country migration and swelling of big cities in Senegal, Mali and Burkina Faso, and even mostly temporary (compared to permanent) rural-rural mobility in Burkina Faso rather than rural-urban mobility. In a review of the literature, Leighton (2011) also suggest that temporary or seasonal mobility compared to migration within the same country (or between countries when the borders are close) is a more likely adaptation response when households are affected by droughts or desertification. In a study on, Massey, Axinn e Ghimire (2010) suggest that environmental migration tends to be higher when the deterioration of livelihoods is higher.

Other examples in the literature discuss mobility as a response to droughts. Henry et al (2004) suggest that rural-urban mobility is higher in drier regions when comparing to wetter regions in Burkina Faso, especially in term of long-term migration related to short-term rainfall deficits. Gray and Muller (2011) use event history models and longitudinal data to show that mobility is an important coping strategy due to drought in most vulnerable households in rural Ethiopia, albeit in women migrate less particularly in short distances. Piguet et al (2011) discuss several case studies showing mixed results regarding the impacts of droughts on migration in terms of i) consistent impacts of droughts causing emigration, as shown by study cases in the sub-Saharan African continent and international migration from Mexico to the United States, ii) minimal impacts of droughts on migration as shown by studies in Mali, Burkina Faso as well as from drought prone provinces in Mexico to the United States, and iii) contrasting patterns depending on the pattern of mobility (long-term versus short term and long-distance versus short distance). While Gray and Mueller (2012) show that migration is an immediate response to climate hazards in Ethiopia, other studies show that *delayed* migration can be an *ex-situ* adaptation response which jhappen when other potential *in-situ* adaptation strategies are exhausted (Bardsley and Hugo, 2010; Gray and Mueller, 2012). Leighton (2011) suggests that persistent drought in rural communities may affect income sources and thus drive families to adopt migration as a common adaptation strategy, particularly in terms of seasonal or temporary mobility in countries such as Burkina Faso, Ethiopia, Mali, Ghana and Senegal.

Together with population mobility, Social Protection (SP) programs is an essential component of livelihoods adaptation amongst the poorest areas in Brazil. SP programs such as cash transfer programs *Bolsa Familia* and *Rural Retirement* in Brazil, as well as a universal pension system, free basic education, and low-cost health systems, are another key adaptation mechanism that create local resilience and may interact with mobility, both in terms of reducing them or affecting its nature (e.g., fostering temporary mobility rather than permanent mobility) (Kuriakose et al., 2013; Barbieri et al., 2011). These programs are a powerful mechanism in impoverished areas to avoid the deleterious impact of climate variation leading to capital depletion and livelihoods diversification for those living on the edge of minimum living standards (VanWey et al., 2012).

Queiroz et al (2016 show that governmental cash transfers in the Brazilian Northeast have been a key mechanism to minimize the impacts of climate hazards on the household and community levels. While most of the poor families in Brazil is covered by one or more Social Protection programs, their prevalence is still higher in the semi-arid Northeast. Barbieri et al. (2014) also show that off-farm employment opportunities combined with cash transfer programs in Brazil (such as rural retirement and the *Bolsa Familia* program) create *ex-situ* cash opportunities and decreases small colonists' dependency on farm production and natural capital. This *ex-situ* possibility to diversify the household portfolio may be facilitated by multigenerational cohabitation patterns which may create family support to release particularly young labor to off-farm activities, as well as assure income flows for older parents (through pensions) or the younger ones (from governmental programs such as *Bolsa Familia* which targets the youngest).

Finally, livelihoods adaption is highly conditional on the timing and the nature of environmental hazards. Droughts represent a distinct environmental impact fostering an adjustment in livelihoods since their impacts on water supply systems may be much less sudden compared, for example to the much more sudden impacts of environmental disasters or floods on livelihoods. For instance, Koubi et al (2016) suggest, based on study cases on Vietnan, Camboja, Uganda, Nicaragua and Peru that environmental hazards with slow onset (droughts, sea rise etc) must be analyzed differently from hazards with sudden onset (floods, hurricanes etc) in what regards an individual´s perceptions about their impacts on mobility and other livelihood strategies. The fact of its being less sudden may open the possibility of the interplay and interaction with other multiple dimensions (social, economic, political etc) which may confound the net impact of droughts on livelihoods (and on mobility in particular). The fast urbanization in the Brazilian Northeast highlight the vulnerability of existing fragile water supply systems. In fact, given the water supply and the spatially concentrated demand, the cities depend on few rivers and dams surrounding them (Barbieri and Confalonieri, 2011).

Droughts in the Brazilian semi-arid Northeast: the Seridó region

Figure 1 shows the location of the study area in the Seridó region, located in the Brazilian semi-arid Northeast (state of Rio Grande do Norte).

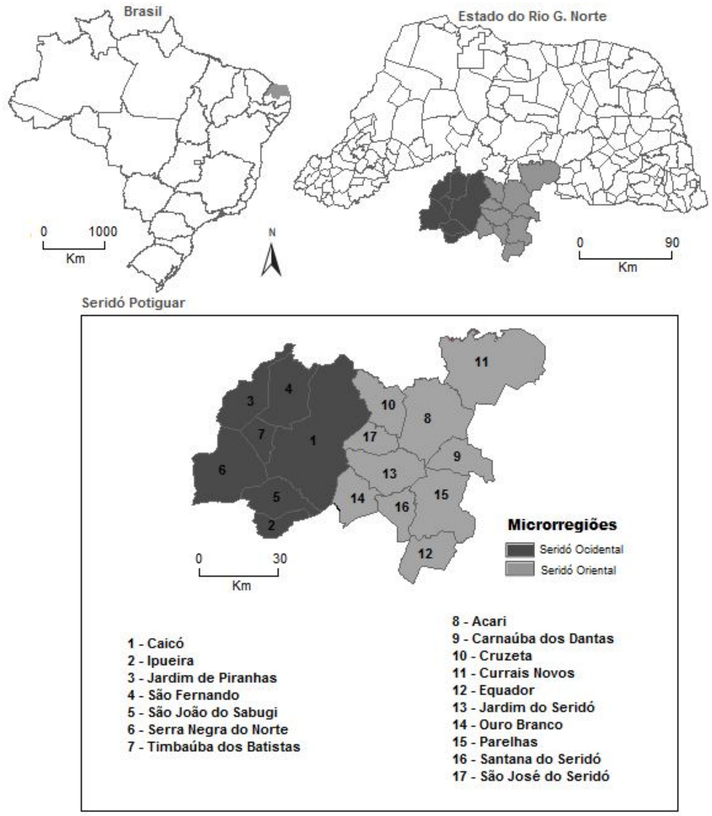

Figure 1: Study Area – Seridó Region, Brazilian Northeast
IBGE, Malha Municipal Digital (2010)

Among all the regions with semiarid characteristics in the world, the Brazilian Northeastern Semiarid is probably one of the most vulnerable regions to climate change in Latin America, due both to its natural conditions and the high population density (Ab'Saber, 1999). It has been historically the main push area with out-migration to other regions in the country due to a combination of factors ranging from environmental factors (drought, desertification, etc.) to low indicators of lower socioeconomic levels and large inequalities and poverty (Barbieri and Ojima, 2018). While still the regional with highest proportion of population living in rural areas, nowadays most of the population live in small or middle size urban areas characterized by huge commuting between regional towns and rural areas, precarious labor conditions (more than 40% of the workforce without formal labor contracts) and heavy dependency on federal government cash transfers which may act as retention of potential out-migration (Ojima et al., 2014; Fusco and Ojima, 2017; Barbieri and Ojima, 2018).

The Seridó region hosts 216,508 inhabitants in seventeen municipalities and two microrregions (an administrative planning region designed by the Federal Government). Population growth was low between 2000 and 2010 (around 2% per year), with very high degree of urbanization (84.4%) and the Human Development Index (HDI) much lower than the national average. The municipalities have precarious infrastructure and services and are small (the most populated according to the 2010 census were Caicó, with 62,709 inhabitants, and Currais Novos with 42,652 inhabitants). Most of the active population is engaged in agricultural-related activities (IBGE, 2010). The Seridó presents high temperatures – mean average of 28.6°C with 23.2°C minimum and 35.4°C maximum, irregular rain regimes with low precipitation (mean 41.3 mm in 2007) and low soil fertility. It faced in 2012-2013 one of the worst droughts in the last thirty years and has faced the worse hydrological crisis in the last fifty years.

Data and methods

Data. The household surveys bring a combination of information on mobility, socioeconomic and demographic characteristics and perceptions on climate hazards in the Seridó region. The survey was financed by federal funds from the Brazilian Network for Climate Change research (Rede Clima) and was conducted in urban areas between January and February 2017, following a three-stage probabilistic sample: selection of municipalities in the first stage, selection of urban sectors – smaller areas within the municipalities – in the second stage, and finally the selection of households in the third stage. The sample involves the final selection of 1,064 urban households.

Besides socioeconomic and demographic characteristics, the two surveys collected specific information on two types of mobility: i) *out-migration*, in which case the informant declares if an individual who used to live in the household moved away; ii) *co-resident migrant*, in which case the informant declares if he or she used to live elsewhere between 2010 and 2016 in the case of Seridó (corresponding to the period of most severe drought in the last decades), and iii) *temporary mobility* (if the informant lives in the household but commute or move temporarily to other places for labor reasons). The surveys also collect information on motivations, aspirations and perceptions about climate hazards and other environmental factors which may shape mobility decisions. Given that these information on perceptions were collected only for the informant, we focus our mobility analysis on co-resident migrants (case ii) instead of and temporary overs (cases ii and iii above).

Descriptive analysis. In order to understand how the data are distributed for the dependent variable of interest (general mobility status), we performed a simple, bivariate descriptive analysis between this variable and the covariates used later in the regression. More covariate variables are described in the descriptive table than in the regression tables, due to lack of fit for some of them under multiple conditional expectations. However, in the descriptive analysis, they are included to give a sense of how all variables related to mobility used in most studies relate to the general mobility status in our study area. We tested for bivariate associations between mobility status and covariates using two different independence test: the ANOVA F test for differences in the means of continuous covariates across mobility status, and the G2 likelihood ratio test based on a loglinear model for contingency tables for categorical covariates. The model used in the latter case was the loglinear model with Iterative Proportional Fitting.

Our *dependent variable* is defined as a three-categorical variable, where 0 is assigned to respondents who have never lived in other places and do not commute to work to surrounding cities; 1 to those who never lived in other places but commute to work, and 2 to those who current live in the household, do not commute but ever lived in another place. We named the variable categories “Non-movers”, “Commuting Coresident”, and “Coresident Migrant”, respectively. These are mutually-excluding categories. The sample distribution of respondents accordingly to their general mobility status is 321 non-mobile respondents (30.2%), 320 commuting coresidents (30.1%), and 423 coresident migrants (39.8%). In the analytical sample used in the regressions (due to missing information to some of the covariates), the proportions are 29.8% (n=287), 30.5% (n=294), and 39.7% (n= 382), respectively. This suggests a very low, if any, potential for selection bias in the analytical sample.

The first group of variables is the state group we are interested in, and the second group is a group of control variables. Experience with previous droughts is a count variable, perception of drought worsening is a dummy variable, choice for living in the city is also a dummy variable, as it is the drought as a motivating for moving out of the Seridó area. Age is a count variable, sex is a dummy variable for male, occupation is a dummy variable for agricultural activity, as it is receipt of non-contributory social benefits by at least one of the household members.

Regression analysis. First we look at how *general mobility status* (the three-categorical variable described above) relates to *climate-related variables* (including experience with previous droughts, perception of drought worsening relative to the past, urban-living choice as a response to droughts, and if drought is an enough motivation for moving out), and *climate-unrelated variables* (age, sex, and occupation of respondents, in addition to non-contributory social benefits). Due to the nominal nature of our dependent variable, we framed the relation between variables within a traditional multiple multinomial regression framework. All the model coefficients had their standard errors adjusted to be robust to heterogeneity in the conditional errors. Regressions are also weighted by the differences in the probability of unit selections in the sampling design.

Then, we look at the mobility status among those who has any mobility experience (*strict mobility status*). Our dependent variable was defined as 0 for those who commute to work but have never lived elsewhere (commuting coresidents), and 1 for those who do not commute for work but has lived somewhere else in the past (coresident migrants). The truncation of the dependent variable here is likely to cause sample selection bias in the regression coefficients due to many unobserved factors, such as the reservation salary for those deciding to move. To correct this potential selection bias we used the Probit Heckman selection model. The identification of the model was obtained by including in the selection equation one covariate not included in the main regression equation. The selection equation would be modeled as a probit model with 1 for those making any mobility, and 0 for the non-mobile respondents. Selection bias will be treated as dependent on the unobservable factors and the test for bias is based on the null hypothesis that the covariance between the main equation conditional error and the conditional error from the selection equation equals zero. In our Heckman probit model, we see that the rho coefficient (that represents this covariance) is statistically significantly different from zero at 1% significance level, providing evidence of sample selection.

For this particular model we used a different set of covariates: *climate-related variables* (experience with previous droughts, perception of drought worsening relative to the past, urban-living choice as a response to droughts – expect for the selection equation, and if drought is an enough motivation for moving out), and *climate-unrelated variables* (age, sex, and occupation of respondents – included in the selection equation for identification, in addition to non-contributory social benefits).

Results

Descriptive results. Table 1 shows descriptive statistics and Independence tests for climate-related and climate-unrelated variables according to the type of the mobility attributed to the household respondent. While by definition the first type of individual resides in the household, we assume that the migrant *can* be a co-resident since we just know that he or she lives in the household at the moment of the interview and lived elsewhere before, regardless of being return migrant or not.

All climate related and climate unrelated variables are statistically significant in terms of their independence across the three mobility types. In other words, each mobility type has distinct features regarding climate related and climate unrelated variables. Regarding the first, even having experienced similar drought experiences (*Number of times hit by droughts)*, most of the commuters and migrants tend to perceive that droughts have been better (or less severe) in recent times, while those non-mobile tend to have a more pessimistic view. The opposite perception between movers and non-movers also appear i) when droughts are associated with the urban condition - commuters and migrants tend to consider life in the urban area more difficult due to droughts compared to non-movers and these last tend to perceive droughts as the most serious environmental problem in the city; and ii) the fact that movers perceive droughts as a cause of health problems in the household (and possibly a motivation to move). Most commuters and no-movers share the perception that droughts is not a motivation to move (*ever thought of moving out because of drought episodes)* while it is a motivation to most migrants. Finally, most commuters believe that global warming is a very serious issue and can be worsened by droughts, a coherent perception that also happens form migrants but in n opposite direction (most of them do not believe global warming is a serious issue and is associated to droughts). Most non-movers do not know how to respond about the seriousness of global warming.

Regarding climate unrelated variables, Table 1 shows that migrant co-resident tend to be older than commuters and no-movers, probably because it incorporates the effect of return migration. While commuters are predominantly male - what seems explained by the high mobility between urban and rural areas for occupational (agriculture) reasons – women are majority between migrants and the number of no-mover respondents tend to be similar. Most households with migrants and no-movers receive any social benefit such as cash transfer programs, while most households of commuters do not receive.

Due to the number of missing information, we did not include *proportion employed in agriculture* and *monthly per capta household income* (in Brazilian Reais) as regressors in the multinomial models. However, the descriptive results show that those engaged in any type of mobility (particularly migrants) have an important share of the labor force in agricultural activities, despite residing permanently in urban areas. Household per Capta Income is substantially higher for households with commuters, and households without movers have substantially smaller income related to movers showing that mobility is usually an effective strategy to increase income.

Table 1 - Descriptive Measures of Mobility and Climate-Related and Unrelated Associated Factors at the Seridó Study Area

Associated Factors	Mobility Type			Independence Test
	Commuting Coresident	Coresident Migrant	Non-movers	
Climate Related				
Perceived change in droughts				
Worse than in the past	36,01	37,42	26,57	G^2 = 133.7***
Same as in the past	32,69	39,18	28,13	
Better than in the past	41,14	43,97	14,89	
Most serious environmental problem in the city?				
Drought	34,85	38,25	26,90	G^2 = 254.2***
Other	35,14	40,83	24,02	
Number of times hit by drought	2,22	2,23	2,05	F = 4.00**
Is it easier to live in the city because of the drought?				
Yes	34,37	37,73	27,89	G^2 = 592.4***
No	38,15	43,75	18,10	
Ever thought of moving out because of drought episodes?				
Yes	33,75	43,25	23,00	G^2 = 678.6***
No	35,52	37,13	27,35	
Has anyone in the household had health issues due to droughts?				
Yes	42,93	41,33	15,74	G^2 =69.0***
No	34,79	38,97	26,24	
Seriousness of global warming				
Very serious	41,23	36,24	22,53	G^2 = 126.6***
Otherwise	35,29	43,71	21,00	
Doesn't know	24,87	42,63	32,49	
Do you believe droughts can worsen due to global warming?				
Yes	40,89	36,85	22,27	G^2 = 94.6***
No	28,56	45,22	26,22	
Climate Unrelated				
Age (years)	44,02	50,62	44,52	F = 18.18***
Sex				
Female	32,64	40,67	26,69	G^2 = 184.8***
Male	42,69	33,28	24,04	
Does anyone in household receive social benefits?				
Yes	27,55	43,85	28,59	G^2 = 22.3***
No	38,18	36,87	24,95	
Proportion employed in agriculture	34,07	39,01	26,92	G^2 = 312.8***
Monthly per capita household income	984,49	682,92	582,16	F = 18.84***

Source: Seridó Survey Data (2017), N=1064.
*** p<0.01, ** p<0.05, * p<0.1. G2 statistics from log-linear models using Iterative Proportional Fitting. F statistics from anova models.

Regression models. Table 2 shows the estimated probit coefficients while Table 3 shows the estimated odds-ratios. We focus our analysis on statistically significant climate related and climate unrelated variables. Regarding the first group of variables, individuals are less likely to be a migrant (and become a non-mover) when they perceive the droughts were worse; nonetheless, the Probit Heckman shows the odds of being a migrant when perceiving the drought as worse is 0,87 the odds of being a commuter. It is likely that the perception about the severity of droughts is more associated is more associated to those who do not move or tend to adopt commuting as a livelihood strategy. We see a similar pattern regarding the perception that it is easier to live in the city because of droughts. In this case, migration is a less likely response compared to not moving or to commute (in the last case, the odds of adopting migration is 0,85 the odds of adopting commuting as a strategy.

The number of droughts faced by a household respondent is significantly associated only in the Probit Heckman model in a sense of making migration a less likely response – their odds are 0,85 of those adopting commuting. On the other hand, the previous intention to move out because of droughts has a positive impact on mobility: it increases the odds of commuting in 57% compared to staying, and in 81% of migrating comparing to staying. In such case, migration seems a more likely response: the odds of adopting migration are 53% higher compared to commuting.

Overall, the joint analysis of the associations between mobility and climate-related variables suggest that three negative perceptions related do drought events (*droughts are worse today than in the past, easier to live in the city because of droughts* and *number of droughts faced by the household) are* more common between those with fixed residence (non-movers or commuters) compared to those who already lived in another residence (migrants). The first group is probably the one which has had more experience with droughts in the region, what impacts their negative perceptions. This is corroborated by the significant and negative association of commuting with agricultural occupation: the odds that a commuter will be in agricultural occupation are only 0.36 compared to a non-mover. As discussed before, migrants are always less likely to move due to negative perceptions about droughts when compared to non-movers or commuters. The fourth climate-related variable, *ever thought of moving out because of droughts,* increases the odds of migration or commuting compared to non-movers, but is even higher (53%) for migrants compared to commuters. This is the only perception variable that directly associates moving out of the household as a consequence of droughts, suggesting that droughts are an important component of *migration intentions,* while the other perceptions variables associate less likelihood of being a commuter or non-mover (and thus fixed residence) with *impacts on life quality (droughts being worse today than in the past, being easier to live in the city because of droughts)* and with *experience from past droughts.*

Regarding Climate-Unrelated variables, *age* is significant selectivity factor for migrants: each additional increase in one standard deviation of age increases the odds of migration in 3% compared to non –movers, or migrants compared to commuters. Men have overall higher odds of being a mover (41% higher odds of being a commuter vis-à-vis a non-mover), and 54% higher chances of being a migrant compared to commuters; thus, they are more likely to move overall. *Households receiving social benefits* are strongly negatively associated with commuting (households receiving benefits have 0,62 the odds of having a commuter compared to a non-mover) and are strongly positively associated with migration (34% higher odds of having a migrant compared to non-mover, and 108% higher odds of having a migrant compared to commuters). Commuters are thus less dependent on social benefits than migrants, what may also be explained by their higher per capta household income (Table 1).

We also used an interaction effect between sex and the number of previous droughts experienced by the respondent in the strict mobility equation (Probit Heckman), looking for evidence of how migration response to droughts may be different between males and females due to social norms and gender expectations. We showed before that experience with droughts reduces the probability of migration, but this reduction is even statistically stronger among men. In other words, men that face several droughts have a higher probability to move compared to women, and their households probably adopt other strategies involving, for example men´s competitive advantage in local labor markets and women´s migration.

Table 2 - Estimated Probit Coefficients on Probability of Mobility Status, Seridó Study Area

Variables	Multinomial Probit (base = no mobility)		Probit Heckman	
	Commuting Coresident	Coresident Migrant	Migrant (base = Commuter)	Selection (Mobility x No Mobility)
Droughts are worse today than in the past (dummy)	-0,092	-0.289**	-0.122***	-0.107***
	(0.153)	(0.144)	(0.013)	(0.014)
Ever thought of moving out because of droughts? (dummy)	0.353**	0.458***	0.254***	0.254***
	(0.150)	(0.145)	(0.013)	(0.014)
Easier to live in the city beause of droughts (dummy)	-0.190	-0.335*	-0.103***	
	(0.185)	(0.180)	(0.013)	
Number of droughts faced by the household	0.104	-0.105	-0.045***	0.126***
	-0,078	(0.076)	(0.008)	(0.007)
Age (years)	-0,006	0.021***	0.018***	0.00199***
	(0.004)	(0.004)	(0.0004)	(0.0004)
Male (dummy)	0.288*	0.0136	0.253***	0.102***
	(0.151)	(0.151)	(0.035)	(0.015)
Does any household member receive social benefits from government? (dummy)	-0.344**	0.250*	0.413***	-0.0131
	(0.149)	(0.141)	(0.014)	(0.012)
Agricultural occupation (dummy)	-0.794*	0.403		-0.677***
	(0.469)	(0.529)		(0.032)
Interaction (male, number of droughts)			-0.139***	
			-0,015	
Constant	1.000*	-0.602	-1.091***	0.915***
	(0.557)	(0.604)	-0,026	-0,039
rho			0.944***	
			(0.016)	
Analytical Sample	963		966	

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: Seridó Survey Data (2017), N=1064.

Table 3 - Estimated Odd-ratios for Associated Factor of Mobility Status, Seridó Study Area

Variables	Multinomial Probit (base (base = no mobility)		Probit Heckman	
	Commuting Coresident	Coresident Migrant	Migrant (base = Commuter)	Selection (Mobility x No Mobility)
Droughts are worse today than in the past (dummy)	0,91	**0,71**	**0,78**	**0,82**
Ever thought of moving out because of droughts? (dummy)	**1,57**	**1,81**	**1,53**	**1,54**
Easier to live in the city beause of droughts (dummy)	0,75	**0,63**	**0,85**	
Number of droughts faced by the household	1,13	0,88	**0,94**	**1,25**
Age (years)	0,99	**1,03**	**1,03**	**1,00**
Male (dummy)	**1,41**	1,03	1,54	**1,19**
Does any household member receive social benefits from government? (dummy)	**0,62**	**1,34**	**2,08**	0,97
Agricultural occupation (dummy)	**0,36**	1,64	**1,67**	**0,37**
Interaction (male, number of droughts)			**0,79**	

Bold odd-ratios are those statistically significant
Source: Seridó Survey Data (2017), N=1064.

Predicted probabilities. We finally use the regression results to estimate predicted probabilities which unveil the trade-offs and synergies in the adoption of two *ex-situ* livelihoods strategies – mobility and income from social benefits – as well as age, this last being probably the most robust selectivity factor of mobility. Table 4 shows the predicted probabilities of mobility, highlighting the much higher probability to move between commuters compared to migrants.

We show in Table 5 and in Figure 2 the predicted probabilities of mobility according to experiences with droughts and considering if the household receives social benefits. Considering the upper part of Table 5, the overall conclusion is that migration and commuting have an inverse relationship when controlled by exposure to droughts: the probability of migration decreases when the number of droughts faced increases, showing it is a more common strategy in events not related to droughts, while the probability of commuting increases when experiences with droughts increases. As a matter of fact, the predicted probability to not move for those exposed to up to one drought and without benefits is 29.3%, but if the individual receives a benefit, the probability to remain immobile *decreases* to 17.9%, while the probability to commute *increases* from 38.7% to 51.2% (and probability to migrate remains stable). This pattern repeats in the case of facing two droughts or more, albeit at higher levels for non-movers (decrease from 37% to 24%) and commuters (33.8% to 51.2%).

In summary, receiving a social benefit reduces the probability of non-moving in both scenarios of drought experiences and increases the probability of commuting while the probability of migrating remains practically stable. While these results seem apparently contradictory with the odds ratio in Table 3 (showing that for those receiving social benefits, the odds of adopting migration are significantly higher compared to those not moving, and higher to migrants compared to commuters), it shows that receiving a benefit may in fact increase the chances of adopting commuting and reducing immobility.

Table 4 - Predicted Probabilities of Mobility in Seridó Study Area

Outcome Category	Mininum	Mean	Maximum
	Multinomial Probit		
Non-mobile	0,0621	0,3052	0,7450
Commuting Coresident	0,0791	0,3966	0,8184
Coresident Migrant	0,0923	0,2982	0,4464
	Heckman Probit		
Commuting Coresident	-	0,6229	-
Coresident Migrant	0,1035	0,3771	0,8107

Source: Seridó Survey Data (2017), N=1064.

Table 5 - Predicted Probabilities of Mobility According to Selected profiles in Seridó Study Area

Profile		Non-movers	Commuting Coresident	Coresident Migrant
		Multinomial Probit		
Face up to one drought	Not receiving social benefits	0,2930	0,3870	0,3200
	Receiving social benefits	0,1790	0,5120	0,3090
Face two droughts or more	Not receiving social benefits	0,3700	0,3380	0,2920
	Receiving social benefits	0,2400	0,4680	0,2920
		Conditional effects on probabilities (% change)		
Social benefits | drought experience				
up to one drought		-38,9	32,3	-3,4
two or more droughts		-35,1	38,5	0,0
Drought experience | benefits				
not receiving		26,3	-12,7	-8,8
receiving		34,1	-8,6	-5,5

Source: Seridó Survey Data (2017), N=1064.

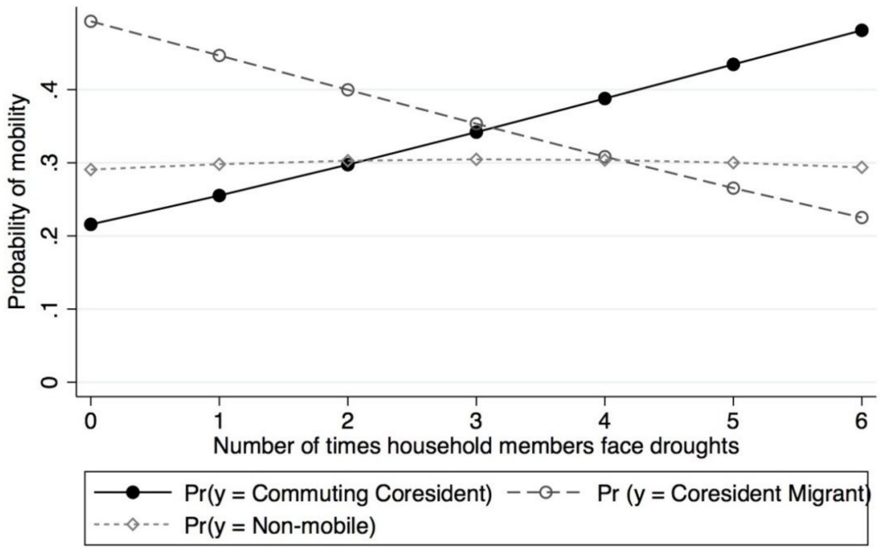

Figure 2 – Predicetd probability of mobility by number of droughts experienced by the household in the Seridó region
Source: Seridó Survey Data (2017), N=1064.

Regarding the bottom part of Table 5, given that an individual experiences less drought episodes, the fact of receiving social benefits (compared to those not receiving) reduces in 38.9% the chance of not moving (a slightly higher change, 35.1%, if experiences more droughts). On the other hand, while the percent change in migration is negative and small, experiencing less drought episodes and receiving social benefits (compared to those not receiving) increases the chances of commuting in 32.3% (38.5% if experiences more drought episodes). Coherently with these results, not receiving benefits and having less drought experiences (compared to having more drought experiences) increases the chances of being immobile in 26.3% (34.1% if receives a benefit), and imply negative chances of commuting or migrating irrespective of receiving a benefit or not.

Finally, Figure 3 shows the predicted probability of mobility (commuting or migration) adding, to the previous analysis involving experience with droughts and receipt of social benefits, the effect of age. It shows that to each additional standard deviation increase in age, the probability of not moving increases in 7%, and the probability to commute increases in 12%. Overall, in terms of patterns, the probability increases by age for migrants and decreases by age for commuters. The effect of social benefits is in the level of the probability and not the pattern, but in opposite direction: lower level in migration probability if *do not receive* benefit, and lower level in commuting probability *if receive* benefit). However, the effect of migration should be seem cautiously, since we are measuring the stock of past migration (those co-residing in the household and migrated in the past) and not last stage or fixed date migration, what may force the migration probabilities to increase with age.

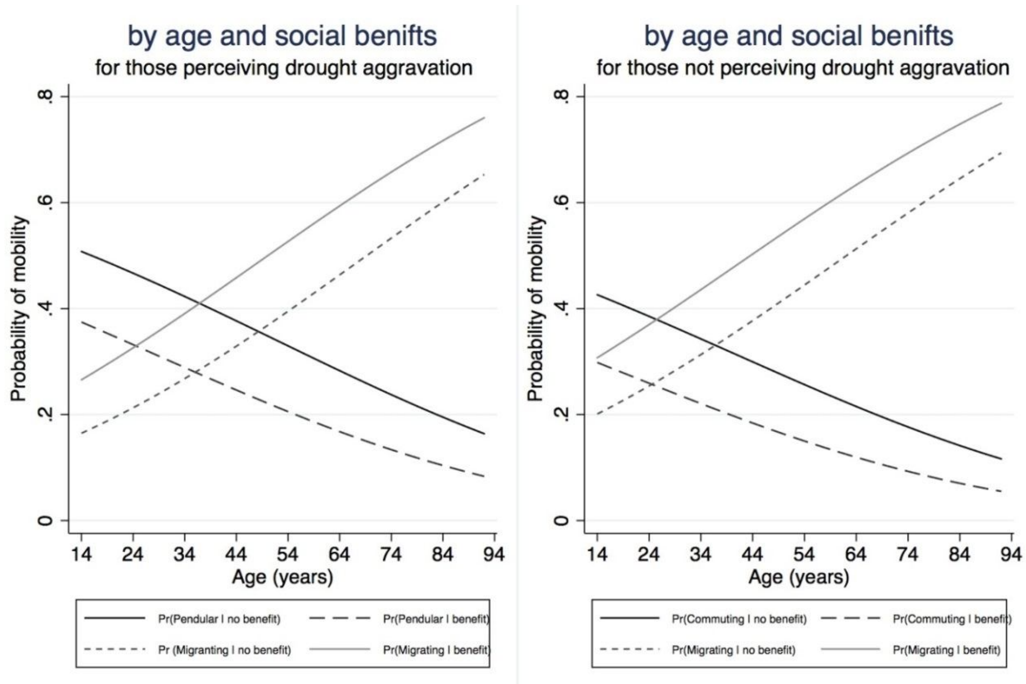

Figure 3 - Probability of mobility in the Seridó region
Source: Seridó Survey Data (2017), N=1064.

Conclusion

To be written

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