Understanding farmers' perceptions/beliefs and adaptation to climate change: The case of Rio das Contas basin, Brazil

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Abstract:

Based on the background of the agriculture sector vulnerability to climate change in developing countries and it´s risks to Brazilian Northeast farmers, the paper put forward an understanding of the factors that guide individuals to adopt adaptive strategies to cope changing environments as a fundamental issue for the direction and effective formulation of well-targeted public policies. Mediation models were estimated considering two different scenarios: (i) adoption of adaptive practices by farmers based only on the impact of climate perception, mediated by knowledge/belief in the occurrence of climate change; (ii) the socioeconomic conditions of the farmers and their properties were additionally included. The main results demonstrated that the Rio das Contas basin farmers' perceptions about the negative effects of climate change, despite being the main driver, will only affect adaptation behavior when the farmers have knowledge and believe in the occurrence of climate change. Socioeconomic conditions are overshadowed in predictive power of adaptation by knowledge/belief about climate change. This outcome may be directly related to the farmers' cultural aspects, nevertheless, the importance of technical assistance or rural extension services should be also emphasized as an expressive part of farmers is no longer adapted due to lack of knowledge of suitable techniques.

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Keywords: Climate Change; Agriculture; Perception; Belief-knowledge; Adaptation; Socioeconomic Conditions.

1. Introduction

Global climate change is one of the major challenges faced by societies around the globe in the 21st century (Food and Agriculture Organization of the United Nations – FAO, 2016). Discussions on climate change and its potential impacts become central for ongoing efforts to achieve sustainable development taking into account the future climate scenarios predicted by the Intergovernmental Panel on Climate Change (IPCC, 2013). However, the magnitude of impacts is not the same in different regional contexts and economic sectors. For example, the agricultural sector is highly dependent on natural resources such as temperature and access to water, and it is especially vulnerable to climate change with local economic risks to farmers (Nelson et al., 2014). Therefore, identifying technologies and adaptive strategies are of pivotal importance to avoid agriculture losses, and thus reduce agriculture's vulnerability to climate change (Cunha et al., 2015).

Adaptation in the perspective of human scopes of global change commonly refers to an action, a process or an outcome in a system (e.g., a household, community, region, or country) in order for the system to better cope with, manage or adjust to certain changing condition (Smit and Wandel, 2006). Furthermore, according to IPCC (2014), adaptation can be defined as the process of adjusting to the current or expected climate either to reduce vulnerability or to enhance resilience. On the other hand, according to Below and co-workers (2012), the adaptive process is the necessary adjustment in human-environmental systems to reduce the vulnerability of a system in response to expected or observed changes in climate patterns. All these concepts are closely related with the fact that adaptation to climate change requires, at first, that farmers perceive and believe that the climate has changed, and then that it is necessary to identify potential adaptive measures and implement them (Maddison, 2006).

Compelling evidence has recently demonstrated that people perceive and adapt to climate change events based on personal observations and cultural factors (Blennow et al., 2012; Blennow and Persson, 2009; Bursztyn and Eiró, 2015; Gebrehiwot and van der Veen, 2013; Hagen, 2016; Howe et al., 2012; Leiserowitz et al., 2012; Persson et al., 2015). However, the perception of individuals in terms of climate change is dynamic and differs between nations or even between different regions of the same country (Capstick et al., 2015). Therefore, a sound understanding of the factors that guide individuals to adopt adaptive strategies to cope with changing environments is a fundamental issue for the direction and effective formulation of well-targeted public policies (Blennow et al., 2012).

The agriculture sector in developing countries such as Brazil is especially vulnerable to climate change (Nelson et al., 2014). Indeed, the Brazilian economy is highly dependent on its agribusiness gross domestic product (Centro de Estudos Avançados em Economia Aplicada – CEPEA, 2015). In addition, developing countries are located predominantly at low latitudes, in areas where temperature rates are already near or above the optimal levels for agricultural practices (Cunha et al., 2015). More specifically, smallholder farmers are likely to be highly vulnerable to climate changes because of barriers related to access to funding, productive infrastructure, and technical assistance (Altieri and Koohafkan, 2008; Cunha et al., 2013; Morton, 2007). These facts highlight the need to account for adaptation initiatives in developing regions, and thus preserve the resilience of social-ecological systems like smallholder farming.

Here we demonstrated how climate change perceptions and local climate change knowledge and beliefs influence the adoption of adaptation practices among farmers of Rio das Contas basin, Brazilian Northeast region. Furthermore, as risk perceptions and their correlated adaptations are socially constructed, they lead personal factors, such as knowledge and socioeconomic conditions, to strongly correlate with responses to climate change.

The analysis of these issues at the regional Brazilian context is very important for at least three reasons. The first one relates to the fact that scientific knowledge about climate change is built and shaped based on the occurrence of events that can be addressed to climate change, available weather information and potential impacts on society and the environment. However, understanding, perception and belief about climate change are based not only on concrete facts (events that have already occurred) or economic facts, but also essentially on psychological conditions and cognitive abilities, that is, the construction of understanding, perception and belief by the general public is something broader and more variable. In this way, it is extremely relevant to study and know how perception/belief are delineated and how they can favor positive behavior in the sense of adapting to climate change (Arbuckle et al., 2015). The second reason one is that few researches have examined farmers' perceptions of climate change and how this knowledge/belief affects their willingness to adapt. Consequently, adaptation behavior at the farm level is less studied. Finally, the Rio das Contas basin region is heavily dependent on agriculture and has high exposure to adverse climatic conditions. According to the climate information presented by Blunden et al. (2017), the region can be included among the most vulnerable to climate change in Brazil due to the exposure of their population to severe drought and high temperatures.

The adoption of a river basin as a study area provides representative local-level fields for adaptation to environmental changes, since agricultural systems are exposed to and directly dependent on the climate (Smit and Wandel, 2006); it also enables a human-level investigation of farmers as members of such system. A local-level analysis enables to provide a better understanding of the major processes underlying adaptation and a better targeting of adaptation policies (Ampaire et al., 2017; Boko et al., 2007; Smit and Wandel, 2006). The combined data are discussed in the context of current models of concerns and beliefs that motivate farmers to adapt to climate change, as well as the risks involved.

2. Methodology

2.1. Study Area

The impacts of climate changes tend to be quite severe in the Brazilian Northeast region, since higher temperature increases and large variations in rainfall indices are expected there, such as a decrease in rainfall patterns and an increase in consecutive dry days (Marengo et al., 2017b). Historically, water stress is the major environmental constraint to smallholder farming in this region, which is extremely reliant on rain-fed practices. According to Marengo et al. (2017b), the predictions of climate change could greatly jeopardize the Northeastern agricultural aptitude. Such agricultural losses may result in several problems, mainly increased rural poverty. Therefore, policy makers will face a major challenge over the coming years.

Our study focuses on the Rio das Contas basin (12º55'/15º10' S; 39º00'/42º35' W), a territory of approximately 55,000 km^2 in Bahia state, located on the Brazilian Northeast (Fig. 1). Overall, the basin extends east-west for about 700 km in 92 municipalities, with a total unevenness of 615 m, comprising three different biomes: (i) Cerrado (Brazilian savanna); (ii) Caatinga (a xeric shrubland and thorn forest); and (iii) Tropical Atlantic Rainforest (Barbosa and Dominguez, 1996; Paula et al., 2010). The region presents high seasonal and spatial climatic variability, mainly due to the merge of characteristics of two climatic sub-regions – the semi-arid and the tropical rainforest climates (Machado et al., 2011) – with a long-term average of annual precipitation of about 800 mm (Climate Research Unit – CRU, 2013).

The Rio das Contas basin is a predominantly agricultural region, and presents small to medium-sized cities and low industrialization rates, which makes it potentially vulnerable to the adverse effects of climate change (Paula et al., 2010). Despite its high absolute population of more than two millions inhabitants, the Human Development Index (HDI) average is only 0.585, a value that falls under the category of "medium human development" according to the

United Nations Development Program (UNDP, 2015). In addition, the basin has approximately 13% of its municipalities in the “low human development” range, whereas no municipalities are found in the “high” or “very high” development categories (UNDP, 2015). Altogether, this data reinforce the need of research and development initiatives involving the social actors that reside in this region and use its natural resources.

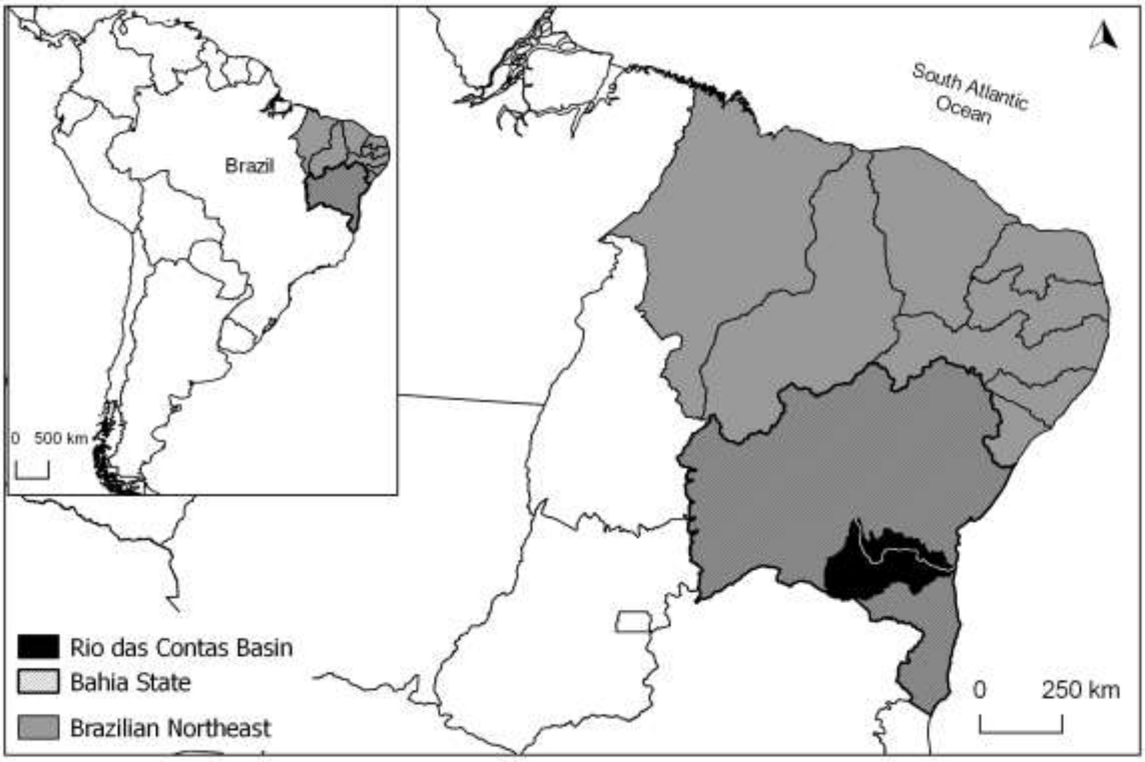

Fig 1. Location of Rio das Contas basin, Bahia state, Brazilian Northeast.

2.2. Primary Data Collection

We designed a semi-structured questionnaire that contained questions about the farmers’ socioeconomic information, their perceptions/knowledge/beliefs/concerns about climate change and views of climate risks, and the adaptive measures implemented. The interviews were carried out in the summer of 2014.

The sample design was created in order to obtain random distribution of agricultural properties through the wide variety of climatic zones within the Rio das Contas basin region.

For this, we followed the methodology of (Hartter, 2009) and created a buffer zone that comprised municipalities located, at most, at 50 km of the full extent of Rio das Contas. The buffer zone covered the study area in the East-West direction and, through it, the geographical coordinates of the properties considered in the study were randomly selected. Thus, among the 145,647 agricultural establishments in the Rio das Contas basin (Instituto Brasileiro de Geografia e Estatística – IBGE, 2006), we selected 289 by simple random sampling with 95% of confidence.

The number of questionnaires applied in each municipality was proportional to the total number of farmers in the municipality reported by the Brazilian Agricultural Census (IBGE, 2006). Moreover, the number of farmers interviewed in each municipality was proportional to the number of owners and non-owners (partners, sharecroppers, tenants, squatters, etc.).

2.3. Statistical Analysis: Mediation Model

In this research, we hypothesized that the experience of extreme weather conditions and past perceptions of temperature and precipitation change may affect the farmers' adaptation behavior through their knowledge/belief about climate change, which act as the mediating variable. Therefore, to conduct the research we estimate a Mediation Model.

Mediation analysis are statistical methods used to respond how an independent variable, *X* (*climate change perception*), transmits its effect on a dependent variable, *Y* (*adaptation*), and this effect is "mediated" by another variable *M* (*climate change knowledge/belief*) (Hayes, 2013). According to Mackinnon et al. (2007), the "mediator is a variable that is in a causal sequence between two variables, whereas a moderator is not part of a causal sequence between the two variables". In other words, the variable M is intermediate in the causal trajectory of X and Y and represents an asymmetrical relationship between such variables.

We estimated binary mediation models according to the methodology described in Hosmer and Lemeshow (2000). Thus, the binary-mediation analysis was conducted using a logit regression. The empirical model can be represented by the following equations:

$$P_i = E(Y = 1 | X_i) = i_1 + cX + e_1 \quad (1)$$

$$P_i = E(Y = 1 | X_i) = i_2 + c'X + bM + e_2 \quad (2)$$

$$M = i_3 + aX + e_3 \quad (3)$$

where P_i is the probability that a farmer *i* implements an adaptation strategy (*Y = 1* if the farmer adopted an adaptive strategy); *c* represents the relationship between the independent (*X*) and dependent variable (*Y*); *c'* is the parameter that relates the independent to the dependent variable adjusted by the mediator variable effect; *b* is the parameter that relates the mediator to the dependent variable adjusted by the independent variable effect; *a* is a parameter that measures the relation between the independent variable and the mediator variable; e_1, e_2 and e_3 represent the errors or variabilities not explained by the models and the intercepts are represented by i_1, i_2 and i_3.

The variables X and M were represented, respectively, by the Climate Change Perception (CCPI) and Climate Change Knowledge/Belief (CCKI) indexes. The formula used for calculating the indexes was based in the methodological proposition of Filmer and Pritchett (2001):

$$I = \sum_k \left[f_k \frac{(a_{ki} - \bar{a}_k)}{s_k} \right] \quad (4)$$

where *I* represents the index to be created, that is, *I = CCPI* if the index is related to climate change perception and *I = CCKI* if indicates climate change knowledge/belief; the observed value of the variable *k* for the farmer *i* is represented by a_{ki}; $\bar{a}_k$ indicates the average value, and s_k the standard deviation of the variable k. The value f_k is the weight given to each variable in the index, which was achieved using the multivariate principal component analysis. The variables used in each index, as well as their respective weights, are presented in Table 1.

Two different scenarios were considered. In the first one, the adoption of adaptive practices was studied based only on the impact of climate perception, mediated by knowledge/belief in the occurrence of climate change. In the second one, in addition to these questions, the socioeconomic conditions of the farmers and their properties were included according to the literature (Below et al., 2012; Cunha et al., 2015). Finally, to test the significance of the estimated effects, we used a bootstrapping method. This methodology allows more robust standard error estimates, confidence intervals, as well result stability verification.

Table 1. Description of the variables and weights – achieved by multivariate principal component analysis – used in the construction of Climate Change Perception and Climate Change Knowledge/Belief indexes.

Indexes	Questions/ Variables	Answer Options	Weights
Climate Change Perception Index	1. Have you ever noticed/perceived any extreme weather conditions?	I do not know how to answer = 0 No, not at all = 1 No, maybe not = 2 Yes, maybe = 3 Yes, definitely = 4	0.51
	2. What is your opinion about this year's winter temperatures?	I did not notice any changes = 0 Cooler than usual = 1 Warmer than usual = 2	0.48
	3. What is your opinion about this year's winter rains?	I did not notice any changes = 0 It rained more than usual = 1 It rained less than usual = 2	-0.06
	4. What is your opinion about last summer's temperatures?	I did not notice any changes = 0 Cooler than usual = 1 Warmer than usual = 2	0.45
	5. What is your opinion about last summer's rains?	I did not notice any changes = 0 It rained more than usual = 1 It rained less than usual = 2	0.24
Climate Change Knowledge/Belief Index	1. Have you heard or discussed about climate change and its impacts on agriculture?	Yes = 1 No = 0	0.56
	2. Do you believe that the climate is changing to such an extent that it will substantially affect your agricultural production and/or livestock?	I do not know how to answer = 0 No, not at all = 1 No, maybe not = 2 Yes, maybe = 3 Yes, definitely = 4	0.24
	3. How do you assess your degree of knowledge about climate change?	I do not know anything = 0 I know a little = 1 I know incompletely = 2 I know comprehensively = 3	0.54

3. Results

3.1. Socioeconomic descriptive analysis

According to the household survey applied concerning the socioeconomic conditions of the farmers of Rio das Contas basin, they are characterized predominantly by married male-headed households of about 51-year-old average age and low educational level, with 27% of them who achieved at most incomplete elementary school and 25% of them illiterate or only know how to read and write.

Despite the low instructive level, the majority (85%) of them has a vast farming experience of about more than 10 years. Descriptions of the farm characteristics pointed that the average size of their rural household land is approximately 34 ha, with preponderance (39%) of properties with less than five hectares. This fact suggests a farming system formed basically by 'subsistence agriculture', in which beans and maize are the most important agriculture activities practiced by 36 and 29% of the farmers, respectively. Moreover, livestock-based production is also highlighted, being experienced by 72% of the farmers, headed by poultry (50%) and cattle (41%) activities. Each headed household shows in average five dependents in the farm household, and a significant part (60%) of the sample has almost the total (75-100%) income dependence on agricultural activities of the farmland.

Regarding the legality condition of the land ownership, most (86%) of the farmers are private landowners. Although the proof of legal relationship of the farmers with the land is a highly relevant aspect to get access to credit lines for agriculture, and consequently contribute to adaptation activities to climate change (Motta, 2011), almost 73% of the farmers do not have access to rural credit facilities. Excessive bureaucracy, lack of knowledge concerning the grant, or even uncertainty to incur financing systems were the main factors mentioned for not getting credit. This situation points that only the land ownership is not a decisive factor in obtaining rural credit among the farmers of Rio das Contas basin.

Besides the educational level, information about access to means of mass communication, to technical assistance and to membership in cooperatives and professional associations is needed to better understand the farmers' degree of access to information and, how it should reduce the vulnerability to extreme weather events and increase their chances of facing adaptation to such events. The majority (70%) of the farmers of Rio das Contas basin did not receive technical assistance, mainly because the technicians were not available (37%) or they did not know who to hire (15% – data not shown). Among those who actually got technical assistance, 51% had it only if necessary, being the Bahia Agricultural Development Agency (EBDA) and town halls pointed as responsible for 66% and 28% of the support, respectively. Nevertheless, around 63% of the farmers participated on rural union councils or class associations. Television (81%), mobile phone (64%) and radio (57%) were pointed as the main means of access to information. However, the internet, such an important source of access to information, was not widespread among Rio das Contas basin' farmers yet (9%).

3.2. Climate Change Perception and Climate Change Knowledge/Belief Index

The multivariate principal components analysis used to compose the climate change perception index (CCPI) showed an average value of 0.73 indicating an upper-middle perception by farmers that the temperature and precipitation are changing in Rio das Contas basin. Higher CCPI weights were detected in variables related to general perceptions of extreme climate events and specific perceptions of high summer/winter temperatures (Table 1). The main extreme event reported by farmers was the drought. Most of the farmers have an opinion that the droughts are happening unpredictably and the heat is increasing progressively. Meteorological data provided by Marengo et al. (2017a) indicate factual evidence to support farmers' perceptions of increasing temperature and droughts. In addition, the study of Blunden et al. (2017) indicated that the Brazilian Northeast has been facing its worst drought in 100 years since 2012.

The CCKI, created to access the knowledge/belief of farmers in climate change, overweight what farmers heard about climate change and its impact on agriculture (0.56) and the degree of knowledge/belief they have about this subject (0.54), more than if they think that the climate is changing so as to harm their agricultural production (0.24 – Table 1). This way, a medium-low knowledge/belief about climate change was detected by an average CCKI value of 0.60.

3.3. Adaptation to Climate Change

The main adaptive strategies used by farmers of the Rio das Contas basin who had adapted to climate changes were respectively: increased irrigation use; environmental conservation; change in harvesting dates; rotation and diversification of crops; and change in planting dates.

We have identified that there is a significant positive relationship between farmers who altered the management of their adapted properties and their belief in harmful effects of climate change ($\chi^2 = 10.35$, $p < 0.016$). A great number of them (89%) stated their beliefs that climate change would affect negatively the financial situation of their property. At the same time, 94% of farmers that believed climate change would affect negatively their properties had previously adapted (Table 2).

Furthermore, an analysis uncoupling the calculated indexes between farmers' behavior of adapting or not pointed that CCPI mean values are significantly higher when adaptive strategies are adopted than when these strategies are avoided (0.79 and 0.69 respectively; $t = -2.92$, $p < 0.01$); as well as for CCKI (0.69 and 0.51 respectively; $t = -8.01$, $p < 0.01$).

These results show, according to Blennow and Persson (2009), that the understanding of the adaptation process to climate change at the local level needs to take the "factor strength of belief in climate change" into consideration. Moreover, Eisenack and Stecker (2010) point out that access to reliable climate information and the climate change perception are determining factors for the adoption of adaptation strategies. According to the authors, individuals seek to protect themselves when they are warned of possible damages caused by climate change. These are early indications that confirm how important the knowledge/belief about climate change in farmers' decision-making is.

Table 2. Frequency of the farmers who had and had not adapted the farm management by the belief that climate change should affect the financial situation of their property.

Adapted	How do you believe climate change will affect the financial conditions of your farm?			
	Not at all (%) n = 18	Positively (%) n = 11	Do not know (%) n = 4	Negatively (%) n = 256
No (n = 140)	9.29	5.00	2.86	82.86
Yes (n = 149)	3.56	2.68	0.00	93.96
Total (n = 289)	6.23	3.81	1.38	88.58

3.4. Mediation Models

Based on the binary-mediation model, we found that the famers' perception and their knowledge/belief in the occurrence of climate change will affect their adaptation behavior ($p < 0.001$). The binary mediation analysis indicated a complete mediation effect occurring once CCPI (independent variable) had a positive significant indirect effect on the adopted agricultural adaptation behavior (dependent variable), which was mediated through CCKI (mediating variable). Thus, the proportion of the total effect mediated was 58.87%. In contrast, the direct effect of CCPI was not significant (Fig. 2).

It is important to note that our result indicates that the relationship between perception and adaptation is most likely to occur when the farmer knows and believes in climate change. Such result is in agreement with the literature. According to the hypothesis of Blennow and Persson (2009), "the strength of belief in an adaptive capacity was shown to be crucial for adaptation among individuals who are exposed to and sensitive to climate change".

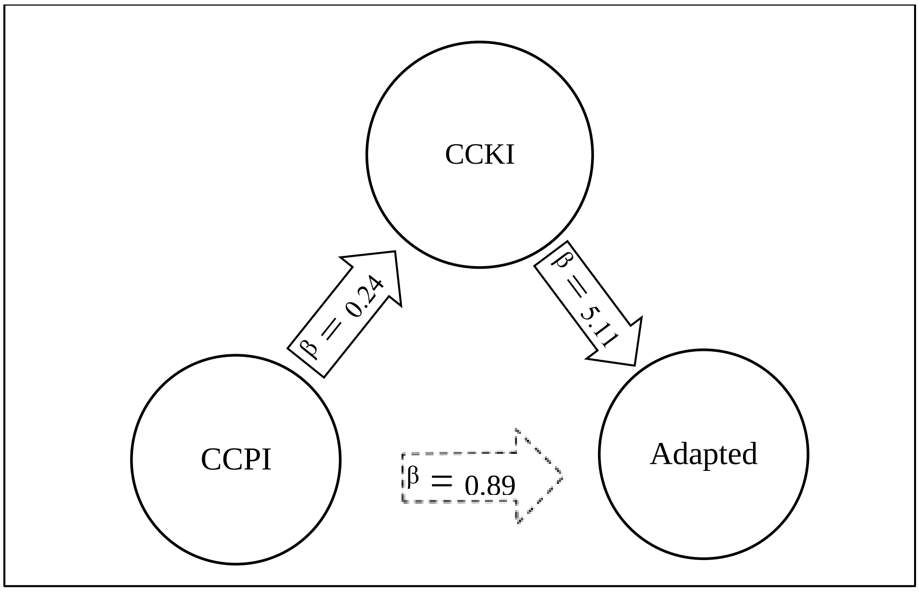

Fig 2. Binary-mediation model examining the direct and indirect effects of the climate change perception index (CCPI) on farmers' adoption of adaptation behavior with Climate Change Knowledge/Belief Index (CCKI) as mediating variable. β's coefficient indicated the strength of the relationship between variables. Solid and broken arrows represent respectively significant and not significant effects between variables based on bootstrap analysis (P-value < 0.01).

After testing for the isolated effects of CCPI, we analyzed the effect of socioeconomic variables on the adoption of adaptation strategies (Table 3). As in the previous analysis, a positive significant indirect effect of a complete mediation prevailed, and the CCKI explained 49.78% of the relation between the variables CCPI and Adaptation. Among the socioeconomic variables, only age, educational level, income dependence on agricultural activities, and technical assistance had a positive and significant effect correlated to the decision to adapt (P-value < 0.10 – Table 3).

Table 3. The Binary-mediation models estimation considering both effects of Climate Change Indexes and socioeconomic variables on adaptation strategies adoption by farmers of Rio das Contas Basin Region.

Variables	β's Coefficient	P-value
Independent variable		
Climate Change Perception Index (CCPI)	1.2251	0.11
Mediating variable		
Climate Change Knowledge/Belief Index (CCKI)	4.3836	0.00
Independent socioeconomic variables		
Age	0.0245	0.01
Educational Level	0.2805	0.00
Number of dependents in the farm household	0.0387	0.26
Income dependence on agricultural activities	0.0070	0.07
Rural Credit	0.3234	0.31
Technical assistance	0.8721	0.00
Constant	-6.6171	0.00

4. Discussion

The understanding of which factors motivate farmers to adapt to climate change in areas of vulnerability to agriculture in developing countries – where agricultural practices are more dependent on natural resources – is urgently necessary to better delineate adaptation public policies. The main results of this research demonstrated that the Rio das Contas basin farmers' perceptions about the negative effects of climate change only affect farmers' agricultural adaptation behavior in an indirect way, so this relation is mediated through climate change knowledge/belief. In other words, perceptions will influence adaptation practices only when the farmers have knowledge and believe in the occurrence of climate change. That is why access to reliable climate information is so important.

By including socioeconomic variables, the mediation modeling confirms that the knowledge/beliefs in the negative climate impacts on agriculture are the main driver to adopt adaptation strategies while socioeconomic variables are in the background, but also noteworthy. The possibility of future losses in plantations motivates producers to have an attitude; therefore, this is not an easy task since it requires great cognitive skills (Haden et al., 2012). The low magnitude of the effect produced by the "*income dependence on agricultural activities*" variable should be evidencing these symbolic, psychological and cultural values represented by the desire to remain on the land or place of origin, which has an important role in the farmers' decision-making. In addition, the agricultural activity is not only perceived by farmers as an income source, but also as something intrinsically linked to their culture and way of life. Thus, if the negative impact on agriculture actually occurs, it will be extremely harmful financially, as well as psychologically and culturally.

As for the techniques adopted, the Rio das Contas basin farmers have been more interested in adopting practices that provide faster benefits (such as the use of irrigation and changes in harvest dates). Although farmers have been adopting these techniques, around 50% of them stated that they do not know how to adjust their agricultural practices to avoid negative effects of climate change. This is a critical aspect and it may be reflecting the low access the farmers have to technical assistance that this research detected. The lack of knowledge about adaptation strategies leads farmers to choose not to adapt to climate change, even knowing their harmful effects.

An extensive literature demonstrates that technical assistance increases the farmers' knowledge level, and consequently, influences the adoption of adaptation strategies (Below et al., 2012; Blennow and Persson, 2009; Cunha et al., 2015; Pires et al., 2014). However, the differential of this research lies on the fact that we were able to identify, by mediation modeling, that after knowledge/belief and perception, technical assistance is the third drive that exert a more positively effect on adaptation adoption strategies.

There are several ways of adapting to climate change. The level and form of adaptation varies mainly in terms of knowledge of practices (Schuchardt et al., 2008), which can be enhanced by technical assistance. Nevertheless, knowledge about the meaning and forms of adaptation is still very incomplete. Belief in the occurrence of climate change and the knowledge of adaptive practices are crucial for the response to these events to be efficient and effective (Mitchell and Tanner, 2006). Having such knowledge, it is possible to reduce risks associated with climate change and increase the chances of minimizing negative impacts on agribusinesses.

5. Conclusion

Our analysis represents an attempt to develop a comprehensive understanding of the influence of climate change perceptions, knowledge/beliefs and farm-level socioeconomic features on the willingness to adapt of Brazilian Northeastern farmers. As a starting point, we considered the fact that we already have a great knowledge about the effects of climate change on Brazilian agriculture, but little is known about adaptation at a regional level. Therefore, the research findings demonstrate the importance of investigative perception of and adaptation to climate change at a local level.

We conclude that the knowledge/belief in climate change and its adverse effects on agricultural activity are the main drivers of adaptation in the Rio das Contas basin. Socioeconomic conditions were overshadowed in predictive power of adaptation by knowledge/belief about climate change. This result may be directly related to the farmers' cultural aspects; their decisions are also based on the desire to remain cultivating the land. Nevertheless, it is important to emphasize the importance of technical assistance or rural extension services; an expressive part of farmers is no longer adapted due to lack of knowledge of suitable techniques.

Our results lead to an important reflection in terms of public policies. Initially, it is necessary to consider actions that facilitate farmers' understanding of the serious consequences of climatic phenomena directly observable that affect their activities in the short-term, such as droughts. At the same time, the provision of technical assistance and rural extension services should be increased to contribute to the farmers' adaptation process. It is important that these policies recognize the heterogeneity of farmers' adaptive capacity and their relationship to agricultural activity. In this way, the farmers' traditional knowledge must be valued, allowing the process of altering productive practices to be constructed along with public agricultural development institutions. Such actions have greater potential for positive effects than just trying to reinforce farmers' belief in the long-term changes/effects of climate change.

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