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ORIGINAL ARTICLE

Farmers' perception of climate change in mediterranean Chile

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Abstract Meteorologists predict that climate change will have an increasing impact on ecosystems and agricultural production; however, many farmers do not have a clear perception of climate change or how it may affect their crop yields and overall farming operation in the near future. This study examines climate change perceptions in four rural municipalities in Central Chile, and the effect that exposure to meteorological information has on such perceptions, using a survey conducted in 2011. It uses a probit model to identify the socioeconomic and productive factors associated with what we define as a "clear perception" of climate change. Most farmers in this survey recognize that there have been changes in temperature and precipitation patterns during the last 24 years: About 62 % perceive that the average temperatures have increased; 93 % that precipitation has decreased; and 87 % that droughts are more frequent. The econometric model shows the significance of education and access to meteorological information for climate change perception. The results reveal that younger, more educated producers and those who own their land tend to have a clearer perception of climate change than older, less educated, or tenant farmers. From a policy point of view, it is important to give all farmers information that will help them to adapt to climate change using appropriate farming technologies and practices. Projects and programs designed to enhance understanding of the consequences of climate change will help farmers to develop the management ability to cope with climate risk.

Keywords Climate change · Climate perception · Probit models · Agriculture · Chile

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Introduction

Recent scientific studies make it clear that global warming is a fact, distinguishable from natural climate variability, and that anthropogenic forces are contributing to this process (ECLAC 2009). Despite this growing scientific evidence, research shows that the general population cannot readily distinguish changes in seasonal weather patterns from climate change (Greene et al. 2011; Solomon et al. 2011). In contrast, other studies, based principally on descriptive analysis, reveal that farmers in different parts of the world do perceive their local climate as changing (Hageback et al. 2005; Deressa 2008; Bryan et al. 2009; Mertz et al. 2009; Osbahr et al. 2011; Sofoluwe et al. 2011; Chaudhary and Bawa 2011; Manandhar et al. 2011; Halder et al. 2012, and others). Moreover, farmers' perceptions tend to be affected by access to weather information (Hageback et al. 2005; Deressa 2008; Gbetibouo 2009). Therefore, in this study, we seek to test the hypothesis that access to weather information is relevant to the perception of climatic change and we provide quantitative estimates of the impact of such access while controlling for other relevant factors.

Much of the available research is qualitative in nature and has focused on various factors related to farmers' perceptions. However, quantitative research, which is scarce in the literature, is needed to enhance our understanding of the relative importance of these factors in increasing farmers' recognition of climate change. Parry (2001), and more recently Shisanya and Khayesi (2007), stress the importance of statistical models in the analysis of individuals' perceptions regarding climate change to help narrow the knowledge gap between policy makers and farmers.

Using data for a representative sample of Chilean producers, the objective of this paper is twofold: first, to compare the actual trends of key climatic variables in Central Chile over a period of 24 years with the perception of those trends by farmers; and second, to identify the factors that drive farmers' perceptions. To the best of our knowledge, this is one of the first attempts to quantify farmers' perception of climatic change in Latin America. Understanding how farmers get information and form opinions about climate change is a crucial step in formulating policies and designing programs to promote and facilitate the adoption of adaptation strategies in the near future.

The rest of the paper is organized as follows: Section 2 presents a background on climate change perception by farmers and variables that affect such perception; Section 3 gives an overview of the methodological framework, a description of the data used, and the empirical model; Section 4 presents the empirical results; Section 5 discusses the findings; and Section 6 summarizes and concludes.

Background

Perception of climate change

The evidence shows that over the past 25 years, temperatures have increased at a rate of 0.19 °C per decade, which corresponds with an important increase in global levels of carbon dioxide emissions from fossil fuels. Those emissions were 40 % higher in 2008 than in 1990 (Allison et al. 2009). In addition, a recent article published in *Science* shows that there has been an unprecedented warming in the planet over the past 1,500 years (Marcott et al. 2013). Changes in rainfall cycles, resulting in droughts in some areas and flooding in others, are impacting agricultural yields in Latin America, Asia, and Africa (Clements et al. 2011), and these changes are being perceived by affected populations around the globe.

Over the past 20 years, considerable efforts have been invested in exploring how the public understands climatic change in Europe and North America, but little is known about perceptions of climate change in developing countries (Vignola et al. 2013; Retamal et al. 2011). AGU (2013) contends that climate change is a widely recognized phenomenon and that its impacts vary across world regions. Nevertheless, a prevailing perception in many agricultural areas is that temperature is rising while precipitation is decreasing. Descriptive evidence supporting this perception for Asia is provided by Piya et al. (2013); Halder et al. (2012); Lata and Nunn (2012); Manandhar et al. (2011); Chaudhary and Bawa (2011); Hageback et al. (2005); and Vedwan and Rhoades (2001). In the case of Africa, support can be found in Silvestri et al. (2012); Clarke et al. (2012); Rao et al. (2011) Sofoluwe et al. (2011); Osbahr et al. (2011); Mertz et al. (2009); Bryan et al. (2009); Deressa (2008); and Gbetibouo (2009).

Studies focused on farmers' perception of climate change in Latin America are limited, but some descriptive work has been done. Browning-Aiken et al. (2007) indicate that most rural respondents in Mexico had experienced lower water supply due to drought in the past ten years. Sanchez-Cortes and Lazos (2011) find that Mexican peasant farmers report decreasing rainfall and increasing temperature, which has led to modification in corn planting dates and a shift to crops from warmer regions. VanderMolen (2011) finds that most of the members of agricultural communities in Cotacachi (Ecuador) perceived that temperatures are rising and affecting crops adversely. In Chile, González and Velasco (2008) studied the impacts of climate change on agricultural profits and report that in recent decades, 97 % of the farmers surveyed have perceived prolonged droughts, higher average temperatures, and alterations in the growing season.

Factors that explain climate change perception

Previous analyses (Lata and Nunn 2012; Barnes and Toma 2012; Hamilton and Keim 2009) have found that variables associated with socioeconomic status, production systems, and social capital can affect farmers' awareness of the climate change phenomenon. Individual farmers' characteristics (age, level of education and training, and experience in farming) can play an important role in the development of the perception of climate change. Hamilton and Keim (2009), and García de Jalón et al. (2013) found a negative relation between age and climate change awareness, while Hansen et al. (2004) reported a negative impact of age on the perception of the usefulness of weather forecast information for decision-making.

In contrast with age, years of experience shows a positive impact on the awareness of climate change, as reported by Silvestri et al. (2012) and Hansen et al. (2004). Moreover, Hansen et al. (2004) finds that Argentinean farmers who had been in farming longer and had been more exposed to extension programs were more likely to report information consistent with recorded climatic data.

While the evidence is not conclusive, it is expected that individuals with more education will have greater perception of climate change and a better understanding that adaptation is necessary. Akompab et al. (2013) claim that education is a significant predictor of adaptative behavior during heat waves among Australian populations. However, Hansen et al. (2004) note that educated farmers tend to make negative judgments about the usefulness of weather forecasts, and Hamilton and Keim (2009) did not find a significant correlation between education and climate change awareness.

Additionally, farm structure (e.g., farming system and size, land security and location) is also relevant in climate change perception. García de Jalón et al. (2013) found that farmers growing rice are less likely to participate in climate change adaptation programs, are less interested on environmental issues, and show less concern about climate change than farmers growing other crops. However, Silvestri et al. (2012) report inconclusive results regarding the association between farm income and perception.

Moelesti et al. (2012) claim that an early warning system for farmers utilizing a messaging scheme has the potential to add value to the farming methods employed and thus to improve food security. Lata and Nunn (2012) found a disparity in awareness and understanding of climate change among urban and rural communities due to differences in access to information, with the rural areas being in a disadvantaged position. Weber (1997) adds that it is not only access to information that is relevant, but also the number of sources of such information.

There is ample evidence indicating that in order to help farmers deal with climate change in a given region, agricultural advisors need to build on local weather knowledge (Mertz et al. 2012, 2009; Chaudhary et al. 2011; Sofoluwe et al. 2011; Bryan et al. 2009; Gbetibouo 2009; Hageback et al. 2005; Vedwan and Rhoades 2001; and others). It has been demonstrated that farmers' strategic decisions are influenced by many factors, including their financial status, their attitude toward risk, their understanding of local weather patterns, and the surrounding policy and institutional environment. Farmers' perceptions about climate are based primarily on their sense of the reliability or variability of weather patterns— especially rainfall, temperature, and drought—in their own regions, and this perception is an important determinant for adaptation (Piya et al. 2013; Osbahr et al. 2011; Patt and Schröter 2008).

There is a growing debate about how policy can be designed to overcome the barriers for effective adaptation (Weber 2006; Paeth and Otto 2009; Lata and Nunn 2012). Clarke et al. (2012) suggest that farmers are receptive to initiatives that enhance their understanding and knowledge of climate change, especially in their own environment, and this may promote adaptation efforts. According to Patt and Schröter (2008), climate risk management policies need to incorporate a great deal of participatory risk appraisal; therefore, people need to be educated as to how climate change may place them at greater and appropriate ways to respond.

Study area and methods

Chile encompasses a variety of ecological zones that are susceptible to erosion, deforestation, drought, and desertification (CONAMA 2006). Chilean historical temperature records show a downward trend over the ocean and on the coast, while in the central valley, the area under study, the trend has been upward, especially in the mountains (Falvey and Garreaud 2009). According to scientific projections, droughts will be more frequent in the country, and these, combined with an average temperature increase of about 2–4 °C over the mid-2000s, could displace the current climate zones southward in this century (AGRIMED 2008).

Family farm agriculture (FFA), the focus of this study, makes up a significant portion of the agricultural economy of Chile. It includes 280,000 small-scale farmers who cultivate 4,010,096 hectares, almost 25 % of the agricultural land in Chile. According to ODEPA (2011), FFA produces roughly 45 % of the annual crops, vegetables, grapes, and livestock, and 29 % of the major fruit crops (apples, avocados, and table grapes). In sum, FFA accounts for 25–30 % of the country's agricultural GDP.

FIA (2010a) claims that in Chile the sector most vulnerable to climate change is farmers who practice traditional agriculture and have low levels of human capital. The Maule Region is one of the most vulnerable areas, since it has the highest rural population in Chile (35.5 %) (UNDP 2008), and a high proportion of small-scale farms (16 %) (INE 2010).

The study area

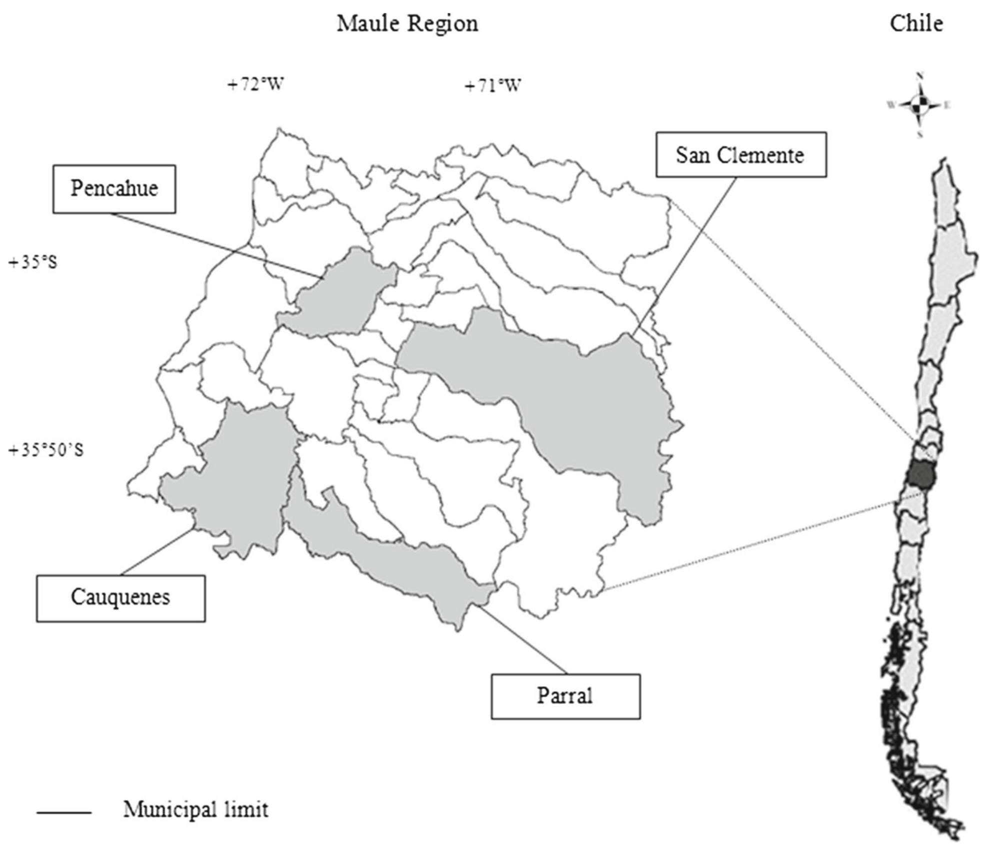
The study reported in this paper was conducted in the central region of Chile, a Mediterranean transition zone between the arid north and the rainy south. This region is a major contributor to the agricultural output of the country, and despite rapid technological progress in recent years, the prevalence of annual crops—fruits and vegetables—makes farming particularly vulnerable to climate change (FIA 2010a). IPCC models predict significant drying and warming effects in this area of Chile due to the ongoing increase in greenhouse gases (Falvey and Garreaud 2007; FIA 2010a). Christie et al. (2011) recently found evidence of an unprecedented increment in the incidence of severe and extreme drought events during the last century relative to the previous six centuries for central-south Chile.

The study area includes four municipalities—Pencahue, San Clemente, Cauquenes and Parral—located in the Maule region of Central Chile. This is a Mediterranean transition area (Fig. 1) and presents climatic and agroecological heterogeneity. Pencahue and Cauquenes are dryland areas, San Clemente is primarily composed of irrigated land near the Andes Mountains, and Parral is located in the central irrigated valley.

There are interesting differences among the four municipalities under study including annual precipitation as depicted in Fig. 1. For instance, Cauquenes shows the lowest level of rainfall and its agricultural systems, typical in dryland areas, are different from those in the other three municipalities. On the other hand, in terms of distance to markets and agricultural extension agencies, Pencahue and San Clemente pose certain advantages, given that both are closer to the regional capital. In addition, Parral's farming is concentrated in the central valley where conditions are favorable for rice production; thus, this is the only municipality out of the four analyzed where this crop is grown.

According to the last agricultural census, these four municipalities account for around 9,000 farms (INE 2010). San Clemente is the largest municipality, with a total of 226,826 hectares (ha) dedicated largely to the production of forage and cereals. Cauquenes and Parral have 128,017 and

Fig. 1 Distribution and general information of municipalities in the study area



Municipality	Zone	Precipitation (mm per year)	N° of farms	Surveys applied (*n*)
Pencahue	Irrigated dryland	709	1,129	40
Cauquenes	Non irrigated dryland	670	3,026	88
San Clemente	Irrigated Andean	920	2,990	90
Parral	Irrigated Central Valley	900	1,813	56
		Total	**8,958**	**274**

125,630 ha, respectively, with a significant area devoted to vineyards, cereals, and forage. Pencahue is the smallest municipality, with 65,118 ha dedicated mostly to vineyards, orchards, and cereals. The focus of the study is farms that produce annual crops, since these are grown in all four municipalities.

Data collection

Data were obtained through a survey of 274 farmers in the four municipalities between August and November 2011. Figure 1 shows the spatial distribution of the study area. Farmers were randomly selected from lists of water communities or lists provided by agricultural extension agencies. These farmers represent about 3 % of total producers in each of the four municipalities considered in the survey and all grow annual crops.

The survey was designed to measure farmers' perceptions of climate change. Farmers were asked if they had noticed any changes in average temperatures and precipitation since 1987 (the year Pope John Paul II visited Chile—a date with special significance for many in the country).[1] This timespan coincides with the availability of continuous climatic data throughout the study area. The answers to these questions were classified into three categories: (1) increase; (2) decrease; and (3) no change. Answers to the questions regarding the occurrence of drought were also classified into three categories: (1) more frequent; (2) less frequent; and (3) no change. At the end of this section of the survey, farmers were asked (yes or no) if they perceived the climate to be changing. Other sections of the survey asked questions regarding socioeconomic and demographic variables (age, education, and years of farming experience), production (farm income and land tenure), access and main source of weather information (mass media and Internet), and major climate change impacts perceived. These variables were used to construct the climate change perception model explained below.

In order to quantify the magnitude of the effects of climate change on atmospheric variables in each of the municipalities since 1987, we estimated the trends of mean temperature and accumulated precipitation between September and December for each of the last 24 years. These months were selected because they represent the growing season for annual crops in the area under study. We estimated the five-year moving average in order to smooth year-to-year variability. A linear regression against time was estimated for each moving average trend in order to establish the average increase or decrease over time. The estimated moving averages for the variables were transformed into natural logarithms to determine the rate of change for each variable.

The climate change perception model

Binary probit models have been used in agricultural and resource economic studies of farmers' perceptions and opinions on a wide range of topics (Sayadi and Calatrava-Requena 2008); agricultural multifunctionality (Vera-Toscano et al. 2007); and farmers' willingness to participate in associations (Thurow et al. 2001). Such models have also been used to explain differences related to socioeconomic characteristics between two groups of farmers, one considered sustainable and other considered conventional (Comer et al. 1999).

In this study, to evaluate the perception of climate change, a probit model was used in which the dependent variable took the value 1 if a farmer clearly perceived the climate to be changing and 0 otherwise. The probit model can be derived from an underlying latent variable model (Greene 2008; Bryan et al. 2009) such as:

$$y^* = \beta_0 + X\beta + \varepsilon, \quad (1)$$

where y^* is the latent variable, X denotes a set of explanatory variables, β are parameters to be estimated, and ε is the error term. Although the latent variable is unobservable, the analyst does observe the binary outcome y, which is equal to 1 if a farmer has a "clear perception" of climate change and 0 otherwise.

The β parameters do not have a direct interpretation; therefore, it is customary to calculate the marginal effects at the mean of each variable. The marginal effect for the jth continuous variable is given by (Maddala 1987; Greene 2008):

$$\frac{\partial P(y=1)}{\partial X_j} = \phi(\beta_x) + \beta_j \quad (2)$$

where ϕ is the cumulative normal density function. The marginal effect is interpreted as the percentage change in the probability of perceiving climate change, given a one-unit change in the continuous independent variable of interest, setting other variables at their mean values.

In the case of a binary variable, the marginal effects are calculated as:

$$\Delta P(y=1) = \phi(\beta_1) - \phi(\beta_0) \quad (3)$$

Thus, the marginal effect is calculated as the difference between the value with the dummy variable set at 1 and the dummy set at 0, holding all other variables at their mean values.

In this study, the concept of climate change integrates three variables: temperature, rainfall, and drought. The

[1] In our sample 94 % of the farmers are 36 years or older. Therefore, we expect that the Pope's visit is a useful event to set the timeframe.

rationale for this integration stems from the historical evidence that for the region under study, average temperatures have risen, average rainfall has declined, and droughts have become more prevalent in a consistent pattern (Falvey and Garreaud 2007, 2009; Andersen and Verner 2010; Christie et al. 2011). González and Velasco (2008) have shown the importance of climate variables, rainfall, and temperature for Chilean agricultural productivity.

In this study, a farmer is considered to have a "clear perception" that climate change is indeed an issue ($y = 1$) if all of the following four conditions hold:

1. The farmer declares the existence of climate change;
2. The farmer perceives an increase in the average temperature over the last 24 years;
3. The farmer perceives a reduction in the rainfall over the last 24 years; and
4. The farmer perceives an increase in the occurrence of droughts over the last 24 years.

It is important to note that this definition of the dependent variable allows for an unambiguous separation of farmers who have a clear perception of climate change from those who do not. If perception were defined solely by any one of the four criteria just listed, then the dependent variable would be highly concentrated with very limited variability and would not yield the required clear balance between 0 and 1 s (Greene 2008).

The climate change perception model used has the following general specification:

$$\begin{aligned} Perception = f(& Age, Education, ExpAg, Income, \\ & LandT, InfoMM, InfoInternet, Pencahue, \\ & Cauquenes, SanClemente, Parral) \end{aligned} \tag{4}$$

Table 1 presents a definition of all variables considered in the model, including socio-demographic and farm variables and their expected effects on climate change perception.

Results

Trends in climatic variables and perceptions

The trends for the climatic variables for the four municipalities are shown in Fig. 2. Rainfall has decreased in the four municipalities, though the decrease is statistically significant only in Parral. The trend for temperature is positive and significant in Pencahue and Parral, positive and nonsignificant for Cauquenes, and negative and nonsignificant in San Clemente. Figure 2 shows the trends as well as the cycles in the climatic variables. The high variability in temperature and rainfall is consistent with the ENSO cycle (El Niño/La Niña). An increase in rainfall

Table 1 Socio-demographic and farm variables considered in the climate change perception model

Variable in the model	Name	Description	Expected effect
Perception	Climate change perception	Dependent dummy variable = 1 if the farmer clearly perceives climate change and 0 otherwise	
Age	Age	Age of farmers in years	(−)
Educ	Education	Years of schooling	(+)
ExpAg	Experience in agriculture	Number of years dedicated to agriculture by the farmer	(+)
Income	Income from crops	Farm income in millions of Chilean pesos (2011) from crops for the previous year	(+)
LandT	Land tenure	Ownership dummy = 1 if the farmer owns land and 0 otherwise	(?)
InfoMM	Weather information from mass media	Dummy variable = 1 if the farmer has access to weather information from mass media (radio, TV and newspaper) and 0 otherwise	(+)
InfoInternet	Weather information from Internet	Dummy variable = 1 if the farmer has access to weather information from Internet and 0 otherwise	(+)
Pencahue	Location	Dummy variable = 1 if the farm is located in the municipality of Pencahue and 0 otherwise	?
Cauquenes	Location	Dummy variable = 1 if the farm is located in the municipality of Cauquenes and 0 otherwise	?
SanClemente	Location	Dummy variable = 1 if the farm is located in the municipality of San Clemente and 0 otherwise	?
Parral	Location	Dummy variable = 1 if the farm is located in the municipality of Parral and 0 otherwise (Omitted variable)	(−)

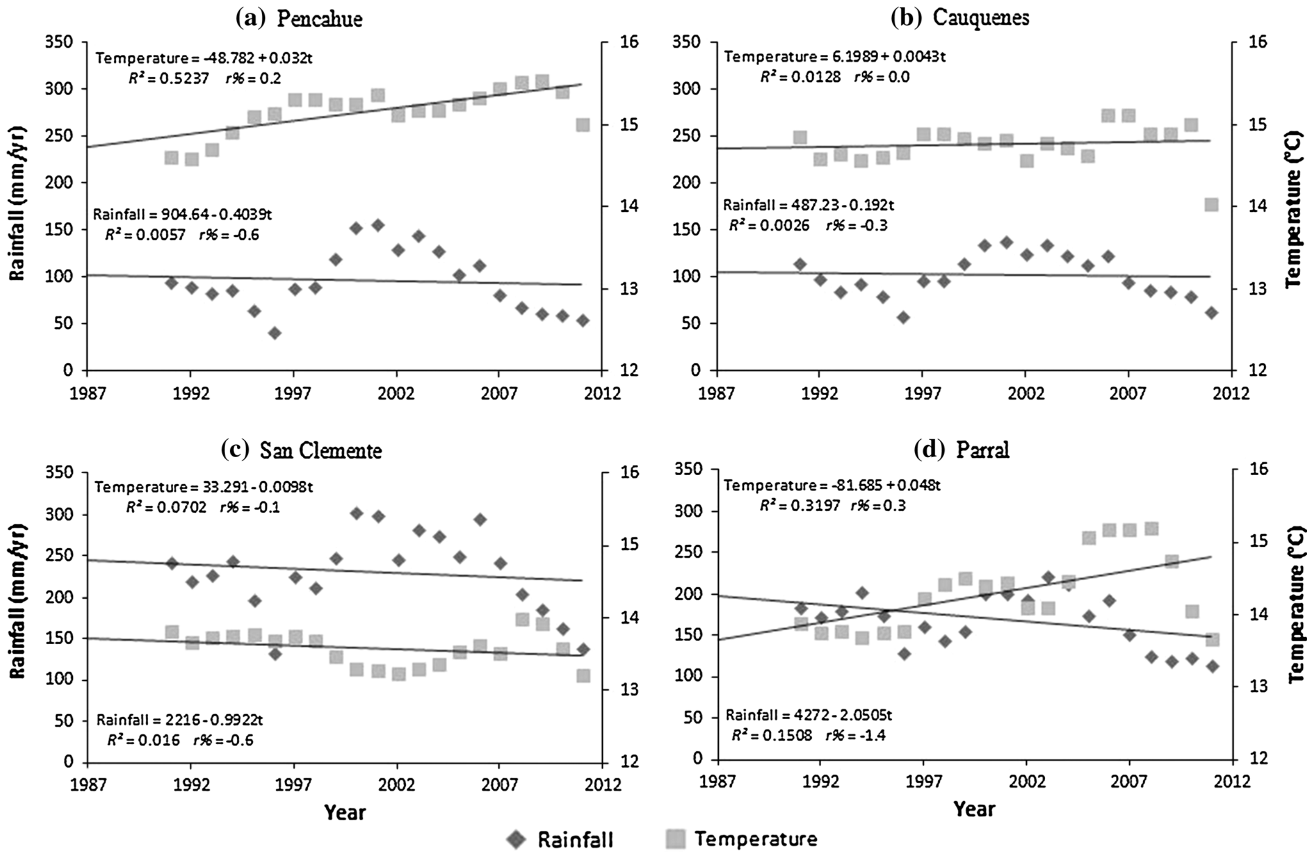


Fig. 2 Average temperature and rainfall between September and December, calculated as a 5-year moving average and shown as a linear trend line, R^2 and annual growth rate (r %), for the four selected municipalities

associated with El Niño can be clearly seen in 1997 and 2005, while the activity of La Niña in 1995 and 2008 brought a decrease in rainfall. The records for the last century show clearly that cyclical ENSO events have been accentuated by long-term changes in temperature and precipitation (USDA 2013; Hansen et al. 2012; NOAA-NCDC 2011). In addition, the data shown in Fig. 2 are consistent with González (2004), who reported colder-than-average temperatures from 1960 to 1976, and a reversal of this pattern from 1977 to 1999, when warmer-than-average temperatures prevailed in the Maule Region.

Most of the farmers surveyed in this study recognized the existence of climate change and perceived a reduction in rainfall over the last 24 years (Fig. 3a, b). Although 87.2 % of farmers perceived changes in temperature (increase or decrease), only 62 % perceived an increase (Fig. 3c). Note that in Parral, 55.4 % perceived a decrease in temperature, although this municipality exhibited the sharpest increase in temperature among the four under study. This perception could be related to the fact that temperature in Parral appears to be more volatile than in the other areas, and therefore perception could be less accurate. Farmers' perception of drought over the past 24 years is more uniform, with 87.6 % of the sample reporting an increase in the occurrence of droughts (Fig. 3d).

Figure 4 summarizes the primary perceived impacts that climate change has had in the study area, based on information obtained from farmers. The main impact identified is a reduction in water available for irrigation (50.8 %), followed by a decrease in crop yields (24.0 %), a higher incidence of agricultural pests (10.1 %), and an increase in the occurrence of frost and high temperatures (8.5 %).

Factors affecting the probability of perceiving climate change

The results of the survey reveal that 50.4 % of the sample clearly perceives climate change as an issue according to the classification criteria shown in Table 2. All the selected climatic variables are important in this classification but, as shown in the Table, average temperature is the most relevant. From the descriptive statistics, those who do not perceive a change in the climate (Table 3) tend to be older (57.7 years

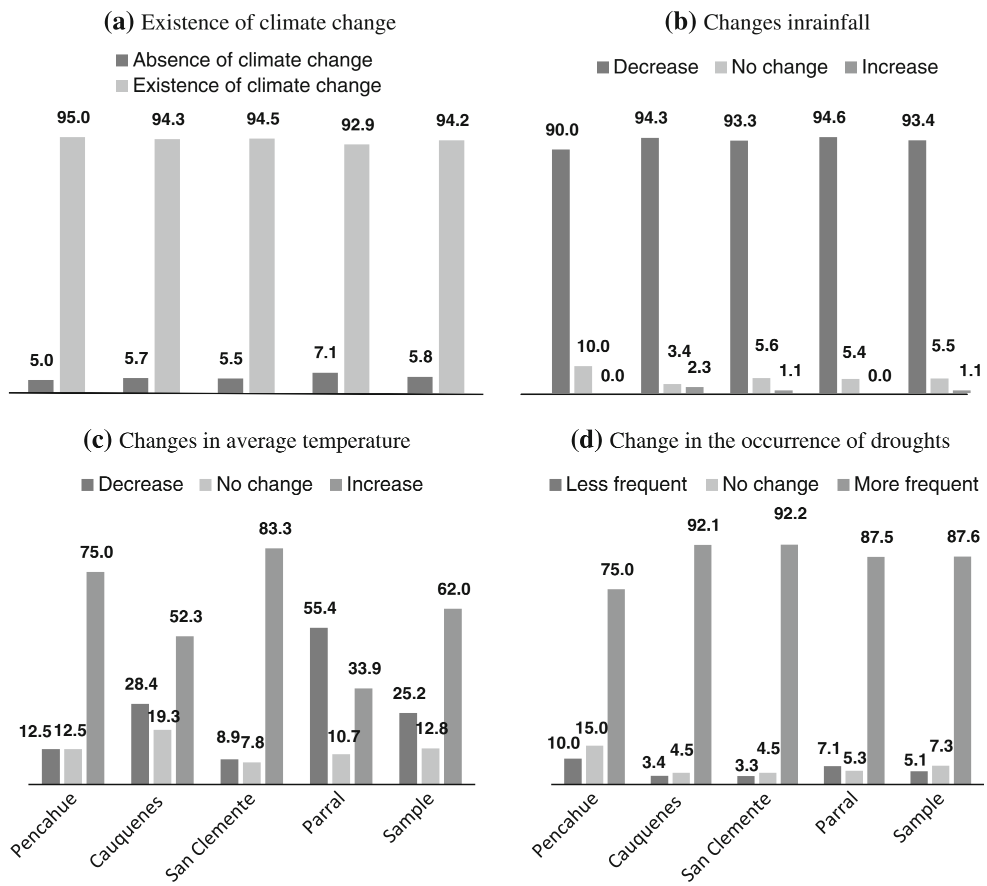


Fig. 3 Farmers' perception of meteorological change over the last 24 years in the four municipalities selected and in the complete sample (%, $n = 274$)

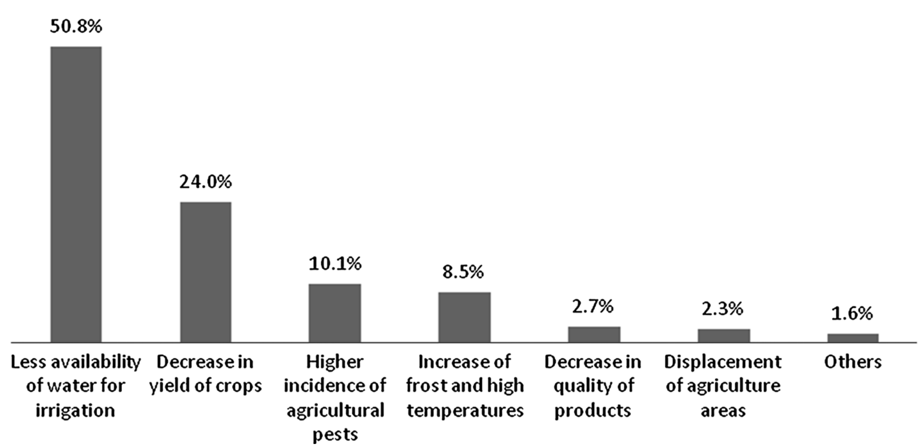


Fig. 4 Major climate change impacts identified by farmers ($n = 258$)

compared to 53.1), less educated, and more experienced in farming than those who do perceive climate change.

The econometric estimates of the probit model indicate that nine of the ten parameters estimated are statistically significant at least at the 10 % level, and the percentage of correctly predicted values is 67.5 (see Table 4). Overall, these econometric results confirm the initial characterization of Table 3.

Age shows a negative and significant relationship with perception, indicating that younger farmers are more likely to perceive climate change than older ones. The *ExperAg* variable shows a direction consistent with that found by Silvestri et al. (2012) although it is not significant in our model. On the other hand, *Education* has a positive impact on perception—the likelihood of a farmer perceiving climate change increases 1.8 % for each year of schooling completed. Among the 13 farmers who had no formal education, three had a clear perception of climate change, but 10 did not.

Table 2 Cumulative percent of farmers that agree with the four conditions defining "clear perception of climate change" ($n = 274$)

Municipality	Existence of climate change	Increase in average temperature	Decrease in rainfall	Increase in occurrence of droughts
Pencahue	95.0	70.0	62.5	50.0
Cauquenes	94.3	50.0	46.7	43.2
San Clemente	94.4	83.0	77.7	73.3
Parral	92.9	35.8	34.0	26.4
Total	94.2	60.6	56.2	50.4

Table 3 General characteristics of farm and farmers

Characteristics	Perceive climate change	
	Yes	No
Sample size	138	136
Farm location (municipality) (%)		
Pencahue	14.5	14.7
Cauquenes	27.5	36.8
San Clemente	47.8	18.3
Parral	10.1	30.1
Farm characteristics		
Mean farm size (hectares)	60.7	49.6
Mean annual income from crops (millions of CH$ 2011)[a]	42.0	20.1
Farmer characteristics		
Mean age (years)	53.1	57.7
Mean schooling (years)	8.0	6.4
Mean experience in agriculture (years)	34.9	38.8
Land owners (%)	50.7	57.3
Users of weather information from mass media (%)	67.4	68.8
Users of weather information form internet (%)	28.2	13.9

[a] One US Dollar is equal to 470 Chilean pesos approximately for the study period

In terms of *Location*, the model indicates that farmers from Parral are less likely to perceive changes in climate, despite the fact that this municipality has experienced sharper increases in temperature and decreases in rainfall than the other three municipalities. Farmers in San Clemente have a 46.1 % higher probability of perceiving climate change than farmers from Parral, and those from Cauquenes and Pencahue are also significantly more likely to perceive climate change than their counterparts from Parral.

The parameters for total crop income from the previous season and land tenure were positive and significant. Thus, producers with secure tenure and higher returns tend to have a clearer perception of climate change than tenant farmers with low incomes. An increase in income of one million Chilean pesos (US $2,000 approximately) improves the likelihood that a farmer will perceive climate change by 0.4 %, while farmers who own their own land are 12 % more likely to perceive climate change than those who do not.

Table 4 Estimates, marginal effects and predictions of the *Probit* regression model

Variable	Coefficient	Robust standard error[a]	Marginal effects
Age	−0.0162*	0.0096	−0.0064
Educ	0.0440*	0.0263	0.0175
ExpAg	0.0097	0.0078	0.0039
Income	0.0008*	0.0005	0.0004
LandT	0.3067*	0.1874	0.1219
InfoMM	0.7977***	0.3086	0.3071
InfoInternet	0.9487***	0.3609	0.3517
Pencahue	0.5294*	0.2837	0.2049
Cauquenes	0.5845**	0.2397	0.2285
SanClemente	1.2583***	0.2534	0.4606
Intercept	−1.3855**	0.5788	
Mc Fadden's R^2	0.1481		
Log pseudolikehood	−161.8		
N	274		

Classified by the model	Original data	
	Perceive climate change *n* (%)	
	Yes	No
Yes	90 (65.2)	41 (30.1)
No	48 (34.8)	95 (70.0)
Correctly classified (%)	67.5	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

[a] Robust standard errors estimated with STATA 11.1 (commands: probit, robust)

The parameters related to access to meteorological information were highly significant and positive in the model. Access to weather information through mass media (press, radio, and television) had a marginal effect of 30.7 %, while access to weather information from the Internet increased the likelihood of perceiving climate change by 35.2 %. Access to the Internet can mean access to social networks that can help accelerate the transfer of information. This point suggests that promoting Internet connectivity among farmers is a good strategy not only for accessing climatological data but also to improve overall farm management practices.

Discussion

Human perception of climate is complex and influenced strongly by elements such as expectations, which may have limited or no correlation with the true nature of climate as provided by data recorded with scientific instruments (Rebetez 1996). Perception can also be affected by the "recency effect", i.e., the recent occurrence of a rainy winter or a dry summer or daily temperature changes (see Hansen et al. 2004; Marx et al. 2007; Weber and Stern 2011; and Li et al. 2011). However, despite the fact that 24 years is a short period of time for analyzing climate trends, the responses provided by the farmers interviewed for this study are generally consistent with the pattern of decreasing rainfall and increasing temperature exhibited by the climatological data and the related literature (Andersen and Verner 2010; Falvey and Garreaud 2009; González and Velasco 2008).

While there are local differences in our study area, the overall perceptions coincide with the trends documented in many parts of the world suggesting that temperature is rising and precipitation is falling (see Tambo and Abdoulaye 2013; Silvestri et al. 2012; Barnes and Toma 2012; Mertz et al. 2012, 2009; Sofoluwe et al. 2011; Osbahr et al. 2011; Rao et al. 2011; Sanchez-Cortes and Lazos 2011; Chaudhary and Bawa 2011; Manandhar et al. 2011). The differences found in this study across the four municipalities can be explained by several factors. First, producers in Pencahue and San Clemente who are close to the regional capital may have more access to meteorological information—a factor shown by Lata and Nunn (2012) to be important in climate change perception—than farmers from more distant municipalities. Second, local agroecological conditions may also play a relevant role. Farmers in dryland Cauquenes have a clearer perception of climate change, perhaps because rainfall is always marginal in their environment, and becoming more so. Farmers in Parral, which has an irrigation infrastructure developed for rice production, may be less sensitive to reduced rainfall. These findings are convergent with the results of García de Jalón et al. (2013), who found that rice farmers are less likely to be concerned about climate change than other farmers. In terms of perceived impacts, our results are consistent with the climatic data analyzed. All the estimated regressions indicated that rainfall has decreased over the last 24 years.

Socioeconomic factors also prove to be relevant in how climate change is perceived. Our finding with regard to the age variable is consistent with findings by Hamilton and Keim (2009). As per the "recency effect" described by Hansen et al. (2004), Marx et al. (2007) and Weber and Stern (2011), recent extreme climate events were found to have a higher impact on the minds of younger than of older people. In terms of schooling, our finding contrasts with that of Hamilton and Keim (2009), who found that education was not significant. Hence, our results are compatible with the notion that more educated famers are in a better position to interpret the information they are exposed to. It is important to note that farmers with land tenure security also exhibit a sharper awareness of the presence of environmental problems.

The results of this study confirm the hypothesis that access to weather information is relevant in climate change perception. Worldwide, farmers tend to have a low use of Internet and a low rate of adoption of information technologies (e.g., Amponsah 1995; Gloy and Akridge 2000; Rolfe et al. 2003; Batte 2005; Taragola and Van Lierde 2011). According to Warren (2004), this situation is especially problematic among medium- and small-size farming units. Reports of Internet use in the Maule region reveal a great gap between urban and rural users. In 2006, 12.8 % of the urban population had access to the Internet, while only 1.3 % of the rural population did (FIA 2010b).

Traditional (visits, extension) and new (Internet) communication techniques, when adapted to local applications, may assist in the dissemination of useful information to farmers and decision makers (Salinger et al. 2005). Despite significant efforts to improve weather and climate predictions and to inform farmers about the use of such forecasts, attitudes toward the adoption of this information remain poor and, according to PytlikZillig et al. (2010), farmer use of forecasts has not increased in recent decades. In this respect, Lemos et al. (2012) claim that the application of forecasts in decision-making is not straightforward, and much work is required to narrow the gap between producers and users of this information. Understanding how farmers judge climate risk is valuable to both extension and meteorological services providing support to farmers in this time of climate change (Osbahr et al. 2011). Documentation of local knowledge and its use for decision-making could have a significant impact on managing the effects of climate change (Chaudhary et al. 2011). Local knowledge about climate change can play a critical role in developing appropriate responses, particularly in regions where data are meager and climate change is rapid.

The perception of climate change is a necessary prerequisite for adaptation (Hansen et al. 2004; Silvestri et al. 2012). It is reasonable to expect that as farmers recognize that the climate is indeed changing, they may become more willing to adopt farming practices to mitigate associated adverse effects (Chaudhary et al. 2011). In this process, improved access to information, education and cash income, as well as more secure land tenure arrangements are critical elements. Natural, social, human and financial capital variables affect the adoption of management practices in the Maule Region, as shown by Jara-Rojas et al. (2013) in their analysis of the adoption of water and soil conservation practices. Farmers' values and beliefs, which may influence their understanding of the environment, must also be taken into account (Otto-Banaszak et al. 2011).

In Chile, water shortages are being addressed by the CNR (*Comisión Nacional de Riego* or National Commission for Irrigation) and INDAP (*Instituto de Desarrollo Agropecuario* or National Agency for Agricultural Development). The CNR allocates annually around U$125 million for investments in irrigation infrastructure at the national level, principally targeted for larger commercial farms. INDAP is implementing an irrigation program for peasants with a budget of approximately U$22 million per year. The objective of those programs is to promote productivity growth and the competitiveness of farmers through the incorporation of improved irrigation technologies, bringing new areas under irrigation and with capacity building to enhance the management of water resources. Furthermore, the Action Plan for Agricultural Adaptation to Climate Change, recently proposed by the Chilean Ministry of Agriculture (2012), and our results suggest that CNR and INDAP's irrigation efforts should be reinforced in order to allow productivity growth and stability in a context of climate change and variability. Breeding programs to generate varieties suited for extreme weather conditions should also be supported and encouraged.

Concluding remarks

A quantitative approach was used to examine factors associated with the perception of climate change by farmers. An unambiguous dichotomous climate change perception variable was defined and a probit regression model was fitted using data from surveys applied to a random sample of farmers in four municipalities of Central Chile.

As expected, education and access to weather information have an important effect on the understanding of climatic change; thus, exposure to relevant information plays a key role in enhancing farmers' awareness of this emerging phenomenon. The analysis suggests that to promote the adoption of adaptation strategies, policy makers should focus on improving access to meteorological information, primarily among older, lower-income, and less-educated tenant farmers. It is important to expand and strengthen farmers' access to climatic information, to improve crop management practices and to reduce risk associated with climatic variability through exposure and training in the use of available technologies. Agricultural extension agencies can help to bridge the information gap between farmers and the mass media, especially through improved access to Internet sources. The recent Action Plan for Climate Change Adaptation of Agriculture (Chilean Ministry of Agriculture 2012) contemplates additional efforts to provide climatic information to farmers. However, this Plan needs to recognize existing barriers to the use and diffusion of information, especially among small-scale farmers.

Since Central Chile is located in a climatic transition zone, measures to cope with a changing climate need to be implemented aggressively to minimize losses in farm output and income. Enhanced perception is a necessary step that needs to precede the adoption of effective adaptation mechanisms; hence, policymakers need to consider these growing challenges carefully in order to design and execute an appropriate policy response.

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References

AGRIMED (2008) Impactos productivos en el sector silvoagropecuario de Chile frente a escenarios de cambio climático. Estudio U. de Chile, CONAMA, ODEPA, FIA, Chile

AGU (2013) Revised position statement of the American Geophysical Union. 5 Aug 2013. http://www.agu.org/news/press/pr_archives/2013/2013-38.shtml#.UgqQNGIJmXI

Akompab DA, Bi P, Williams S, Grant J, Walker IA, Augoustinos M (2013) Heat waves and climate change: applying the health belief model to identify predictors of risk perception and adaptive behaviours in Adelaide, Australia. Int J Environ Res Public Health 10(6):2164–2184

Allison, I, Bindoff N, Bindschadler R, Cox P, de Noblet-Ducoudré N, England M, Francis J, Gruber N, Haywood A, Karoly D, Kaser G, Le Quéré C, Lenton T, Mann M, McNeil B, Pitman A, Rahmstorf S, Rignot E, Schellnhuber HJ, Schneider S, Sherwood S, Somerville R, Steffen K, Steig E, Visbeck M, Weaver A (2009) The Copenhagen diagnosis, 2009: updating the world on the latest climate science. The University of New South Wales Climate Change Research Centre (CCRC), Sydney, Australia

Amponsah W (1995) Computer adoption and use of information services by North Carolina commercial farmers. J Agric Appl Econ 27(2):565–576

Andersen LE, Verner D (2010) Social impacts of climate change in Chile: a municipal level analysis of the effects of recent and future climate change on human development and inequality. Policy research working paper 5170. The World Bank. Sustainable Development Department

Barnes A, Toma L (2012) A typology of dairy farmer perceptions toward climate change. Clim Chang 112(2):507–522

Batte MT (2005) Changing computer use in agriculture: evidence from Ohio. Comput Electron Agric 47:1–13

Browning-Aiken A, Morehouse B, Davis A, Wilder M, Varady R, Goodrich D, Carter R, Moreno D, McGovern ED (2007) Climate, water management, and policy in the San Pedro Basin: results of a survey of Mexican stakeholders near the U.S.–Mexico border. Clim Chang 85:323–341

Bryan E, Deressa TT, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ Sci Policy 12(4):413–426

Chaudhary P, Bawa K (2011) Local perceptions of climate change validated by scientific evidence in the Himalayas. Biol Lett 7(5):767–770

Chaudhary P, Rai S, Wangdi S, Mao A, Rehman N, Chettri S, Bawa K (2011) Consistency of local perceptions of climate change in the Kangchenjunga Himalaya landscape. Curr Sci 101(4):504–513

Chilean Ministry of Agriculture (2012) Plan de adaptación al cambio climático del sector silvoagropecuario. Proposal Accessed February 2013, http://www.mma.gob.cl/1304/articles-52367_PlanAdpatacionCCS.pdf

Christie D, Boninsegna JA, Cleaveland MK, Lara A, Le Quesne C, Morales MS, Mudelsee M, Stahle DW, Villalba R (2011) Aridity changes in the Temperate-Mediterranean transition of the Andes since AD 1346 reconstructed from tree-rings. Clim Dyn 36:1505–1521

Clarke CL, Shackleton SE, Powell M (2012) Climate change perceptions, drought responses and views on carbon farming amongst commercial livestock and game farmers in the semiarid Great Fish River Valley, Eastern Cape province, South Africa. Afr J Range Forage Sci 29(1):13–23

Clements R, Haggar J, Quezada A, Torres J (2011) Technologies for climate change adaptation: agriculture sector. In: Zhu X (ed) UNEP Risø Centre, Roskilde

Comer S, Ekanem E, Muhammad S, Singh SP, Tegegne F (1999) Sustainable and conventional farmers: a comparison of socio-economic characteristics, attitude, and beliefs. J Sustain Agric 15(1):29–45

CONAMA (2006) Estrategia nacional de cambio climático. Comité Nacional Asesor sobre Cambio Global. National Commission for Environment of Chile, Chile

Deressa TT (2008) Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 798. International Food Policy Research Institute (IFPRI). Washington DC, USA

ECLAC (2009) La Economía del Cambio Climático en Chile. Synthesis. United Nations. Santiago, Chile

Falvey M, Garreaud R (2007) Wintertime precipitation episodes in central Chile: associated meteorological conditions and orographic influences. J Hydrometeor 8:171–193

Falvey M, Garreaud R (2009) Regional cooling in a warming world: recent temperature trends in the southeast Pacific and along the west coast of subtropical South America (1979–2006). J Geophys Res 114:D04102

FIA (2010a) El cambio climático en el sector silvoagropecuario de Chile. Fundación para la Innovación Agraria, Ministerio de Agricultura de Chile, Santiago

FIA (2010b) Modelos cooperativos para el acceso a Internet en sectores rurales: La experiencia de COOPESIC y sus aprendizajes

García de Jalón S, Iglesias A, Quiroga S, Bardají I (2013) Exploring public support for climate change adaptation policies in the Mediterranean region: a case study in Southern Spain. Environ Sci Policy 29:1–11

Gbetibouo GA (2009) Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa. IFPRI discussion paper 849

Gloy BA, Akridge JT (2000) Computer and Internet adoption on large U.S. farms. Int Food Agribus Manag Rev 3:323–338

González P (2004) Behaviour of the cold-hours, degree-days, frosts and precipitations in the Region del Maule's agroecosystems during the events El Niño 1997 y La Niña 1998–1999. In: Avaria S, Carrasco J, Rutllant J, Yañez E (eds) El Niño-La Niña 1997–2000: Sus efectos en Chile. CONA, Valparaíso, pp 231–252

González J, Velasco R (2008) Evaluation of the impact of climate change on the economic value of land in agricultural systems in Chile. Chil J Agric Res 68(1):56–68

Greene W (2008) Econometric analysis, 7th edn. Prentice Hall, Upper Saddle River

Greene AM, Goddard L, Cousin R (2011) Web tool deconstructs variability in twentieth-century climate. EOS Trans AGU 92(45):397–398

Hageback J, Sundberg J, Ostwald M, Chen D, Yun X, Knutsson P (2005) Climate variability and land-use change in Danangou Watershed, China: examples of small-scale farmers' adaptation. Clim Chang 72:189–212

Halder P, Sharma R, Alam A (2012) Local perceptions of and responses to climate change: experiences from the natural resource-dependent communities in India. Reg Environ Chang 12:665–673

Hamilton L, Keim B (2009) Regional variation in perceptions about climate change. Intl J Climatol 29:2348–2352

Hansen J, Marx S, Weber E (2004) The role of climate perceptions, expectations, and forecasts in farmer decision making: the argentine pampas and South Florida, IRI Technical Report 04-01

Hansen JE, Ruedy R, Sato M, Lo K (2012) NASA GISS surface temperature (GISTEMP) analysis, in Trends: a compendium of data on global change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge

INE (2010) Cifras Censo 2007. Cuadro 1 y cuadro 6: http://icet.odepa.cl/exp/ficha.php

Jara-Rojas R, Bravo-Ureta BE, Engler A, Díaz J (2013) An analysis of the joint adoption of water conservation and soil conservation in Central Chile. Land Use Policy 32:292–301

Lata S, Nunn P (2012) Misperceptions of climate-change risk as barriers to climate-change adaptation: a case study from the Rewa Delta, Fiji. Clim Chang 110:169–186

Lemos MC, Kirchhoff CJ, Ramprasad V (2012) Narrowing the climate information usability gap. Nat Clim Chang 2:789–794

Li Y, Johnson E, Zaval L (2011) Local warming: daily temperature change influences belief in global warming. Psych Sci 22(4):454–459

Maddala GS (1987) Limited-dependent and qualitative variables in econometrics. Econometric society monographs. Cambridge University Press, Cambridge

Manandhar S, Vogt DS, Perret SR, Kazama F (2011) Adapting cropping systems to climate change in Nepal: a cross-regional study of farmers' perception and practices. Reg Environ Chang 11(2):335–348

Marcott S, Shakun JD, Clark PU, Mix AC (2013) A reconstruction of regional and global temperature for the past 11,300 years. Science 339(6124):1198–1201

Marx SM, Weber EU, Orlove BS, Leiserowitz A, Krantz DH, Roncoli C, Phillips J (2007) Communication and mental processes: experiential and analytic processing of uncertain climate information. Glob Environ Chang 17(1):47–58

Mertz O, Mbow C, Reenberg A, Diouf A (2009) Farmers' perception of climate change and agricultural adaptation strategies in rural Sahel. J Environ Manag 43:804–816

Mertz O, D'haen S, Maiga A, Moussa IB, Barbier B, Diouf A, Diallo D, Da ED, Dabi D (2012) Climate variability and environmental stress in the Sudan-Sahel zone of west Africa. Ambio 41:380–392

Moelesti ME, Mellaart EAR, Mpandeli NS, Hamandanawa H (2012) The use of rainfall forecasts as a decision guide for small-scale farming in Limpopo Province, South Africa. J Agric Educ Ext 2012:1–13

NOAA-NCDC (2011) State of the climate: global analysis for annual 2011. NOAA National Climatic Data Center. http://www.ncdc.noaa.gov/sotc/global/2011/13

ODEPA (2011) Chilean agriculture overview. Agrarian Policies and Studies Bureau, Chilean Ministry of Agriculture, Chile

Osbahr H, Dorward P, Stern R, Cooper S (2011) Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmers' perceptions. Expl Agric 47(2):293–316

Otto-Banaszak I, Matzac P, Wessler J, Weschung F (2011) Different perceptions of adaptation to climate change: a mental model approach applied to the evidence from expert interviews. Reg Environ Chang 11:217–228

Paeth H, Otto C (2009) The population's view on climate change and mitigation: inferences for media and policy. Adv Sci Lett 2:310–318

Parry M (2001) Climate change: where should research priorities be? Glob Environ Chang 11:257–260

Patt AG, Schröter D (2008) Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies. Glob Environ Chang 18(3):458–467

Piya L, Maharjan K, Joshi N (2013) Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal. Reg Environ Chang 13(2):437–447

PytlikZillig L, Hu Q, Hubbard K, Lynne G, Bruning R (2010) Improving farmers' perception and use of climate predictions in farming decisions: a transition model. J Appl Meteor Climatol 49(6):1333–1340

Rao KPC, Ndegwa WG, Kizito K, Oyoo A (2011) Climate variability and change: farmer perceptions and understanding of intraseasonal variability in rainfall and associated risk in semiarid Kenya. Expl Agric 47(2):267–291

Rebetez M (1996) Public expectations as an element of human perception of climate change. Clim Chang 32:495–509

Retamal MR, Rojas J, Parra O (2011) Percepción al cambio climático y a la gestión del agua: aportes de las estrategias metodológicas cualitativas para su comprensión. Ambient Soc 14(1):175–194

Rolfe J, Gregor S, Menzies D (2003) Reasons why farmers in Australia adopt the internet. Electron Commer Res Appl 2:27–41

Salinger MJ, Sivakumar MVK, Motha R (2005) Reducing vulnerability of agriculture and forestry to climate variability and change: workshop summary and recommendations. Clim Chang 70(1–2):341–362

Sanchez-Cortes M, Lazos E (2011) Indigenous perception of changes in climate variability and its relationship with agriculture in a Zoque community of Chiapas, Mexico. Clim Chang 107(3–4):363–389

Sayadi S, Calatrava-Requena J (2008) Gender needs awareness and gender asymmetry: an analysis of a rural women survey in mountainous areas of south-eastern Spain. Span J Agric Res 6(3):453–468

Shisanya CA, Khayesi M (2007) How is climate change perceived in relation to other socioeconomic and environmental threats in Nairobi, Kenya? Clim Chang 85:271–284

Silvestri S, Bryan E, Ringler C, Herrero M, Okoba B (2012) Climate change perception and adaptation of agro-pastoral communities in Kenya. Reg Environ Chang 12:791–802

Sofoluwe N, Tijane A, Baruwa O (2011) Farmers' perception and adaptation to climate change in Osun State, Nigeria. Afr J Agric Res 6(20):4789–4794

Solomon A, Goddard L, Kumar A, Carton J, Deser C, Fukumori I, Greene A, Hegerl G, Kirtman B, Kushnir Y, Newman M, Smith D, Vimont D, Delworth T, Meehl G, Stockdale T (2011) Distinguishing the roles of natural and anthropogenically forced decadal climate variability: implications for prediction. Bull Am Meteor Soc 92:141–156

Tambo J, Abdoulaye T (2013) Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian Savanna. Reg Environ Chang 13(2):375–388

Taragola NM, Van Lierde DF (2011) Factors affecting the Internet behaviour of horticultural growers in Flanders, Belgium. Comput Electron Agric 70(2):369–379

Thurow AP, Conner JR, Thurow TL, Garriga MD (2001) A preliminary analysis of Texas ranchers' willingness to participate in a brush control cost-sharing program to improve off-site water yields. Ecol Econ 37:139–152

UNDP (2008) Desarrollo humano en Chile rural. Seis millones por nuevos caminos. Santiago de Chile. United Nations Development Programme. Santiago, Chile

USDA (2013) Climate change and agriculture in the United States: effects and adaptation. Agricultural Research Service. Technical Bulletin 1935. Washington, DC

VanderMolen K (2011) Percepciones de cambio climático y estrategias de adaptación en las comunidades agrícolas de Cotacachi. Ecuador Debate 82:145–158

Vedwan N, Rhoades R (2001) Climate change in the Western Himalayas of India: a study of local perception and response. Clim Res 19:109–117

Vera-Toscano E, Gomez-Limon JA, Estrada EM, Fernandez FG (2007) Individuals' opinion on agricultural multifunctionality. Span J Agric Res 5(3):271–284

Vignola R, Klinsky S, Tam J, McDaniels T (2013) Public perception, knowledge and policy support for mitigation and adaption to climate change in Costa Rica: comparisons with North American and European studies. Mitig Adapt Strateg Glob Chang 18(3):303–323

Warren MF (2004) Farmers online: drivers and impediments in adoption of Internet in UK agricultural businesses. J Small Bus Enterp Dev 11(3):371–381

Weber EU (1997) Perception and expectation of climate change: precondition for economic and technological adaptation. In: Bazerman M, Messick D, Tenbrunsel A, Wade-Benzoni K (eds) Environment, ethics, and behavior: the psychology of environmental valuation and degradation. New Lexington Press, San Francisco, pp 314–341

Weber EU (2006) Experience based and description based perceptions of long term risk: why global warming does not scare us (yet). Clim Chang 77:103–120

Weber EU, Stern PC (2011) Public understanding of climate change in the United States. Am Psychol 66(4):315–328