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Empirical Analysis of Farmers' Drought Risk Perception: Objective Factors, Personal Circumstances, and Social Influence

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Drought-induced water shortage and salinization are a global threat to agricultural production. With climate change, drought risk is expected to increase as drought events are assumed to occur more frequently and to become more severe. The agricultural sector's adaptive capacity largely depends on farmers' drought risk perceptions. Understanding the formation of farmers' drought risk perceptions is a prerequisite to designing effective and efficient public drought risk management strategies. Various strands of literature point at different factors shaping individual risk perceptions. Economic theory points at objective risk variables, whereas psychology and sociology identify subjective risk variables. This study investigates and compares the contribution of objective and subjective factors in explaining farmers' drought risk perception by means of survey data analysis. Data on risk perceptions, farm characteristics, and various other personality traits were collected from farmers located in the southwest Netherlands. From comparing the explanatory power of objective and subjective risk factors in separate models and a full model of risk perception, it can be concluded that farmers' risk perceptions are shaped by both rational and emotional factors. In a full risk perception model, being located in an area with external water supply, owning fields with salinization issues, cultivating drought-/salt-sensitive crops, farm revenue, drought risk experience, and perceived control are significant explanatory variables of farmers' drought risk perceptions.

KEY WORDS: Drought; farmers; risk perception

1. INTRODUCTION

Droughts are a global and urgent problem affecting societies, economies, and ecologies. Global environmental changes, and their links to and feedbacks with drought events and human activities, are major issues of concern.(1) Climate change projections, together with prospective population, economic, and corresponding water demand growths, indicate that the risk of drought is expected to increase in many parts of the world in the 21st century.(2) Freshwater is a key production factor for the agricultural sector as crop growth is sensitive to water quality and quantity. Water shortages cause a drop in crop production, reduce crop quality, and increase production costs,

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eventually resulting in a decline in farm income and anxiety over food security. These economic losses spread through forward and backward linkages within and between socioeconomic sectors, resulting in considerable economy-wide losses.

Adaptation is key to reducing the sector's drought vulnerability. Successful adaptation of the agricultural sector depends on there being competence to coordinate private and public adaptation initiatives. The synergy between public and private adaptation is a central topic in the economics of climate change.[3–6] In order to design effective public freshwater adaptation strategies, it is seen as crucial to understand farmers' adaptive decision making at the farm level and the consequences of their actions for the performance of the agricultural sector at large.

Effective and efficient adaptation in the context of natural hazards, such as droughts, is highly dependent on individual risk perceptions.[7,8] Recent studies on farmers' adaptive behavior regarding climate stress the significance of a positive causal relationship between climate risk perceptions and adaptive decision making.[9–12] Although studies connecting individual adaptation decisions to risk perceptions are quite comprehensive, they treat risk perception as an exogenous and static variable, thereby disregarding the factors that shape risk perceptions. However, viewing farmers' drought risk perceptions as endogenously formed is crucial as this empowers scholars and policymakers by providing a basis for understanding and anticipating dynamic responses to droughts and, consequently, for designing public risk management strategies.[13]

Several studies have investigated the determinants of farmers' risk perceptions with regard to climate change in general.[14–17] These studies focus on the perceptions of farmers in developing countries regarding climate change risks and highlight the significance of sociodemographic, economic, and biophysical factors. They measure farmers' risk perceptions as a climate change observation on a binary scale: either a respondent observes or does not observe climate change. However, observing changes in temperature and precipitation is more an expression of climate change awareness than of climate change risk perception. Risk perception goes beyond climate change risk awareness as it is associated with the probability of such an occurrence, negative outcomes, and feelings of dread related to climate change events.[18]

Considerable research has been devoted to specifically describing factors in farmers' drought risk perceptions. Most of these studies use open-ended questionnaires, interviews, and group discussions to characterize drought risk perceptions and to identify drought risk factors.[19,20] However, a few studies have quantitatively tested the causal relationships between drought risk factors and farmers' drought risk perceptions. Tang *et al.*[21] is the only available study that estimates the factors that contribute to farmers' perceptions of irrigation water scarcity risk. This study gives insight into the sociodemographic, economic, and psychosociological variables of farmers' water scarcity risk perceptions.

None of the above-mentioned studies testing the relationship between farmers' perceptions of climate change, or drought risk, and risk factors are based on a theoretical framework, conveying the impression that the choice of risk perception variables included is rather eclectic. Several theories on the formation of risk perceptions exist. However, few of the empirical investigations of farmers' risk perceptions employ them, resulting in empirical studies of risk perception that are rather disconnected from mainstream theories. This problem has also been identified in the field of flood risk perceptions research.[22]

The aim of this article is to assess which risk perception factors are potentially able to enhance the adaptive capacity of farmers against droughts. This study contributes to the existing risk perception literature in the context of climate change and agriculture in three ways. First, it enriches the very limited literature on factors that shape farmers' drought risk perceptions by including biophysical, sociodemographic, psychological, and social influence variables. Second, it contributes by measuring farmers' drought risk perceptions along three dimensions: perceived risk probability, perceived risk severity, and affective feelings. Third, whereas previous risk perception studies are of an exploratory nature, resulting in the inclusion of various risk perception factors, we build on theories and empirical evidence regarding each of those factors and formulate research hypotheses that we will then test statistically using empirical data from a survey. Specifically, we assess how various theoretical approaches explain risk perceptions. Four models will be investigated and compared: an objective model, a subjective model, a full model including both objective and subjective risk factors, and a full model with an interaction term.

2. DETERMINANTS OF FARMERS' RISK PERCEPTIONS

2.1 Objective Risk Factors

Expected utility theory assumes that agents have perfect information on the probabilities and potential damages related to risky events. Given the assumption of perfect information, agents then make decisions in a risky context that optimize their expected utility or profit. Economic models relying on this perfect information assumption regarding the formation of expectations, and on rationality with regard to adaptive behavior, are often employed to investigate drought-induced economic losses and adaptation by the agricultural sector.[23] This theory implies that, as farmers have perfect information on drought probabilities and damages, their drought risk perceptions are identical to the actual drought risk and can be fully predicted from objective drought risk factors alone. In this article, we define objective risk factors as those that determine an agent's actual drought risk. We distinguish between two types of objective risk factors: (1) the factors determining farmers' drought risk exposure and (2) the determinants of farmers' drought risk sensitivity. The general hypothesis is that the more vulnerable farmers are to droughts, the greater their drought risk perceptions.

2.1.1 Drought Risk Exposure

Drought exposure is the degree to which agricultural producers are subject to drought, and is partly determined by the biophysical characteristics of the area in which a farmer is located.[24] Farmers observe the biophysical properties within their environment, and thus their drought risk perceptions depend on these attributes.[25] Evidence on the relationship between biophysical features and risk perceptions originates from empirical risk perception studies of floods, hurricanes, and climate change. Specifically, flood risk studies show that the distance to a watercourse, the elevation, and the exposed financial value are significant explanatory variables of residents' flood risk perceptions. Similarly, hurricane risk studies show that being located in a specific wind zone explains hurricane risk perceptions.[26–29] Considering farmers and climate change risk, Gbetibouo[15] shows that farmers' perceptions of climate change and climate variability are dependent on soil fertility and access to irrigation water. Access to a water supply reduces farmers' drought exposure as drought damage is expected to be less in these areas than in areas without an external water supply. This leads to our first hypothesis:

H1: Farmers located in areas without a water supply generally perceive greater drought risks than those located in areas with access to a water supply.

A second issue in agricultural production is salinization. Drought-induced soil and groundwater salinities are unfavorable conditions for crop production since increased salt concentrations in the crop's root zones cause crop damage. This leads to our second hypothesis:

H2: The larger the percentage of fields with salt issues, the greater a farmer's perception of risk.

Access to freshwater supply and salinization are interrelated issues. In dry conditions, freshwater lenses disappear, causing salt–water percolation. One method to keep freshwater lenses intact, and so avoid saltwater reaching a crop's root zone, is flushing the water system with freshwater. However, access to freshwater is a prerequisite for applying this strategy. Consequently, we hypothesize that the effect of salinization on risk perception is moderated by access to water supply:

H3: Farmers with salt-related problems perceive lower risks when they have an access to a freshwater supply.

Drought risk exposure is not exclusively determined by the biophysical characteristics of an area, it also depends on the extent to which an agent is exposed. Botzen *et al.*,[26] for example, show that Dutch residents' flood risk perceptions depend on the financial value of their assets exposed to flooding. In the case of farmers, the financial exposure or potential drought damage depends on farm revenue,[17] leading to our fourth hypothesis:

H4: The greater a farm's revenue, the stronger a farmer's perception of a drought risk.

2.1.2 Sensitivity to Drought

Sensitivity is often referred to as the extent of the transformation of a system per unit of change in the disturbance, sometimes referred to as the dose-response relationship.[24] Research on flood risk perceptions has found that biophysical sensitivity is one aspect that shapes risk perceptions.

Kellens *et al.*,[30] for example, show that Belgian residents' flood risk perceptions depend on the characteristics of their homes as the potential damage is determined by whether the house contains a ground floor or cellar. Economic farm-level models, which are sometimes integrated with crop growth modules, show that a farmer's sensitivity to drought depends on the drought resistance and salt tolerance of his or her cultivated crops.[31–33] The literature shows that flowers and fruit are less drought and salt tolerant than arable crops and grass,[34,35] leading to a fifth hypothesis:

H5: Farmers cultivating fruit and/or flowers generally have higher risk perceptions.

2.2 Subjective Risk Factors

In contrast to economic theory, which assumes perfectly rational agents, empirical studies provide evidence of individuals showing biases and heterogeneity in their climate-related risk judgments. Research employing the psychometric paradigm has investigated social and psychological factors that might explain differences in the risk perceptions of individuals.[36] Such heterogeneity exists with farmers. Pat and Schröter,[37] for example, show that behavioral factors cause farmers' climate risk perceptions to deviate from expert estimates of risk. In this article, we view subjective risk factors as agents' personal elements and personality traits that explain why risk perceptions potentially deviate from the objective or actual risk. We distinguish between four types of subjective risk factors: (1) sociodemographic factors, (2) experiential factors, (3) psychological factors, and (4) social factors.

2.2.1 Sociodemographic Factors

Technology adoption models expose heterogeneity in risk perceptions due to sociodemographic differences. Risk perceptions vary across different sociodemographic groups. Consequently, studies often include sociodemographic characteristics as explanatory variables of risk perceptions of natural hazards. However, the direction of the relationships between both age and education and risk perception varies among studies and this possibly affects the other estimates. Some authors present significant positive contributions of these variables[17,26,30,38] whereas others report negative parameter estimates[21,27,28,39] or insignificant results.[14–16,22] Furthermore, there is no clear theory on the relationship between these factors and risk perception. Consequently, we do not formulate any hypotheses regarding relationships between these sociodemographic factors and risk perception, but include these as control variables.

2.2.2 Experiential Factors

Kahneman and Tversky[40] introduced the availability heuristic as a key mechanism in agents' risk judgments. According to the availability heuristic, people judge risks based on the ease with which examples and images of the risk come to mind. Experiencing a risky event feeds a person's feeling of worry or dread and consequently influences his or her risk perception.[18] Many risk perception studies include past risk experience to account for the availability heuristics and find positive relationships between both hazard experience and damage experience and risk perceptions.[21,22,26–28,38] This leads to our sixth hypothesis:

H6: The more often farmers have experienced financial damage due to drought events the greater their risk perception.

2.2.3 Psychological Factors

Early psychological work on risk perceptions showed that the perceived level of control is negatively related to individual risk perceptions.[36] The feeling of control refers to the extent to which people perceive a capacity to protect themselves against a specific risk.[41] In terms of the vulnerability literature, perceived control can also be referred to as perceived personal adaptive capacity, which is the farmers' perceptions of their own ability to adjust to drought, to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.[42] This leads to our next hypothesis:

H7: A feeling of personal control generally reduces farmers' perceptions of drought risk.

Alongside a personal feeling of control, trust in public risk management is a frequently investigated factor in risk perception studies.[43] Studies report a positive relationship, leading to our eighth hypothesis:

H8: The greater a farmer's trust in risk managers controlling the risk of drought, the lower a farmer's drought risk perception.

2.2.4 *Social Factors*

In the literature, social processes have also been identified as factors influencing individual risk perceptions.(44) The social amplification of risk framework states that individual risk perceptions are susceptible to social norms through interactions within social networks.(45) Individuals perceive risks in different ways due to differences in their reliance on affective feelings and past experiences.(18) Social networks serve as a medium to exchange perceptions and information on risks, leading to social amplification or attenuation of risk perceptions.(45) A person's receptiveness to this information depends on his or her desire to conform to social norms and on the person's sensitivity to social influence.

In the agricultural sector, informal peer networks are important channels for interactions. Informal communications among peers provide references to validate one's risk perception against the social norm.(45) Empirical research shows that social peer influence is a significant variable in farmers' risk perceptions and adaptive behavior.(21,46) Barnes *et al.*,(47) for example, show that the frequent use of social networks increases farmers' perceptions of climate change risks. Tang *et al.*(21) found a positive relationship between connectedness to a social network with knowledge on water scarcity and a farmer's risk perception. This is summarized in our final hypothesis:

H9: The more susceptible farmers are to social influence, the greater their perception of a risk.

3. METHODS

3.1 Study Area

The southwest of the Netherlands was selected as it is a vulnerable agricultural area due to the diversity of water supply systems and the occurrence of salinization, as shown in Fig. 1. Climate change scenarios suggest drought risks will increase in the future.(48,49) We further distinguish between areas with and without access to external water supply. Areas without an external water supply are dependent on the natural system for their water supply, whereas areas with an external water supply have access to freshwater from lakes, rivers, or pipelines, as reflected in Table I.

Agriculture in Walcheren and Noord-Beveland exclusively depends on the natural system, i.e., precipitation and fresh groundwater, for its water supply. Historically, the southwest of the Netherlands is a transition area from fresh to saltwater. Due to saltwater percolation, both groundwater and surface water resources contain high chloride concentrations across a large share of these areas, making it unsuitable for irrigation. In a normal year, excessive precipitation infiltrates, forming thin freshwater lenses in the crops' root zone that float on deeper salt groundwater. The desired functioning of the natural system is contingent on precipitation and evaporation. Under dry circumstances, freshwater lenses evaporate, causing crop damage due to excessive dry and salt conditions.

Since 1970, large compartment dams have been constructed to protect the southwest of the Netherlands from flooding and to create large freshwater lakes. Goeree-Overflakkee and Tholen have gained access to freshwater supplies since that time. Nowadays, water boards use freshwater from these basins primarily to flush the water system to reduce salt concentrations in ground and surface water resources. Water availability from the lakes depends on discharges from the water sources that feed these basins. During droughts, discharges fall, reducing the external water available for flushing, irrigation, and supplying water to other sectors such as for drinking water and industry. In extreme dry situations, water boards could intervene by prohibiting irrigation. Zeeuws-Vlaanderen has historical access to freshwater from the regional water system in Belgium. On-farm piped water supplies are only available in Zuid-Beveland. In typical years, with sufficient precipitation, there are no bottlenecks in this water supply system. In dry years, however, the pipeline capacity is insufficient.

3.2 Data Collection

To elicit farmers' perceptions of drought risks, a survey was conducted among a population of 1,474 members of the Dutch agricultural organization (LTO) during January and February 2013. TNS-NIPO, a professional organization in the Netherlands specializing in data collection using questionnaires, supported the survey design, web application, communication with respondents, and database management. The survey was pretested in 12 face-to-face

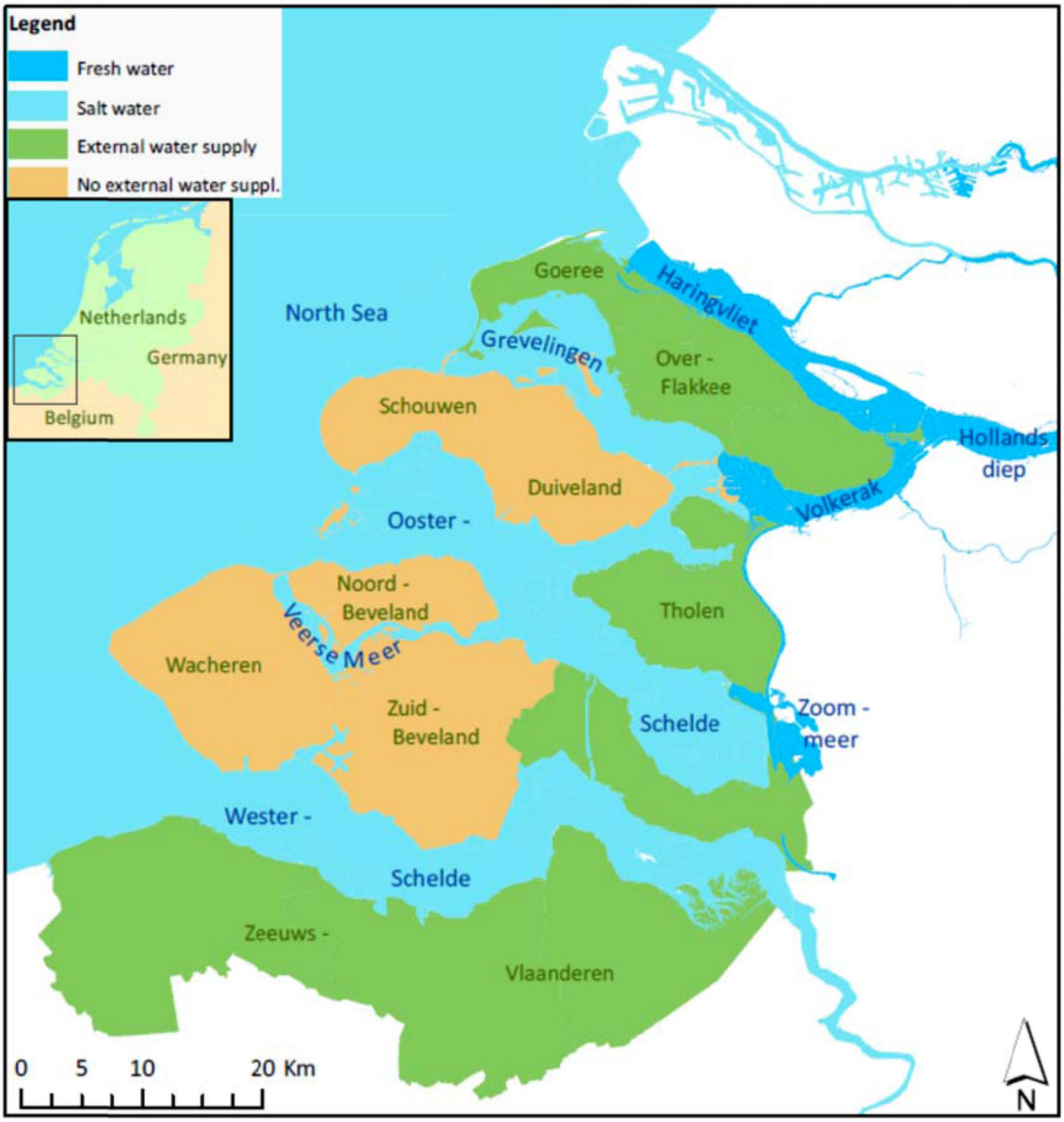

Fig. 1. Location of study area.

interviews and in consultation with the water board responsible for the area "Scheldestromen" and LTO. Based on the feedback from these pilot studies, redundant questions were removed and indistinct questions were reformulated.

Farmers in the Goeree-Overflakkee area received an explanatory letter and a paper version of the questionnaire with the request to participate, either by returning the paper questionnaire by mail or by participating in an online survey. Two reminders were sent out in this area. In the other areas, farmers only received an email with the request to participate in the online survey and received one reminder. To stimulate responses, people had a chance of winning a prize in a lottery.

The 1,474 survey requests elicited 142 replies (9%).

Table II presents the response rate for each area for both respondents approached by Internet and by mail. The response in Goeree-Overflakkee is higher than in the other areas, probably because respondents had the choice to fill out the

Table I. Freshwater Supply in the Southwest Netherlands

System	Source of Water Supply	Geographical Location
No external water supply	Natural system (i.e., precipitation)	Walcheren, Noord-Beveland, part of Zuid-Beveland
With external water supply	Natural system + water supply from lakes and rivers	Goeree-Overflakkee, Tholen, Zeeuws-Vlaanderen
	Natural system + water supply pipeline	Part of Zuid-Beveland

Table II. Response in Each Area

	Number	%
Goeree-Overflakkee[a]	54	38
Schouwen-Duiveland	16	11
Walcheren	9	6
Tholen	12	9
Noord-Beveland	4	3
Zuid-Beveland	16	11
Zeeuws-Vlaanderen	31	22

[a]Only respondents from Goeree-Overflakkee had the option to complete a paper version.

questionnaire online or on paper, and received an additional reminder than respondents in the other areas. The content and phrasing of the paper questionnaire was identical to the online survey, and therefore we would not expect any bias due to the different data-collection methods. Indeed, an independent sample *t*-test reveals no significant difference in risk perception (RPS) between farmers on Goeree-Overflakkee who responded through the two different data-collection methods ($t_{(52)} = -1.16, p > 0.05$).

To judge the representativeness of the sample, two indicators have been selected and compared with statistical data from CBS Statistics Netherlands. The first indicator is the representation of farmers located in areas with and without external water supply. In our sample, 71% of the farmers are located in areas with an external water supply compared to 68% in the actual population. The second indicator is the representation of farm types. Here, farmers who cultivate grass and corn, most likely livestock farmers, are underrepresented. In the sample, only 12% of the farmers cultivate grass or corn compared to 26% in the actual population. This is reflected in an overrepresentation of arable farmers (81% compared to 70%) and those cultivating fruit and flowers (7% compared to 4%).

3.3 Measurement

The survey contained eight questions that were designed to reveal farmers' drought risk perceptions. Respondents were asked to give a quantitative estimate of the return period and damage under two drought scenarios: (1) a dry year and (2) an extreme dry year (Table III).

The formulation of the perceived probability questions followed the approach of Botzen *et al.*,[26] who claim that respondents find it easier to estimate return periods than likelihoods. Definitions of a dry year and an extreme dry year were based on the description of characteristic drought years by Klijn *et al.*[50] They define characteristic drought years based on the precipitation deficit during the growing season (April to end of September) and on their return period. A "dry year" has a cumulative precipitation deficit of 220 mm, which occurs approximately once every 10 years; an "extreme dry year" has a cumulative precipitation deficit of 360 mm, which occurs approximately once every 100 years.

Given that respondents often find it difficult to give accurate estimations of probabilities, four additional scale items were included to assess farmers' drought risk perceptions.[26] All items were measured on a seven-point scale, including a neutral risk option. Questions 1 and 2 concerned perceived likelihood and damage, and were based on previous risk perception studies.[26,30,51,52]

The possibility of developing a single measure for risk perception, based on the survey items, was explored using reliability analysis and principal component analysis (PCA). The analysis included eight risk perception items. The calculated Cronbach's α for risk perception was 0.80, indicating a good internal consistency. Table III shows the factor loadings, with all variables loading strongly and uniquely onto one component. This component explains 46% of the total variance. Factor scores were subsequently assigned to all respondents. These factor scores represent the risk perception score (RPS) and follow a normal distribution $N(0,1)$ ranging from -2.11 to 4.10.

The exogenous variables were measured as follows. First, since access to an external water supply is a natural dichotomy, it was coded as a dummy variable (external water supply = 1). To elicit current

Table III. Results of a Principal Component Analysis on Risk Perception Items

Items		Factor Loadings
1.	How often (once in how many years) do you expect your farm to be exposed to an extreme dry year?	0.52
2.	In an extreme dry year how much financial damage do you expect for your farm?	0.49
3.	How often (once in how many years) do you expect your farm to be exposed to a dry year?	0.61
4.	In a dry year, how much financial damage do you expect for your farm?	0.59
5.	How likely is it that your farm will face financial damage caused by drought-induced water shortage and/or salinization?	0.72
6	If water shortage and/or salinization occur as a result of drought, how serious is the financial damage for your farm?	0.80
7	I am worried about the risk of drought	0.82
8	I dread the effects of droughts	0.71

Note: Eigenvalue 3.58, explained variance 45%.

Table IV. Descriptive Statistics ($N = 141$)

Variables	Definition	Min.	Max.	Mean	*SD*
RPS	Risk perception score	−2.11	4.10	0	1
Water supply	Presence of external water supply (1 = yes)	0	1	0.47	
Salinization	% of total area suffering from salinization	0	100	17.51	29.6
Fruit and flowers	Presence of fruits of flower in the cropping pattern (1 = yes)	0	1	0.18	0.38
Farm revenue	Farm revenue in 1,000,000 Euro	0.01	1.5	0.42	0.39
Age	Age in years	19	71	50	9.79
Education	Education level (five categories)	1	5	3.16	0.87
Drought experience	Sum of drought damage years since 2000	0	13	2.23	3.02
Perceived control	Average of five items on seven-point scales	0	5.40	2.69	1.27
Trust in water board	Average of seven items on seven-point scales	0	5.25	2.64	1.20
Social influence	Average of four items on seven-point scales	0	5.25	2.42	1.20

salinization, respondents were asked to indicate the percentage of their land suffering from salinization. As such, salinization was measured as a continuous variable as a percentage of the total land surface. To distinguish drought-sensitive farm types, a dummy variable was constructed (cultivating fruit and flowers = 1). Farm revenue is represented as a categorical variable with 16 categories[6] and, because class sizes differ, the median of a class was taken as a measure of farm revenue.

Social-demographic characteristics were measured as follows. Age was measured on a continuous scale in years. Education was a categorical variable with five categories. To reveal personal experience of drought damage, respondents were asked in which years they had experienced financial damage due to drought since 2000. Based on this question, personal drought risk experience was measured as the number of years in which farmers indicated they had experienced drought damage. Table IV summarizes these descriptive statistics.

The psychological factors were measured as follows. First, the measurement of perceived control included items on self-efficacy and controllability.[53] Five items on self-efficacy and perceived control were adapted from Martin[52] and measured on a seven-point scale (Table V). The Cronbach's α of the perceived control scale was 0.83, indicating a good internal consistency. A PCA revealed one component with an eigenvalue of 3.12 that explained 62% of the total variance. Therefore, we defined a single construct for perceived control as the average of the underlying items.

Trust in water managers was measured using eight items adapted from Poortinga and Pidgeon[54] and measured on a seven-point scale (Table VI). The Cronbach's α for trust in government was 0.91, indicating a good internal consistency. The PCA found one component with an eigenvalue of 5.12 that

[6]Farm revenue categories: 1 = <€25,000, 2 = €25,000–€50,000, 3 = €50,000–€100,000, 4 = €100,000–€150,000, 5 = €150,000–€200,000, 6 = €200,000–€250,000, 7 = €250,000–€300,000, 8 = €300,000–€350,000, 9 = €350,000–€400,000, 10 = €400,000–€450,000, 11 = €450,000–€500,000, 12 = €500,000–€750,000, 13 = €750,000–€1,000,000, 14 = €1,000,000–€1,250,000, 15 = €1,250,000–€1,500,000, 16 = >€1,500,000.

Table V. Results of Principal Component Analysis of Perceived Control Variables

Items		Factor Loadings
To what extent are you able:		
1.	To protect yourself against the consequences of droughts	0.53
2.	To act correctly when a drought occurs	0.87
3.	To take the appropriate measures against droughts	0.88
Considering the probability of being confronted with drought-induced water shortage and/or salinization, to what extent do you agree with the following statements:		
4.	I have control of drought risks	0.88
5.	For people like me it is easy to protect their farm against the effects of drought-induced water shortages and salinization	0.72

Note: Eigenvalue 3.11, explained variance 62%.

Table VI. Results of Principal Component Analysis of Trust in the Water Board Variables

Items		Factor Loadings
Below you will find several statements about the role of the water boards with respect to droughts; to what extent do you agree with the following statements:		
1.	The water board is worried about the risk of droughts for farmers	0.74
2.	The water board has the same opinion on droughts as I have	0.72
3.	Considering droughts, the water board acts in the interest of farmers	0.76
4.	The water board is capable of managing droughts	0.81
5.	The water board cares about the opinions of farmers regarding droughts	0.76
6.	I trust the water board to protect me against droughts	0.64
7.	Freshwater policy is safe with the water board	0.71

Note: Eigenvalue 5.12, explained variance 73%.

Table VII. Results of Principal Component Analysis on Social Influence Variables

Items		Factor Loadings
Below you will find several statements about the role of the water boards with respect to droughts; to what extent do you agree with the following statements:		
1.	I only take important decisions when I am sure peer members would recommend them	0.63
2.	It is very important that colleagues are positive about important farm decisions	0.71
3.	I look at others to be sure I am making the right decisions	0.52
4.	When I am insecure about decisions, I seek the opinions of colleagues	0.48

Note: Eigenvalue 2.34, explained variance 58%.

explained 73% of the total variance. Therefore, a single construct for trust in government was defined as the average of the underlying items.

The extent of a farmer's susceptibility to social influence was measured using an extension of the existing scale by Bearden *et al.*[55] to identify opinion leaders. The questions were rephrased (Table VII), as social influence on farmers' drought adaptation is different from consumer behavior. The Cronbach's α of the social influence scale is 0.83, indicating that this is a reliable scale. The PCA showed one component with an eigenvalue of 2.34 that explained 58% of the total variance. Based on these results, we defined a single construct for social influence as the average of the underlying items.

4. RESULTS

First, a correlation analysis was conducted to check for multicollinearity among the independent variables. As shown in Table VIII, the highest correlation is 0.30, which is a strong indication that multicollinearity is not a concern. Second, we controlled for the possibility that our data might have a hierarchical structure. Therefore, we tested for a relationship between risk perception and

Table VIII. Correlations Between Dependent and Independent Variables

	Risk Perception Score (RPS)	External Water Supply	Salinization	Flowers and Fruit	Farm Revenue	Age	Education	Personal Damage Experience	Perceived Control	Trust in Water Board	Social Influence
RPS	–	0.29***	0.35***	0.27***	0.37***	−0.18**	-0.03	0.44***	−0.12*	-0.02	−0.06*
Water supply		–	0.14	−0.10	0.30***	0.01	−0.09	0.08	0.21**	0.30***	−0.02
Salinization			–	0.07	−0.05	0.06	−0.06	0.26***	−0.06	−0.08	−0.03
Fruit and flowers				–	0.17**	−0.17**	−0.08	0.12*	0.07	0.01	−0.04
Farm revenue					–	−0.30***	0.15**	0.20**	0.21**	0.12*	−0.17**
Age						–	−0.30***	−0.08	−0.23***	−0.05	−0.01
Education							–	0.07	0.08	0.04	0.09
Drought experience								–	−0.02	−0.11*	−0.14*
Perceived control									–	0.15**	0.12*
Trust in water board										–	0.18**
Social influence											–

Note: All correlations are Pearson correlations, * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

geographical location as farmers from the same area are likely to interact with one another. However, results from a random intercepts model show that the intercepts for risk perception do not vary significantly among areas and, therefore, we felt justified in continuing the analysis using multivariate regression.

To test the nine research hypotheses, a control model is first estimated including the control variables. Then, an objective (Model 1) and a subjective (Model 2) risk perception model are estimated including the control variables and the objective and subjective risk perceptions respectively. Model 3 combines the control variables with both the objective and the subjective risk factors in a full model. Finally, a full model with an interaction effect is estimated to test H3. Here, the interaction between access to an external water supply and the level of salinization is assessed by including the product of these variables as an additional independent variable in the full risk perception model.

Table IX shows the results of the ordinary least squares (OLS) estimations. Unstandardized coefficient values, standardized coefficient values, and standard errors are presented for all models. The significance of the hypothesized variables is estimated using a one-sided test, while the significance of the age and education control variables are estimated using a two-sided test. Furthermore, the adjusted R^2 is presented as an indicator of the models' goodness of-fit, and the R^2 change is presented as an indication of whether models significantly differed from each other with respect to the percentage of variance accounted for. Finally, the lowest and the highest values of the standardized residuals, as well as the highest Cook's distance, are presented to verify whether the distributions of the residuals meet the normality assumption and to check for influential outliers.

Model 1 estimated the effects of objective risk variables on risk perception. The goodness fit of the model is fair. According to the adjusted R^2 value, the model explains 30% of the variation in risk perception and makes a significant contribution to the control model (ΔR^2 model $1 = 0.29, p = 0.00$). The minimum value of the standardized residuals is -2.16 and the maximum is 3.50. The relatively high maximum value could indicate the presence of outliers. A visual inspection of the frequency table of the standardized residuals and the boxplot of the RPSs revealed one outlier. However, this outlier is not an influential case as the highest value of Cook's distance is 0.18. The fact that the control model and Model 1 seem to be slightly affected by an outlier is not surprising given

Table IX. Regression Results of Four Risk Perception Models ($N = 141$)

Variables	Model 0: Control			Model 1: Objective			Model 2: Subjective			Model 3: Full		
	B	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*SE*	*B*	*SE*	*β*
Intercept[a]	1.37**	0.62		−0.74	0.58		1.38**	0.63		0.43	0.57	
Age[b]	−0.02**	0.01	−0.21**	−0.10	0.01	−0.10	−0.02***	0.01	−0.22***	−0.01*	0.01	−0.13*
Education[b]	−0.10	0.10	−0.09	−0.05	0.09	−0.05	−0.13	0.09	−0.11	−0.07	0.08	−0.06
Water supply[a,c]				0.37***	0.15	0.18***				0.49***	0.15	0.24***
Salinization[a]				0.01***	0.00	0.30***				0.01***	0.00	0.20***
Fruit and flowers[a,c]				0.53***	0.20	0.20***				0.52***	0.18	0.20***
Farm revenue[a]				0.70***	0.00	0.28***				0.66***	0.00	0.26***
Drought experience[a]							0.15***	0.03	0.43***	0.10***	0.02	0.29***
Perceived control[a]							−0.13**	0.06	−0.16**	−0.19***	0.05	−0.25***
Trust in water board[a]							−0.07	0.07	0.03	0.04	0.06	0.05
Social influence[a]							0.00	0.06	0.06	0.06	0.06	0.08
Adjusted R^2	0.03			0.30			0.22			0.42		
Δ R^2 compared to Model 0				0.29***			0.21***					
Δ R^2 compared to Model 1										0.13***		
Δ R^2 compared to Model 2										0.21***		

*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
[a]Significance based on two-tailed test.
[b]Significance based on one-tailed test.
[c]0 = No, 1 = Yes, *B*s are unstandardized betas, *SE*s are standard errors, *β*s are standardized betas.

that they are partial risk perception models. These model results are presented to demonstrate the robustness of objective and subjective parameter estimates when these variables are combined in a full risk perception model.

Model 2 estimates the effects of subjective risk variables on risk perception. The subjective risk model explains 22% of the variation in risk perception, indicating a reasonable model performance. A considerable improvement in the percentage of variance in risk perception explained was found after the subjective risk variables were added to the control model (ΔR^2 Model 2 = 0.21, p = 0.00). The range of the standardized residuals (min. = −2.00, max = 2.96) as well as the maximum Cook's distance (0.14) are a strong indication that influential outliers are not present. Model 3 included both objective and subjective risk factors in a full model of risk perception. The full model explains 42% of the variation in farmers' drought risk perceptions. Compared to both Model 1 and Model 2, this is an improvement in the variation in risk perception explained (ΔR^2 [Model 3 − Model 1] = 0.13, p = 0.00; ΔR^2 [Model 3 − Model 2] = 0.22, p = 0.00). The range of the standardized residuals (min. = −2.63, max = 2.60) and the maximum Cook's distance (0.16) suggest an absence of influential outliers.

In both the control model and Model 2, the age variable showed a significant negative relationship with farmers' drought risk perceptions. However, in Models 1 and 3, this variable did not offer any explanatory power. Our analysis failed to find a relationship between farmers' education and their drought risk perceptions. Based on the results of Model 3, the first hypothesis on the positive relationship between the absence of an external water supply and risk perception is rejected. In line with H2, we found a significant positive relationship between the percentage of land with salinization issues and a farmer's drought risk perception. We tested for the moderating effect of access to a water supply on the relationship between the occurrence of salinization and risk perception, H3. A small and insignificant improvement in the goodness fit was found after adding the interaction effect to the full model (ΔR^2 = 0.01 [Model 4 − Model 3], p = 0.06). Adding the interaction effect does not result in a significantly better model; therefore, H3 is rejected. The significant positive *B* value for cultivating fruit and flowers supports the fourth hypothesis. Farmers who cultivate drought- and/or salt-sensitive crops have a significantly higher risk perception than farmers who do not grow such crops. Furthermore, we found a significant positive effect of farm revenue on risk perception, supporting H5. Comparing the objective risk factors from Model 3 with Model 1 indicates that these variables are not affected by subjective factors in the full model.

H6 is confirmed in the full model. The greater the previous experience of drought damage, the higher farmers' risk perceptions. Comparing the subjective model with the full model shows that the effect of personal experience decreases when controlling for objective risk variables in the full model. The significant negative *B* value for perceived control confirms the seventh hypothesis. Farmers who perceive drought to be within their scope of control and who have confidence in their skills and expertise to act against drought perceive lower drought risks. However, H8 can be rejected: there is no causal relationship between trust in water managers and a farmer's perception of risk. Also, the ninth hypothesis on the positive relationship between susceptibility to social influence and risk perception can be rejected.

5. DISCUSSION

This study has examined factors influencing farmers' drought risk perceptions. A survey was conducted among 142 farmers to elicit their drought probabilities and damage evaluations as well as their affective feelings regarding drought events. Several risk perception models, drawing on the theoretical and empirical literature, were estimated including drought vulnerability variables, social psychological variables, and socioeconomic variables. The results provide several insights into the determinants of farmers' risk perceptions.

First, farmers' drought risk perceptions consistently reflect actual drought risk exposure and drought risk sensitivity. While this has been empirically explored for other types of hazards, this is the first systematic quantitative study on the link between objective drought risk factors and farmers' risk perceptions.[26,30] Our results provide evidence that farmers who are more exposed to drought risks, due to current salinization issues on their fields, perceive greater risks. Further, we find that farmers who are objectively more sensitive to droughts because they cultivate fruit and flowers perceive higher risk. These results support economic theory arguing that farmers' expectation formation is determined by rational considerations of probabilities and damages (actual risk).

Second, we failed to find empirical support for the hypothesized negative effect of access to external water on farmers' perceived drought risk. This was also been observed in another study.[56] A possible explanation is that farmers who do have access to an external water supply are uncertain about the future availability of these water resources. For several years, the government's intention regarding opening the "Haringvliet" and the "Volkerak Zoommeer" sea sluices, causing salinization of these freshwater basins, has been under discussion. This has possibly raised farmers' awareness of their dependence on these freshwater resources and their vulnerability to drought and salinity if these sources become unavailable. In our case, the uncertainty over public water management policies could have raised farmers' awareness of their dependence on these fresh water basins and their vulnerability to drought and salinity if these resources become unavailable, indirectly increasing their perceptions of drought risks. In the survey, 46% of the farmers who have access to external water resources refer to these intentions as a future threat. Another explanation could be that farmers located in areas without an external water supply have become used to drought-induced water shortages and salinity risks and therefore systematically underestimate drought risks.

Third, the significant contribution of several subjective risk variables in explaining farmers' risk perceptions provides evidence that farmers' drought risk perceptions deviate from the actual objective drought risk due to heterogeneity in their personal circumstances and personality traits. Specifically, we find evidence in support of the availability heuristic.[40] Farmers who have frequently experienced droughts in the past have higher risk perceptions. This is in line with risk perception studies on other types of natural hazards.[21,22,26–28,38] The effect of personal experience of damage decreases when controlling for objective risk variables in the full model. From this, we conclude that drought risk experience is partially mediated by objective drought risk variables. That is, farmers located in areas that are more exposed to drought risks, or who have farm characteristics that make them more exposed or sensitive to droughts, are more likely to have experienced drought damage in the past. Further, we found that farmers who perceive themselves to be in control of the drought risk have lower risk perceptions.[36] An unrealistic sense of control or reliance on the availability heuristic in risk judgment will bias risk perceptions and consequently could give rise to risky behavior or excessively protective behavior.

Fourth, it seems that objective and subjective factors are stronger risk perception factors than the socioeconomic variables age or education. Several other studies have found similar nonsignificant relationships between age and risk perception when objective as well as when experiential and social-psychological variables are included.(14–16,21,22,27,30,56)

Finally, as both the objective and subjective risk perception factors retain their explanatory power in a full risk perception model, we have empirically demonstrated that farmers rely on both analytical (or rational) and experiential systems in forming judgments about drought risk. This is in line with the dual-process theories of risk evaluation that argue that rational and experiential systems operate in parallel in forming risk perceptions.(18)

Although this study has successfully demonstrated that farmers' drought risk perceptions are heterogeneous and affected by both objective and subjective risk factors, it has its limitations. The high nonresponse rate could lead to biased estimates. Comparing the sample data with statistical data on two indicators revealed that livestock farmers are slightly underrepresented in our sample. It is likely that such farmers have lower drought risk perceptions than arable and horticulture farmers, as their farming is typically less sensitive to drought. However, there is no reason to presume that the regression estimates are considerably biased since we would expect the currently included variables to behave in a similar way for livestock and other farmers.

This study did not address the question as to what extent farmers' risk perceptions are similar to actual drought risk estimates. Additional research efforts are needed to investigate the conformity, in terms of expected damages and probabilities, of farmers' risk perceptions with expert estimates. Finally, a survey can only indicate a farmer's risk perceptions at a given moment in time, while the literature shows that risk perceptions are dynamic.(57) Two processes that could change risk perceptions over time are actual drought events and risk mitigating behavior, for example, irrigation measures or weather insurance.(58) Longitudinal risk perception data are necessary to investigate the relationship between these variables. Addressing these limitations in future research could also increase the reliability of the current analysis and improve its utility in formulating drought-related climate adaptation policies.

6. CONCLUSIONS

The purpose of this study was to provide an understanding of the determinants of risk perception that could potentially support policymakers in anticipating and steering behavioral responses to minimize risk. The results show that the occurrence of salinization, the cultivation of drought- or salt-sensitive crops, farm revenue, drought risk experience, and perceived control are significant factors of farmers' drought risk perceptions. Farmers rely on both an analytical system and an experiential system to judge drought risks as both objective and subjective factors are important variables of famers' drought risk perceptions.

For policymakers, these results imply that it is especially important to consider heterogeneity in risk perceptions in policy formulation and communication. Future research should address the question to what extent farmers' drought risk perceptions correspond to expert estimates. If farmers appear to have unrealistic drought risk perceptions, this could affect their adaptation decision making and consequently the vitality of the agricultural sector at large. In order to judge whether it is worthwhile correcting for biases in risk perceptions, for example, through communication campaigns or other drought risk management strategies, the association between risk perception, potential biases, and risk behavior should be further investigated.

Finally, important policy recommendations may follow from further investigating the role of access to an external water supply on farmers' drought risk perceptions. Future research could usefully clarify the role of farmers' reliance on an external water supply and the influence of their uncertainty on the continued availability of these resources on drought risk perceptions. Similarly, the role of familiarity and habituation to drought risk of farmers without access to an external water supply should be further investigated.

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