Risk Perception and Adoption of Conservation Practices to reduce natural resource Degradation

ABSTRACT

Palabras clave: Pobreza, invocación, adopción, percepción riesgo, secano, Chile.

Las bajas tasas de adopción de prácticas para reducir la degradación de recursos naturales continúan siendo un tema de discusión. Este paper investiga los efectos del proyecto de reducción de la pobreza rural en Chile Central, Prodecop-Secano, financiado por el Banco Mundial. El estudio se realizó en el Secano Costero (comuna de Curepto, región del Maule) en octubre a noviembre 2003. El diseño de investigación fue un ex-post fact con grupo control histórico. La población objetivo fue pequeños agricultores que participaron del proyecto Prodecop-Secano (ejecutado de 1997 a 2003).La muestra fue 90 pequeños agricultores. El estudio investigó: si el ingreso agrícola intrapredial de los beneficiarios aumentó después del proyecto; el efecto participación sobre el sistema productivo de los beneficiarios; el grado de adopción de prácticas agrícolas sustentables. Principales resultados indican que: la adopción de prácticas agrícolas sustentables fue variable. Los agricultores temen a riesgos ambientales, particularmente sequías severas. El temor hacia riesgos ambientales fue más fuerte que hacia riesgos económicos, tales como pérdida de acceso a mercados o caída de precios.

Key words: Poverty, innovation, adoption, risk perception, dray land, Chile.

Low rates for the adoption of practices to reduce the degradation of natural resources continue to be widely reported. This paper investigates the effects of a World Bank-supported poverty reduction project in Central Chile ("Prodecop-Secano", 1997-2003) on the adoption of agricultural resource conservation practices, and relates these results to farmer risk perception and coping strategies in face of common environmental and economic risks. The study was carried out in the Secano Coastal (coastal dry land) in Chile's Curepto province (VII Region). An ex-post facto research design with an historic control group was used. From the target population of small farmers who participated in Prodecop-Secano, a random sample of 90 farmers was selected. Data were sampled by face-to-face interviews. On average, adoption rates were rather low after the cessation of direct project support. Single resource conservation practices, such as terraces and irrigation systems were more frequently adopted. The farmers fear environmental risks -particularly severe droughts- strongly. The fear towards environmental risks was even stronger than the fear of economic risks, such as loss of market access or falling crop prices.

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I. INTRODUCTION

Rural poverty and environmental degradation are serious issues in Chile - particularly in the VII Region of Central Chile (see section 1.1). The Prodecop-Secano project (see section 1.2) was implemented to combat rural poverty and natural resource degradation in Central Chile's semi-arid Secano area (see section 3.1). While well-intended, it is not *a priori* clear that programs such as Prodecop-Secano are successful. The Word Bank and other donors increasingly demand efforts to evaluate actual project results:

- What is the impact of the project intervention on the target population?
- Did the program contribute to reducing poverty and environmental problems?
- If the project aims were not fully reached, what are the reasons?

Only if questions like these are asked and investigated, the further development of poverty alleviation programs can systematically progress (Rossi & Freeman, 1993). This contribution aims at adding to the data base of carefully investigated case studies in an emerging economy setting.

1.1. Rural poverty in Chile

The agricultural sector is highly important in Chile as it comprises 4.5 % of GDP. Nevertheless, Chilean agri-

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culture shows marked differences in performance and natural resource management among regions, crops and farmers. The most pronounced differences in productivity and profitability are between large scale entrepreneurial agriculture and Rural Family Agriculture (RFA). The extreme separation of farming businesses belonging to either of the two farm types is known as the "dual model" of Chilean agriculture (Hachette and Rozas, 1993; Apey, 2001).

About 276,000 rural families conduct Rural Family Agriculture in Chile. RFA uses ~45% of Chile's arable land. Its contribution to total agricultural production is about one third. RFA farming households often belong to the poorest population segment in rural areas although their economic situation can differ substantially (MINAGRI, 2003). Furthermore, RFA farmers frequently face deteriorating soils, limited access to credit and important social services (Gomez, 1992).

In 1991, 84% of the poorest communes[1] in Chile were rural communes. The rural population tends to be older and to have lower education in comparison to the urban population. In 1998, three-quarters of rural houses lacked a dependable source of potable water, and almost one half lacked electricity. The illiteracy rate in rural areas is 14.2% vs. 3.0% in urban areas (MIDEPLAN, 1999). Unsurprisingly, also the rural poverty rate is higher than the urban poverty rate. For instance, between 1990 and 1998, rural poverty fell from 39.5% to 27.6% while urban poverty fell much stronger from 38.4% to 20.7%. The investigated VII Region[2] has the third highest incidence of poverty among the twelve regions in Chile (MIDEPLAN, 2000). Its rural population is also confronted with deteriorating soils and increasing desertification. This is an issue for approximately 62.6% of the total area of Chile. A particularly susceptible agro-ecological zone is the Coastal Dry Land (*Secano Costero) in which the project area is located (Soto, 1997). The Secano Costero* extends from V Region to VIII Region.

1.2. The poverty reduction program Prodecop-Secano

Prodecop-Secano was a poverty alleviation project agreed upon between the World Bank and the Chilean government in 1995. Its focus was on the needs of RFA farmers from *coastal* and *inland* Secano areas (INDAP, 2000b). The implementation of the project used a micro-region approach. A micro-region was defined as a geographical area with common agro-ecological and climatic conditions, including at least one micro-catchment area and a population with common cultural characteristics. Eight micro-regions were selected from VI to VIII Regions. To be eligible, a commune had to be among Chile's 100 poorest communes, and it had to be representative of the rural part of the Secano (World Bank, 1995).

Prodecop-Secano had two key components (see figure 1). The first component consisted of Production Projects (component A). It included two sub-components: Agricultural Development Projects (PDA)[3] and Value Adding Projects (sub-components A1 and A2). The second component was Local Support Services (component B) which included training, institutional capacity building, and improvement of rural infrastructure (World Bank, 1995; INDAP, 2001a). The project sought to reduce rural poverty and natural resource degradation through the development of a comprehensive strategy. This strategy aimed at increasing sustainable rural production activities and family income. Particularly, sub-component A1 sought to promote rational natural resource use and sustainable agriculture by supporting:

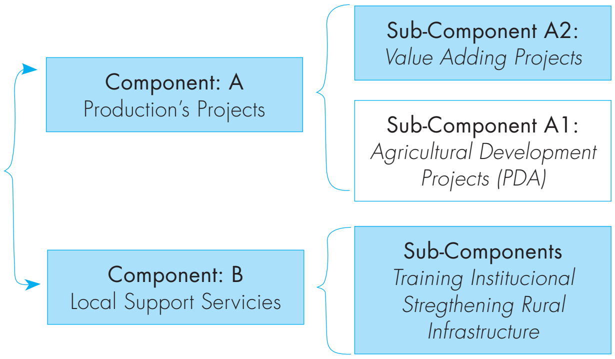
- investment in soil conservation,
- small irrigation works,
- improved pastures and livestock production,

1 Commune refers to the smallest political and administrative division in Chile.
2 The regions of Chile begin with Region I in the North and extending to Region XII in the exteme South.
3 In Spanish Proyecto de Desarrollo Agricola (PDA).

- crop diversification, and
- forestry development on very fragile lands (World Bank, 1995).

Figure 1

Main components and sub-components of the Prodecop-Secano project



Source: Own elaboration based on World Bank, 1995; INDAP, 2001a, 2001c

This paper only shows results linked with a reduction of natural resource degradation (points 1 and 2), and analyses their relation to farmer risk perception. The main conservation practices promoted by the project were *contour cultivation, terrace construction, contention docks, water conduction channels, infiltration ditches* and *irrigation systems* (sprinkling and drip irrigation).

II. THEORETICAL BACKGROUND

2.1. Risk perceptions and coping strategies

Risk refers to uncertain events that can damage well-being (World Bank, 2001a). The term risk denotes 'the possibility that an undesirable state of reality (adverse effect) may occur due to natural events or human activities' (Renn, 1992). More generally, risk (R) indicates the product of the probability that some uncertain event occurs (P) and either the utility (U) or the harm (H) caused by the event (Douglas, 1985; Adams, 1998):

$$R=P * U \qquad \text{or} \qquad R=P * H$$

From a social science perspective, perceived risk can be measured psychometrically. This approach allows to better under, for instance, the extreme aversion people have to certain hazards, indifference to others, and the discrepancies between the two reactions - as well as differences of lay person and expert risk assessment (Fischhoff, Slovic and Lichtenstein, 1982; Slovic, Fischhoff and Lichtenstein. 1980; Slovic, Fischhoff and Lichtenstein. 1985; Sjöberg, 1997; Dake, 1991).

A measure of perceived risk can be used to explain and forecast human actions in facing uncertain events. Risk perception has been shown, such as, to influence household behaviour and decision-making processes on land use and environmental threats (Mbaga-Semgalawe and Folmer, 2000).

Rogers and collaborators developed Protection Motivation Theory (PMT) to analyse individual action in the face of health risk (Rogers and Dunn, 1997). More recently, PMT was applied to environmental risks including, for instance, global species loss (Menzel, 2003), degradation of natural tourism resources (Yan et al. 2008), or environmental risks at the rainforest margin (Barkmann et al, 2008). Two important PMT variables are threat appraisal and coping appraisal. Treat appraisal comprises the perceived *severity* of an adverse event if it occurs, and the perceived *probability* of that event. The empirical results of the application of the PMT show that threat appraisal of laypersons is the sum rather than the product of these two variables. Coping appraisal comprises two variables, *responsive efficacy* and *self-efficacy*. Responsive efficacy is the belief of a decision-maker that some response to a specific risk is truly effective in mitigating the negative effects of the uncertain event. Self-efficacy is the belief of a decision-maker that s/he can successfully perform this response (Rogers and Dunn, 1997).

2.2. Adoption of innovative conservation practices

Adoption is the act of accepting an innovation. Adoption of a new agricultural practice is based on subjective perceptions or expectations rather than directly on 'objective truth'. Risk perceptions depend on three broad sets of issues: the process of learning and experience, the characteristics and circumstances of the landholder within the social environment, and the characteristics of the practice (Pannell et. al., 2006). According to innovation theory by Rogers (2003), potential adopters evaluate an innovation based on their perception with regard to five attributes of the innovation:

- *trialability:* How easy is it to shift from non-adoption to adoption?
- *observability:* Can the results of adoption readily be observed?
- *relative advantage*: Compared to other innovations, how high are the net benefits of adoption?
- *complexity:* How difficult is it to actually master the innovation?
- *compatibility* -it refers to the similarity and compatibility with the existing practices and values (Rogers, 2003).

Here, innovation refers to an idea, practice or object that is perceived as new by an individual or other unit of adoption. Mainly, there are four key factors influencing the diffusion process of an innovation: (i) the innovation itself, (ii) how information about the innovation is communicated, (iii) time available for the diffusion process, and (iv) the nature of the social system (Rogers, 2003).

The initial adoption of a farming innovation is often discountinued. A number of reasons that explain the abortion of an adoption of natural resource conservation practices have been identified. Frequently cited are: (i) a top-down approach in the planning process, (ii) inappropriateness of the technologies, (iii) limited availability of resources to farmers and, (iv) institutional and organizational problems (Berhanu, 1999).

Furthermore, non-permanent adoption can occur if incentives have been used to facilitate initial adoption of a specific innovation. Such incentives may include information provision or financial incentives. This was also observed for the adoption of resource conservation practices . . Farmers discontinued adoption when incentives were discontinued (Bekele and Holden, 1998).

Particularly in Chile, the adoption of soil conservation measures by RFA farmers is low although erosion control has been shown to be successful. The acceptance of new innovative management practices is hindered in part due to social problems related to poverty and subsistence farmland (Ellies, 2000).

III. METHODOLOGY

3.1. Study area

The study area is located in the Coastal Dry Land of Central Chile. Geographically, it is situated in the micro-region Curepto, in the Commune of Curepto, Province of Talca, VII Region (figure 2). The area has a Mediterranean climate and shallow soils with an uneven rugged pattern with slow drainage. Most of the soils are predominantly classified as Alfisols and Ultisols. The surface is highly eroded with frequent gully erosion (Universidad de Talca, 1987).

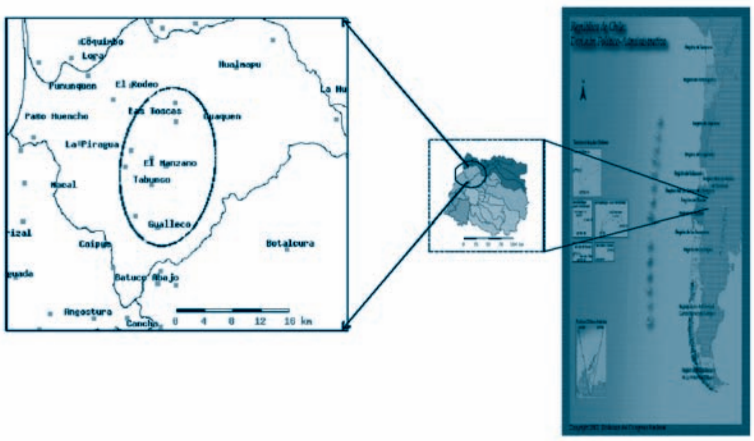
The micro-region comprises a total area of 15,400 hectares approximately. Roughly 435 farming households lived in the micro-region before the project started. Implicitly, the Prodecop-Secano approach assumed that the identified "micro-regions" were homogeneous enough to carry out the project in a uniform manner within a micro-region (World Bank, 1995).

In the face of considerable socio-economic and particularly agro-ecological heterogeneity within the study area in Curepto, several analyses are carried out also at the level of three altitudinal strata:

- High altitude stratum. It has steep slopes, poor and highly erodible soils, and severe erosion problems. It is characterized by an uneven and mountainous topography with presence of rocks from granitic origin, which has led to the in situ formation of red clayey infertile soils.
- Middle altitude stratum. This area is limited to the inter-mountain sector of the coastal mountain range. It is lower than the high altitude area, but it has similar morphologic characteristics.
- Low altitude stratum. This area has soils with high clay content. Its climate and soil characteristics make this area suitable for the establishment of spring crops in rotation, legumes, cereals, grapes, and high yielding grasslands (Diaz et al. 2003).

Figure 2

Location of the study area (scale only approximate)



Source: Library of the Chilean National Congress

3.2 *Frame Sampling*

The sampling frame consisted of all small farmers in the Curepto micro-region who participated in the Prodecop-Secano project for three or more years. This period was considered as the minimum time needed to evaluate any change caused by project interventions on the adoption of resource conservation practices. 190 RFA farmers living in 11 localities within the Curepto micro-region composed the target population as identified by project member lists. A stratified random sampling was performed. The altitudinal strata were used for sample stratification in order to test for micro-region uniformity. From each altitudinal stratum, 30 farms were sampled.

Owing to the lack of true baseline data, it was necessary to rebuild the baseline information for the key variables. Thus, an *ex-post facto* research design was carried out. A *reflexive comparison* was performed for analyzing the historic control group, for which a *before* and *after* comparison was done by the use of the re-call method (Baker, 2000; Rossi and Freeman, 1993).

Primary data were obtained from sampled farmers using a structured questionnaire in face-to-face interviews. The sampled variables with relevance to the results presented in this contribution are shown in table 1. The questionnaire was pre-tested on 10% of the sample, and the final version of the questionnaire administered during October and November 2003. Additionally, informal interviews with professionals involved in project implementation were performed. Statistical procedures included analysis of variance, multiple comparisons, the t-Student test for paired samples, Scheffe and LSD tests. Statistical analyses were carried out with SPSS version 12.0 (McPherson, 2001).

Table 1

Main variables and indicators used according to each specific objective sought

Objective	Variable	Description	Measurement
Characterization of farming households	Socio-demographic status	Age of household head and his spouse	years
		Education level of household head and his spouse	years
		Household size	number of individuals
		Gender	male, female
Quantification of the adoption of sustainable agricultural practices	Adoption	Farmers who initially used or implemented a conservation practice	initial implementation in % of sampled households at the micro-region and altitude stratum level)
		Farmers who initially adopted the conservation practice and continued using it in fall 2003 successful 'adopters' in % of initially adopted households at the micro-region and altitude stratum level	
Exploration of risk perception and coping strategies in regard to environmental and economic risk events	Risk perception and coping strategy	Risk perception towards specific risk events	Likert-scale rating: Hardly (1), Bit (2), Much (3), Very much (4)
		Type of coping strategies towards specific risk events used by the farmers.	Account of coping strategies for each risk event.

Source: Own elaboration

IV. RESULTS

4.1 Socioeconomic characteristics of project participants

The average age of the household head was 54 years (see table 2); the spouse mean age was 40 years. On average, the household head had 3.9 years of education, varying from 0 (no education) to 12 years (completed secondary school). 56.6 % of all sampled individuals had an education level of 4 years or lower. The highest education level was found in the Low altitude stratum. Household head and spouse of the Low altitude stratum were also younger. The High altitude stratum had the highest proportion of female household heads (13.3%), and the Low altitude stratum the lowest (3.3%). Average household size was 4.1 individuals with a range of 1 to 8 individuals. The largest household size was found in the High altitude stratum and the smallest in the Low altitude stratum with 4.5 and 3.7 individuals respectively. In 17.8 % of the households, at least one household member had emigrated after the project started, mostly in search of employment.

Table 2

Summary of socio-demographic characteristics for the total sample and strata

Variable	Total Sample		High altitude strata		Middle altitude strata		Low altitude strata	
	HH-head	Spouse	HH-head	Spouse	HH-head	Spouse	HH-head	Spouse
Age								
Mean	54.8	40.1	55.3	40.3	55.3	40.2	53.7	39.7
SD	12.4	22.2	11.7	22.3	12.6	23.0	13.4	21.9
Education								
Mean	3.9	4.0	2.8 (c)	3.2	3.5 (b)	2.8	5.4 (a)	5.7
SD	2.8	5.1	2.3	2.5	2.5	2.4	3.1	7.9
Household size								
Mean	4.1		4.5		4.0		3.7	
SD	1.6		1.7		1.8		1.2	
Gender (%)	91.1 Masc.	8.9 Fem.						
Migration (%)	17.8							

HH-head: household head; ; SD: Standard Deviation; letters indicate statistically significant differences between strata at the 5 % level (2-tailed LSD multiple comparison)

Source: Own elaboration

4.2. Adoption of resource conservation practices

80% of farmers started to use an *irrigation system*, 65.6 % constructed *terraces*, 20% built infiltration ditches, 14.4 % constructed *contention docks*, 12.2 % adopted *contour cultivation,* and 6.7% built *water conduction channels*.

Because of the small number of initial adopters for infiltration ditches, contention docks, contour cultivation and conduction channels, a more detailed adoption analysis is carried out only for irrigation systems and terraces. Of all farmers who had started to use a promoted irrigation system, only 56.9% used it in a regular way, and their equipment was in good condition ('adoption') when checked after cessation of project incentives. 43.1% stopped using the irrigation system or it was in bad condition ('*non-adoption'). M*ost cases of non-adoption were found in the High altitude stratum (61.9%). For the *construction of terraces*, 71.2% of initial adopters continued to use them and kept the terraces in good conditions. Again, the highest share of *non-adopters was found in the High altitude* stratum (36.4%) (see table 3).

Table 3

Summary of implementation and adoption of irrigation systems and terraces

	Initial Implementation of irrigation system		Successful adoption of irrigation system		Initial implementation of terraces		Successful adoption of terraces	
	No	Yes	No	Yes	No	Yes	No	Yes
Total sample (No.)	18	72	31	41	31	59	17	42
Total sample (%)	20.0	80.0	43.1	56.9	34.4	65.6	28.8	71.2
Low altitude stratum								
Number	7	23	9	14	18	12	2	10
(%) within area	23.3	76.7	39.1	60.9	60.0	40.0	16.7	83.3
(%) of total	7.8	25.6	12.5	19.4	20.0	13.3	3.3	16.7
Middle altitude stratum								
Number	2	28	9	19	5	25	7	18
(%) within area	6.7	93.3	32.1	67.9	16.7	83.3	28.0	72.0
(%) of total	2.2	31.1	12.5	26.4	5.6	27.8	11.7	30.0
High altitude stratum								
Number	9	21	13	8	8	22	8	15
(%) within altitudinal stratum	30.0	70.0	61.9	38.1	26.7	73.3	36.4	63.6
(%) of total	10.0	23.3	18.1	11.1	8.9	24.4	13.3	25.0

Source: Own elaboration

The key reasons mentioned by the farmers during field research for *non-adoption* are presented below in table 4.

Table 4

Key reasons for *non-adoption* of both irrigation system and terraces

Irrigation System	Terraces
• Maintenance is complicated. the drippers get blocked or lost. • Land is lost for cropping. • Pipes crossing the field make cultivation activities, e.g. soil preparation and sowing, more difficult. • Some farmers believe that the irrigation does not "wet the plant" as they do not see the water flowing into the ground • It was observed that the irrigated trees died. • The irrigation system did not work (mainly sprinkling irrigation). Among the causes are insufficient installation and high operating costs (electricity).	• Natural deterioration of the terraces • Due to constructional weakness, the terraces were destroyed or damaged by rain. • Lack of maintenance. The terraces were set for the cultivation of fruit trees. However, in some cases, trees were not planted or the plants died, leaving the terraces unattended. • Inappropriate sitting • During the field visit by the researcher, it was observed that some terraces were built on only slightly sloping terrain, where their construction was inappropriate. The farmers decided to plough the soil again and destroyed the terraces because they perceived a loss of cropping area.

Source: Own elaboration

4.3. Risk perception and coping strategies

4.3.1. Descriptive analysis: Farmers' risk perception

Table 5 presents a summary of farmer perceptions on relevant risk events. The events A, B, and D refer to economic risk events, event C is related to a potential policy change (subsidy). Events E, F, G, and H represent environmental risks, while event I is about a potential technology failure. By far, drought is the most feared risk event ('very much feared' by a majority of farmers) with erosion risks also scoring high values ('much feared'). Generally speaking, the other environmental risks assume a medium position while economic risks are less feared.

Table 5

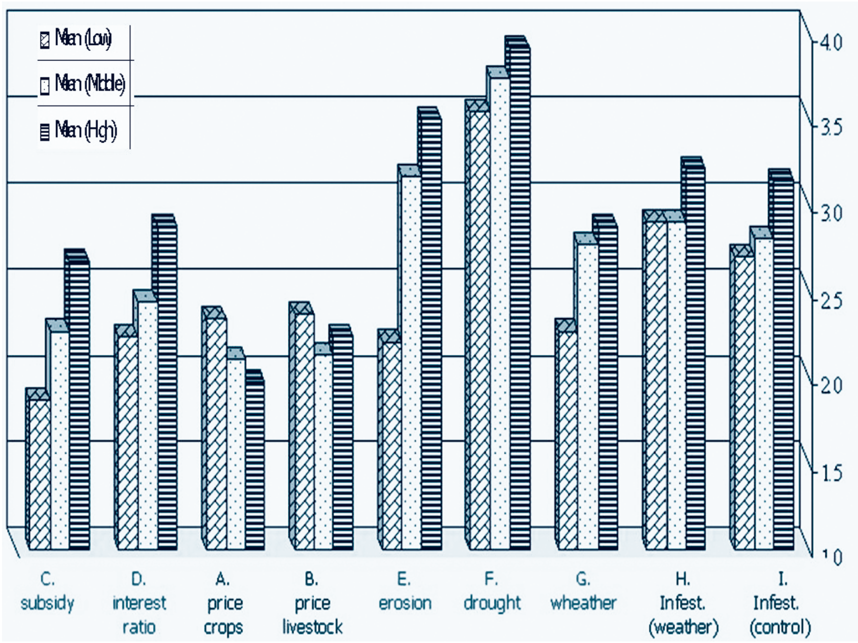
Intensity of fear with respect to risk events

Event	Modus	% of modus in all answers	Mean
A. Much lower price to crops	2	34	2.13
B. Much lower price to livestock	1	31	2.24
C. Reduction of the subsidy for forest plantations	3	37	2.27
D. Increase of the interest ratio	3	42	2.51
E. Increase of soil erosion due to rain	4	38	2.96
F. Occurrence of severe drought	4	74	3.72
G. Presence of extreme weather (e.g. Niño phenomenon)	3	54	2.63
H. Increase of pest infestation of crops (by weather causes)	3	54	3.00
I. Higher pest infestation rate of crops induced by control technology used	3	53	2.88

Question: How much do you fear the following event?
Likert answer scale (coding): hardly (1), a bit (2), much (3), very much (4)
Source: Own elaboration

Figure 3 presents the average values of risk perception broken down by altitudinal strata. Farmer responses from the High altitude stratum show average values which are nominally higher than those in other two land areas for all risk events save price risks for crops and livestock. The differences are significant (Anova test, with p-value lower than 0.05) for five events (red color coding in Fig. 3). Multiple comparisons (Tab. 6) reveal that the risk perceptions for the high and low altitude strata always differ. The perceptions of farmers of the middle altitude stratum are not different from the other two strata; in the case of precipitation related risks (E, G) they side with the high altitude stratum.

Figure 4
Risk perception values disaggregated by strata



Source: Own elaboration

Table 6
Differences in risk perception across altitudinal strata

Risk event	Low	Middle	High
C. Reduction of the subsidy for forest plantations	a	a, b	b
D. Increase of the interest ratio	a	a, b	b
E. Increase of soil erosion due to rain	a	b	b
F. Occurrence of severe drought	a	a, b	b

Different letters indicate statistically significant differences indicated by the Multiple Comparisons Scheffe test.
Source: Own elaboration

4.3.2. Coping strategies in face of risk events

We present coping strategies for the two most feared events, drought and erosion.

Drought risk event

The most mentioned coping strategy was *Asset disposition* (21%), followed by *Production adjustment* (18%), *Consumption reduction* (14%), and *Water management* (11%). The remaining 20% was composed of a combination of *Food stock, Asking for help at the Municipality, and Temporal migration*. Some *farmers* stated *Resignation* as a *'coping' strategy* (see figure 5).

Erosion risk event

The mostly used coping strategies were: *Crop management-extensification* (26%), *Conservation management* (23%), *Diversification of income sources* (16%). 22% of respondents stated that they would do *Nothing* while *11% did not identify the problem in the first place* (see figure 6).

Figure 5

Main coping strategies and their frequency for the event severe drought

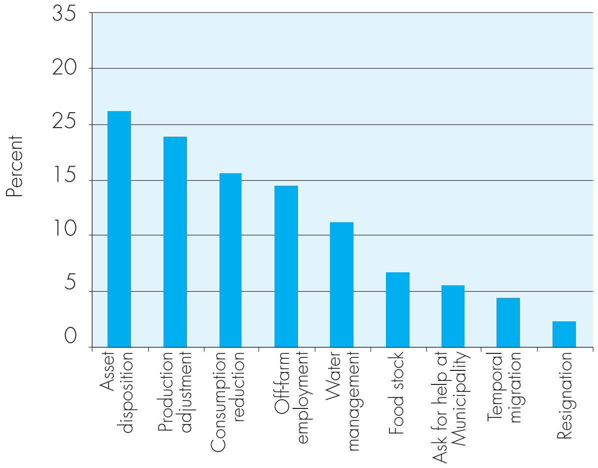
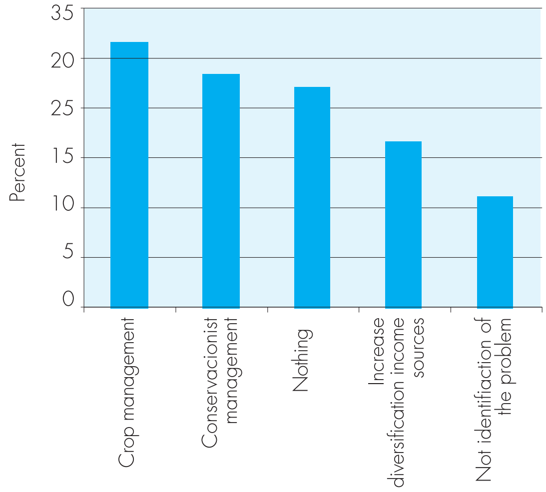


Figure 6

Main coping strategies and their frequency for the event soil erosion



Source: Own elaboration

In table 7, we provide an initial attempt for a systematic analysis of coping with response statements. This categorization presents for each event the two most frequently mentioned strategies. Also coping strategies are classified according to their timing (ex-ante or ex-post the manifestation of the risk). Also the strategies were preliminarily classified with regard to their adaptive potential and to their ease of successful application.

Table 7

Most frequent coping strategies for each risk event classified according their time of occurrence and their adaptive potential and to their ease of successful application

Event / Strategy	Ex-ant	Ex-post	Adaptive potential high (+) ; low (-)	Ease of successful application high (+) ; low (-)
F. Severe droughts				
1. Asset disposition		x	-	+
2. Production adjustment		x	+	+
E. Soil erosion				
1. Crop management by extensive system	x	x	+	+
2. Conservationist management	x		+	+
A. Much lower price for crops due to domestic market forces				
1. Feel no power to do something		(x)	-	-
2. Improve the commercialization	x		+	+
B. Much lower price for your livestock by external market forces, e.g., Mercosur				
1. Home consumption orientation	x	x	+	+
2. Diversification of income sources	x	x	+	+
C. Reduction of the government subsidy for the establishment of pine or eucalyptus plantations				
1. Not plant forest		x	o	o
2. Resignation		x	-	-

D. Increase of the interest rate agricultural credit by 2.5% in the next years				
1. Not take credit	x	x	+	+
2. Pay the debts	x	x	+	+
G. Extreme whether condition (Niño phenomenon) in the next years				
1. Production adjustments	x	x	+	+
2. Increase charcoal production and collection		x	+	+
H. Increase of weed or pest infestation of your crops caused by adverse whether				
1. Resignation / Accept		x	-	-
2. Get information	x	x	+	+
I. Increase of weed or pest infestation caused by decreasing effectiveness of the current control measures				
1. Improve crop-livestock-land management		x	+	+
2. Increase fallow period		x	+	+

o: Clear relation to self-efficacy cannot be defined; (x): it is difficult to define if strategy is only ex post or ex ante.
Source: Own elaboration

V. DISCUSSION

In the discussion, we start with a view on potential explanations why resource conservation innovations are not successfully adopted by many of the investigated farmers, proceed with a discussion of farmer risk perception, and finally discuss farmer coping strategies.

In table 8, we have compiled possible reasons that explain the low adoption rates based on innovation theory by Roger (2003) for the two innovations initially implemented most frequently.

Table 8

Possible explanations of successful adoption of irrigation and terraces depending to the perceived attributes of the innovation

Perceived Attributes	Explantation (graveness of the problem in parenthesis)
i) Trialability	• Irrigation (- - -). Lack of trial and pre-testing of the irrigation systems at the single farms caused massive problems. • Terrace (-). Lack of trials caused only a few problems.
ii) Observability	• Irrigation (-). The farmers recognized the usefulness of irrigation for them readily. However, some farmers do not perceive the benefits of the irrigation system because they feel that it does not 'wet' the crops. • Terraces (- -). Low perception of direct/immediate benefits as the prophylactic nature of the practice makes it more useful in the long term.
iii) Relative advantage	• Irrigation (-). The advantages were readily apparent also in comparison with other techniques. • Terraces (- - -). Farmers do not perceive advantages of the' construction of terraces versus the traditional cropping system. Some farmers have only a low perception of erosion risk.
iv) Complexity	• Irrigation (- - -). Farmers find the operation and maintenance of the equipment complicated. • Terraces (-). A few farmers did not have the appropriate tools needed for terrace construction.
v) Compatibility	• Irrigation (- - -). The new irrigation systems are widely incompatible with the traditional way to perform central cropping activities, for example ploughing or sowing. • Terraces (-). The terraces take up a small section of the land, thus, compatibility is not a major issue.

High degree of conflict or problem (- - -); medium degree (- -); low degree (-)
Source: Own elaboration

Other factors useful for the explanation of aborted adoption of *terraces* refer to the type of payment for their construction. Financial incentives had been paid for the construction of the terraces but not for the maintenance of them. In agreement with Bekele and Holden (1998), we found that farmers did not maintain the terraces and some even destroyed them later on.

Also, the top-down implementation approach of Prodecop-Secano and low participation of farmers in project decision-making may have contributed to low initial adoption for several innovations, and to substantial medium-term failure rates. According to Berhanu (1999), this approach introduces, in many cases, inappropriate technologies for the specific population. With more careful attention to the needs and production system requirements of the sampled population, better results would be expected.

Regarding risk perceptions, farmers feared most prolonged *drought events*. Given the agro-ecological and climatic conditions in the Secano study area, this may not be surprising. The lower importance of *economic and policy related risks* appears to document a limited exposure to such risks because of the subsistence-oriented production of many of the sampled RFA households. Still, 40% of farmers fear low livestock prices, probably, as minor livestock (sheep and goats) is frequently sold in markets.

In order to structure the discussion on farmer *coping strategies*, table 8 presents a preiminary classification inspired by Protection Motivation Theory (PMT). In particular, we consider the two variables *Response efficacy and Self-efficacy*.

a) Response efficacy (+) and Self-efficacy (+)
b) Response efficacy (-) and Self-efficacy (-)
c) Response efficacy (-) and Self-efficacy (+)
d) Response efficacy (o) and Self-efficacy (+) or another combination of them

First, case (a), it means that the farmer mentioning this response perceives that the coping strategy reflects an effective response, which will contribute to reduce his/her vulnerability towards the risk event. Also, the farmer feels that he/she can successfully perform the coping strategy. For example from table 8, in face of *soil erosion due to rain in the next years* risk event, an effective coping strategy would be *conservationist land management*. Second, case (b), it implies that the farmer does not perceive that his/her actions reduce his/her vulnerability towards the risk event. Simultaneously, answers imply that the farmer does not feel that he/she can successfully perform an *adaptive* coping strategy. In table 8 one example is coping with soil *erosion due to rain in the next years* risk event, to say *Abstention/Nothing*. Third, case (c), it is a sign of how the farmer feels that he/she can successfully perform the coping strategy. However, it suggests that the action performed through such coping strategy by the farmer reflects a *non-adaptive response*, which will not contribute to reduce his/her vulnerability towards this risk event in the long term. In table 8, one example coping with *the occurrence of the severe drought in the next years*, a *non-adaptive* coping strategy would be *Asset disposition*. At last, case (d), denotes that the farmer believes that he/she can successfully perform the coping strategy, but from the coping strategy can not be deduced to have implication on the adaptiveness of the response.

It was found that the nature of the risk event determines the type of strategies implemented by farmers. When events have an environmental or natural character, farmers mentioned a large number of coping strategies. Mainly, these events influence the usual production activities performed by the farmers. Along with the way how farmers cope with these risk events a kind of cause-effect relation made by them can be inferred. These cause-effect relations are not only rational but also include beliefs on Nature or have a religion or destiny-related character.

In sum, the risk management found among farmers reveals that they use formal and informal strategies. In fact, if the identified coping strategies are matched with Prodecop-Secano actions, Prodecop-Secano helped to reduc farmer vulnerability. This applies particularly towards drought and erosion, which were two of the risk events that had been identified as problems by the project, which were perceived as most fearful by farmers, and which where utilized Prodecop interventions. However, farmers also perform other 'coping' strategies with a low adaptive potential such as asset disposition, resignation, and the extraction and recollection of natural resources. In the long run, reliance on such strategies may contribute to increase farmer vulnerability instead of helping them to cope with the risks.

VI CONCLUSIONS

The low rates of successful adoption of conservation practices observed are related to the perceived attributes towards these practices. This applied particularly to attributes which are in conflict with traditional production systems. Furthermore, the low average educational level of the farmers made it difficult for some of the farmers to successfully adopt some of the most complex innovations, particularly regarding the proposed technical irrigation systems.

- The environmental risks were most relevant to and feared by farmers.
- The character of the risk events, in part, determined the type of coping strategies used by farmers.
- The Prodecop-Secano project has contributed, at least for some farmers with successful adoptions, to a reduction of their vulnerability towards environmental risk events.

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