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# Land clearance and social capital in mountain agro–ecosystems: the case of Opuntia scrubland in Ayacucho, Peru ☆

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**Abstract**

Opuntia scrublands are important ecological–economic systems in rural Andean areas. They provide goods for peasants' diet and animal feed, as well as cochineal insects, a highly valued source of dyes. Land clearance on these scrublands promotes changes in land use, from nonproductive wilderness to cochineal and fruit harvest areas, grazing lands, and fuel–wood supply zones. Here we empirically explore the role of social capital on land clearance, based on a case study of the Humanga region of Ayacucho, Peru. The literature on social capital is showing evidence of the positive effect of social capital on development actions and on environmental conservation in rural areas of developing countries such as participatory forest management. Here, the notion of social capital is captured by the idea that some features of social organization, such as networks, facilitate coordination and cooperation within the peasant communities that help in managing different economic activities, both on- and off-farm. The habilitation of the scrublands in the Andean mountain environment could be generating negative externalities as a consequence of altering the vegetation cover such as soil erosion. Because the benefits arising from land clearance activities are obtained by cochineal collecting households and the negative environmental effects are costs imposed upon noncochineal collectors, the social capital associated with scrubland habilitation could be perverse from an agro–environmental viewpoint and a revision of some government policies and of some NGOs actions for rural development through the promotion of various community networks in this deprived area could be needed.


*Keywords:* Social capital; Peru; Opuntia; Cochineal; Land clearance

## 1. Introduction

Opuntia scrublands are a part of one of the most important socio–ecosystems in the Andean area. The vegetation cover performs a major environmental role protecting slopes against erosion and flooding, as well as improving the levels of soil humidity and soil retention capability (Le Houérou, 1996). The Opuntia scrubland provides a variety of

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nontimber products, such as fruits and young cladodes employed in the human diet (Pimienta-Barrios, 1994), succulent fodder for animal feeding (Guevara et al., 1996), and raw material for the manufacture of ornamental and rustic work (Pardo, 2002). However, Opuntia scrubs are especially important because they are hosts for cochineal insects. These insects are the source of carminic acid, a natural dye used in the food, textile, and pharmaceutical industries. The collection of the insect has represented an important economic activity for local communities in the Andean area and Mesoamerica since pre-Columbian times. Along the period of Spanish domination, the insect was collected as tribute and harvested from small family plots where their host plants were interspersed between subsistence crops. Cochineal was a Spanish monopoly and represented the second export product of the American viceroyalties after silver mineral. The importance of cochineal persisted until 1870's when synthetic dyes such as anilines became cheaper and brought the decline of the cochineal industry. After the ban of some synthetic dyes due to their negative secondary effects, the market is leaning again toward the use of natural dyes. As a consequence, cochineal production has experienced a revival. Peruvian production grew to cover between 85% and 90% of the global market, mainly based on recollection of the insect in natural Opuntia scrublands located in the Andean areas of Ayacucho. Due to the favorable environment for both the insect and its host plant, cochineal collection in Peru has a considerable social and economic importance, representing a source of income for some 100,000 peasant families (Flores-Flores and Tekelemburg, 1995). These families inhabit poor communities exposed to social vulnerability, disruption of livelihoods, and loss of security as consequence of the impact of 12 years of violence derived from the actions of groups like Shining Path, armed peasant patrols and the Peruvian army (Fumerton, 2001).

Current government policy in Ayacucho is focused on poverty alleviation, reconstruction, and repopulation mainly based on distribution of subsidized food, creation of social infrastructure, and support to education, health and sanitation works (PROMUDEH, 1997). NGO's and official institutions are promoting productive activities in communal lands including the participatory management of the Opuntia scrubland for cochineal collection. These scrublands, comprising 38,000 ha in the Andean slopes of Ayacucho, are dense natural formations where cacti of the genera *Cleistocerus* and *Azureocereus* and specimens of *Schinus molle* (Anacardiaceae), *Caesalpina tinctoria* (Caesalpinaceae) and *Agave americana* (Agaveaceae) are interspersed among the dominant species, *Opuntia ficus indica* (Cactaceae), which reaches stand densities over 2000 plants/ha as the slope increases (Piña-Lujan, 1981).

The participatory strategy considers support the communal organizations by providing assistance to the local committees of cochineal collectors, the improvement of the capacity of peasants to supply cochineal by promoting the habilitation of the scrubland, and the increase of profitability of the activity by avoiding the intermediary traders.

Opuntia scrubland habilitation comprises opening trails of access, pruning spiny bushes, and land clearance to facilitate cochineal harvest and to obtain fuel–wood and fodder from the associated vegetation without affecting the arable layer of the soil. In this sense, because scrubland habilitation involves household decisions, it has much similitude with other land clearance activities such as tropical deforestation or mangrove conversion. Hence, many of the numerous analyses and approaches used in these studies may be applicable, e.g., the effect of output prices and rural wage on the conversion rate (e.g., Barbier and Burgess, 2001), the influence of socio–economic characteristics of the agents involved in land clearance, such as income level, household size or education (e.g., López, 1997; Godoy and Contreras, 2001), as well as the effect of spatial and institutional factors such as distance and accessibility to forest areas, land conflicts, or property rights (e.g., Nelson et al., 2001; Cropper et al., 2001). Interestingly, to our knowledge, the effect of social capital on land clearance has not been addressed.

Social capital is a broad concept that captures the idea that some features of social organization, such as networks, norms and social trust, facilitate coordination and cooperation for mutual benefit (Putnam, 1995). There is growing evidence of the positive effect of social capital on development actions (Grootaert and van Bastelear, 2002; Isham et al., 2002), as well as on actions related with environmental tasks

such as watershed management, irrigation and water use, or participatory forest management (Pretty and Ward, 2001; Katz, 2000).

The Andean communities have a long history of communal work, reciprocity, and common resources management (Gonzáles de Olarte, 1984; Cotlear, 1989; Trawick, 2001). Ayacucho exhibits a high level of communal organization evidenced by the elevated number of associations, and their capacity to mitigate risk and generate collective actions (CTAR, 2001). In this regard, the promotion of scrubland habilitation for cochineal collection and the existing social structure in their communities make Ayacucho an ideal case to test the effect of social capital on land clearance.

In this article, we investigate the role of social capital on Opuntia scrubland habilitation. The structure of the paper is as follows. The next section provides a few guidelines of social capital issues relevant to the problem and a brief background of cochineal collection industry. Section 3 defines the variables considered in the analysis and presents the estimation of the model. Finally, Section 4 discusses the results.

## 2. Background

Any form of capital represents an asset that produces a stream of benefits. Social capital, like other forms of capital, is productive making possible the achievement of certain goals that in its absence would not be possible (Coleman, 1990). Social capital is not a single entity but a variety of multidimensional entities. Thus, the concepts of bonding and bridging social capital (Gittell and Vidal, 1998), and the construct of (Uphoff and Wijayaratna, 2000), focusing on structural and cognitive forms of social capital, are important in the understanding that, contrarily to human capital which resides in individuals, social capital resides in relationships (Lin, 2001). Bonding social capital refers to links between people, which facilitate intragroup interaction and collective action, while bridging social capital reflect the links between groups and other actors and organizations (Narayan, 2002). Structural social capital is an arrangement of roles and social networks supplemented by rules, procedures, and precedents that facilitate information sharing, decision-making, and collective action. Cognitive social capital is a more subjective and intangible concept referred to shared norms, values, attitudes, and beliefs (Uphoff and Wijayaratna, 2000). From a point of view focused on the consequences of social capital rather than its sources, social capital is a subset of social interaction processes which generates durable externalities. Collier (2002) recognizes three types of those externalities: (i) information about the behavior of other agents, which is reflected in knowledge about their reliability, hence, in a decrease of transaction costs; (ii) information about the nonbehavioral environment that is evidenced in sharing knowledge in order to take better allocative decisions; and (iii) collective action, which mitigates risks, lower transaction costs, and enables the management of common pool resources and economies of scale.

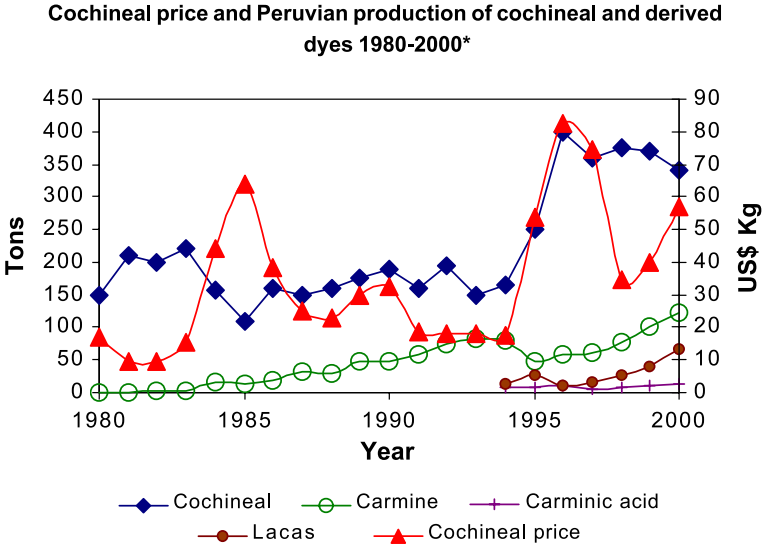
For empirical purposes, social capital is measured using proxy variables; nevertheless, there is no consensus about which are the best proxies (Grootaert and van Bastelear, 2002). Social capital indicators differ geographically and sectorally, and the decision for the selection of proxies is often inspired by the specific outcomes of the social interaction. Thus, membership in networks, meeting attendance, labor input, and participation rate are some of the most frequently used proxies for social capital. The number and types of relations among agents and the characteristics of the group such as heterogeneity of composition, inequity level, or leadership features have also been employed as proxies in several studies (Grootaert and van Bastelear, 2002; Isham, 2002b).

Along the Peruvian Andes, the main and more extended form of social organization in the rural villages is the "*comunidad campesina*" (peasant community). A community is a group of families tied together by consanguine or symbolic patronage relationships, which communally own a defined territory, where for productive purposes land is allocated into communal and individual family plots. Communal holdings are communally farmed in an obligatory basis, while individual plots are mainly exploited using family labor force and reciprocity relationships in the communal network. In Ayacucho, there are 452 recognized *comunidades campesinas* that own 72% of the agricultural land available in the region (INEI, 1996). The commu-

nity not only possesses productive dimensions but also provides a sense of belonging and identity to their members, and generates the social structure needed to develop collective actions such as infrastructure building or common resources management. The high level of communal organization in Ayacucho is evidence by the large number of producers' committees, peasants associations, and other social groups existing within and outside the community. Some of these groups, such as women associations, glass of milk committees, and community kitchens, are vital for the subsistence of their members by promoting responses to mitigate the risk of famine and creating bridges with donors (CTAR, 2001). The extraordinary capacity of communities in Ayacucho to promote collective actions was evidenced by the peasant initiative to create armed peasant patrols to combat Shining Path in various parts of the region. Through time, in some communities, these organizations have exhibited flexibility, often diversifying they role from self-defense to involvement in infrastructure construction or resource management activities such as regulation of the access to Opuntia scrubland for cochineal collection (De Gregori et al., 1996).

### 2.1. Cochineal production

Cochineal collection is a source of income for Andean peasants. Annual world production of cochineal in 2002 was estimated as 1045 tons. The Peruvian production was over 885 tons, of which nearly 40% was collected from Opuntia scrublands in Ayacucho (PRA, 2002). Cochineal is a source of carmine and carminic acids, a group of highly valued dyes in the food, cosmetic, and pharmaceutical industries of the United States, the European Union, and Japan. The Peruvian production of cochineal and its dyes has increased in the last 20 years although the price of cochineal has oscillated (Fig. 1). The high prices motivated the interest to expand the cochineal industry into other countries. Highly technified plantations were initiated in northern Chile and plans were developed to promote cochineal collection in Bolivia and Mexico (Sáenz, 1998), as well as to introduce the insect in the Kalahari Desert in Southern Africa as part of poverty alleviation programs (African Development Foundation (ADF), 1999). Currently, the cochineal price is under US$12/kg and many of the commercial firms that initiated Opuntia plantations in order to produce the insect and its dyes are constrain-




** The production of derived dyes such as carmine and carminic acid requires a large amount of the total Peruvian cochineal production. Hence, the amount of cochineal in the graphic represents the share of the total production that is exported as dried insects; the rest is included in the graphics as deerived dyes.*

Fig. 1. Cochineal price and Peruvian production 1980–2000 (Source: PRA, 2002).

ing their production (PRA, 2002). Nevertheless, cochineal in Ayacucho is still an important product. Due to the small size of individual harvests, there is a long chain of intermediary traders between the producers and the export companies. Peasants are regularly visited by traders who buy cochineal and develop arrangements for future transactions. These traders accumulate cochineal stocks and dispatch them to more wealthy traders in Lima who gather and sell larger stocks to export companies.

In spite of current low prices, government institutions and NGOs are promoting actions based on cochineal collection in extreme poverty areas of Ayacucho. These actions are focused on generating sources of income, incorporating marginal lands into productive activities by habilitating Opuntia scrublands, enhancing the communal organization by supporting local producers committees, and increasing the profitability of cochineal collection by improving the trading channels from producers to export companies.

## 3. Definition of variables and empirical estimation of the model

An important area of research into land clearance consists in the statistical analysis of the factors determining declining vegetation cover. Several reviewers (e.g., van Kooten et al., 1999) have synthesized many different study cases, and a set of factors that have potential importance on the land clearance processes have been identified. Thus, the analyses of land conversion models have tended to confirm the hypothesis that land conversion is positively related to output prices and decreases with high rural wage rates (e.g., Barbier and Burgess, 1996). Competing land use models (e.g., Barbier and Burgess, 1997) indicate that increasing population density increases vegetation clearance, whereas rising income per capita and agricultural yields reduce the demand for vegetation conversion. The accessibility and distance to the forest areas and some socioeconomic characteristics of the involved agents, such as household size and education, have been also evidenced as factors affecting the land clearance process (e.g., Cropper et al., 2001; Godoy and Contreras, 2001). Recently, some empirical analyses have begun to explore the effect on land clearance of institutional factors such as land use conflict, security of ownership, property rights, or political stability (e.g., Alston et al., 2000). Although institutional models have demonstrated the importance of these factors in determining land clearance, the judgment concerning the weight given to such factors compared to explanatory variables identified by other approaches is still a research topic.

Because each model is able to produce its unique insight into possible factors explaining land conversion, an interesting issue is to construct synthetic models based on previous approaches in order to avoid the effect of omitting potentially important explanatory variables (Barbier and Burgess, 2001). In this sense, data referring to many of the potential factors affecting scrubland habilitation were collected in six villages of the province of Huamanga, one of the most important areas of cochineal collection in Ayacucho.

Because this was a cross-sectional study and we focused on villages within a limited geographic area having similar environmental and socioeconomic characteristics, no differences were found in the cochineal price and wage rate among villages or between households in the community; consequently, these variables were not considered in the study.

Given the difficulty to define and measure social capital, we chose some proxy variables relevant to Ayacucho and to the desired output in order to evaluate scrubland habilitation. Putnam (1993) used membership in formal associations, voter turnout, and newspaper readership, as proxy variables for social capital. Nevertheless, some of them are not applicable because newspapers do not arrive to the communities, and the voter turnout is not useful because the electoral system was affected during the years of local internal conflict. Membership in formal associations was selected as a proxy variable. This variable was demonstrated useful in other studies of social capital in the Peruvian Andes (Swinton, 2000; Swinton and Quiroz, 2000). Although many of these associations were set up originally by external agencies, they constitute voluntary organizations if people consider them as such (Paldam, 2000). Furthermore, Bebbington (1997) recognizes external agencies as capable of inducing the formation of social capital in Andean communities; hence, membership in associations was considered in the study without distinction of their origin. Participation rate and meeting attendance have been used as proxy variables for social capital in

several studies covering issues as diverse as education, agriculture, credit access, humanitarian assistance, or watershed management. (e.g., Gugerty and Kremer, 2002; Grootaert et al., 2002; Narayan, 2002). These variables were considered relevant to the problem at hand and were included in the analysis. Group characteristics, such as heterogeneity, ethnic affiliation, or kinship, have been used in several studies as proxies for social capital (e.g., Isham, 2002a; Gugerty and Kremer, 2002; Grootaert et al., 2002). Because kin-based groups are the basis of the social organization in the Andean communities, as was emphasized by Bebbington and Carroll (2002), a kinship variable was considered useful to understand internal bonding in the communities and was consequently included in the study. Leadership is considered an important variable that can accelerate the diffusion of innovations and has been used in other studies involving social capital (Isham, 2002b). Because Opuntia habilitation is in part externally promoted, it may incorporate elements of innovation; hence, we considered a leadership variable in our analysis.

Along with these proxies for social capital, complementary household socioeconomic variables, such as age, gender, and income, were included in the study, as well as scrubland area habilitated and density of Opuntias in the cleared plot. Table 1 shows a list of the variables considered in the analysis.

Because the habilitated scrubland is a variable censured at zero, the general approach for data analysis was to estimate the effect of the social capital variables on vegetation clearance using a Tobit model with the area of habilitated scrubland as a dependent variable. The estimated Tobit model presented in Table 2 shows that the age of the head of the household, the number

Table 2
Tobit analysis of scrubland habilitation in Ayacucho

| Variable | Coefficient | S.E. |
|---|---|---|
| Constant | −0.87719** | 0.402638 |
| Age of the head of the household (ln) | 0.180873*** | 0.066622 |
| Sex of the head of the household (1: male) | −0.00951 | 0.044239 |
| Agricultural income (ln) | 0.004459 | 0.031703 |
| Outfarm (dummy) | −0.01848 | 0.043475 |
| Density of Opuntia (ln) | 0.002262 | 0.019921 |
| Membership (ln) | 0.145136* | 0.087897 |
| Participation rate in cochineal committee | 0.395066*** | 0.068749 |
| Number of days employed in habilitation (ln) | 0.159054*** | 0.026415 |
| Kinship (dummy) | 0.00337 | 0.034262 |
| Leadership (dummy) | 0.013191 | 0.034737 |
| Dummy community 1 | 0.123921* | 0.066026 |
| Dummy community 2 | −0.33893*** | 0.067771 |
| Dummy community 3 | −0.17501*** | 0.064687 |
| Dummy community 4 | 0.003349 | 0.066164 |
| Dummy community 5 | −0.22489*** | 0.060195 |
| Sigma | 0.152606 | 0.010664 |

Log likelihood function 42.54.
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

Table 1
Definition of variables and selected summary statistics ($N = 110$)

| Variable | Mean | S.D. | Min. | Max. |
|---|---|---|---|---|
| Habilitated scrubland in the last 12 months (ha) | 1.01 | 0.70 | 0 | 2.9 |
| Age of the head of the household (years) | 40.69 | 11.65 | 22 | 72 |
| Gender of the head of the household (binary: 1 male, 0 female) | 0.85 | 0.35 | 0 | 1 |
| Agricultural income (nuevos soles) | 1523.18 | 680.46 | 144 | 4645 |
| OUTFARM (binary), represents if the household obtains income from sources other than farm on a regular basis | 0.27 | 0.44 | 0 | 1 |
| Density of Opuntia in the scrubland (plants per ha) | 1294.22 | 892.35 | 110 | 4600 |
| Household membership in associations (units) | 5.56 | 0.93 | 2 | 7 |
| Attendance rate in cochineal collectors committee (proportion of total meetings) | 0.54 | 0.26 | 0 | 1 |
| Number of days labored in habilitation in the last 12 months (days) | 26.68 | 15.96 | 0 | 66 |
| Kinship (binary), represents if the household belongs to the prevailing group in the community | 0.47 | 0.50 | 0 | 1 |
| Leadership (binary), considers if in the family group, there is a leader in any of the associations | 0.3 | 0.46 | 0 | 1 |

of associations to which the household is affiliated, as well as the participation rate in the committee of cochineal collectors, and the number of days employed in the habilitation all have a positive and significant effects on the amount of habilitated scrubland. Other social capital variables, such as leadership and kinship, were not significant. The density of Opuntia in the scrubland as a proxy for land quality and accessibility has nonsignificant effect on the habilitation. Other sources of income out of the farm and a larger income from agriculture are also nonsignificant on the scrubland habilitation.

## 4. Discussion

The results of the analysis show that the age of the head of the household significantly affects scrubland clearance. In Ayacucho, as in many parts of the Andes, land is scarce and its tenure is a cyclic phenomenon of accumulation and release in synchrony with the age of the head of the household (Ossio Acuña, 1992). Younger peasants have smaller land plots mainly located in marginal or slope areas and much of their labor force is sold to wealthier peasants or they are involved in temporal migration for non-skilled occupations mainly in the tropical forest of Ayacucho (IER, 1985; Pérez-Liu, 1988). Older peasants stay in the community; hence, they need to be involved in local activities that represent alternative sources of income such as habilitation of the scrubland for cochineal collection.

As expected, the number of days employed in the habilitation is a positive and significant variable. The participation rate in the cochineal collectors committee has a positive and significant effect on the amount of scrubland cleared. Although the participation in the committee has substantial costs including the time committed to attending meetings, it also has benefits including the diffusion of knowledge from other peasants and from extension activities or demonstrative events. Group attendance help members obtain information related to Opuntia and cochineal, such as market prices or trading arrangements, as well as information about the behavior of other collectors and intermediary traders, all of which are reflected in lower transaction costs and lower searching costs that consequently diminish the costs of habilitation.

Different studies do not necessarily agree with the effect of a selected indicator of social capital because the results may depend of the outcome variable considered, as well as the level of analysis, the geographical area, and historical factors (Bebbington, 1999; Grootaert and van Bastelear, 2002). The household number of memberships in associations positively and significantly influenced habilitation of scrubland. This proxy variable was also significant in explaining the adoption of sustainable farming and grazing practices in the Peruvian Andes (Swinton, 2000; Swinton and Quiroz, 2000), and some indexes that combine membership were also significant, evaluating the effect of social capital on household expenditure in other areas like Tanzania (Narayan and Pritchett, 1999). On the other hand, Krishna and Uphoff (2002) did not find a correlation between the number of associations and the Index of Common Land Development that they constructed in India but considered that the relatively low number of associations made this variable not relevant in their area of study.

In this part of the Andes, after the years of war, there are an elevated number of government agencies and NGOs working with funds of external donors and focusing on strategies of rural development, microcredits for agriculture, food security, and human assistance. Many of these external agencies create associations of peasants along the development of their projects, as a strategy to promote communal work and to efficiently distribute the aid (e.g., Díaz et al., 2000). Due to the scarcity of resources, extension agents promote household affiliation to as many associations as possible because the membership costs are low or inexistent and the benefits are evident in terms of food security, development of skills, and acquisition of external contacts. In this scenario, with communities under 100 households that continuously interact as part of their traditional livelihood, we should be careful before attributing very much weight to the number of associations as the specific channel that influences the habilitation of scrublands and should be aware that current or past membership in certain associations could directly influence the habilitation; that is, membership in microcredit agencies could mean a way to obtain new tools, or previous experience in producers peasants associations help them to develop skills for their more efficient use.

The large statistical significance of the dummy variables for some communities suggests that factors other than those considered in our model affect scrubland habilitation in Ayacucho. Other social capital proxies such as leadership and kinship were not significant and both exhibited the expected positive effect on scrubland habilitation because leaders are usually persons with higher skills, and households that belong to the dominant kinship habitually have differentiated access to means of production (Bianco and Sachs, 1998).

The importance of social capital in the Andes has been evidenced in some successful experiences of external aid agencies promoting development in specific places where environmental conditions offer the possibility of producing particular high-value goods (Bebbington, 1997). The results indicate that bridging social capital between local producers and external institutions could be effective in promoting the intensification of the productive activity and adding value to the products by processing or transforming them (Bebbington, 1996; Healy, 2002). In this regard, cochineal collection in Ayacucho could be a candidate for success, due to the commercial importance of the insect and the possibility of adding value to cochineal by extracting and transforming the dyes.

Research on social capital has demonstrated its importance for community development but gradually it has become evident that social capital can have negative effects (e.g., Rubio, 1997; Paldam and Svendsen, 2001; Woolcock, 2002). The negative effects of social capital may be a consequence of within group actions that imposes costs on nonmembers (Knack, 2002). Land clearance decisions rarely take into account the environmental benefits of conservation, such as biodiversity maintenance, watershed protection, or carbon storage, generating a range of negative externalities (Gergiou et al., 1997). From a cost–benefit perspective, Isham (2002a) demonstrates that social capital can have potential negative effects in the expected outputs of a development project, either directly because the expected productivity of a form of social capital is negative, or indirectly if social capital has a negative effect on other productive inputs such as labor, physical, human, or natural capital. In this regard, the habilitation of scrublands could be generating negative externalities as a consequence of altering the vegetation cover such as increasing erosion or diminishing protection against flooding. The negative effects of these externalities would be evidenced only on the long term due to the temporal and spatial discontinuities between the site where erosion or soil degradation occurs, and the site and the time where the harm occurs. Because the benefits of land clearance are for the group involved in cochineal collection and the negative environmental effects are costs imposed on nonmembers, the social capital associated with scrubland habilitation could be perverse and a revision of the promotion policy will be needed.

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