Why do individuals behave differently in commons dilemmas? The case of alpine farmers using common property pastures in Grindelwald, Switzerland

Ivo Baur
Department of Geography, University of Munich (LMU), Germany
ivo.baur@geographie.uni-muenchen.de

Karina Liechti
Centre for Development and Environment (CDE), University of Bern, Switzerland
Karina.Liechti@cde.unibe.ch

Claudia Rebecca Binder
Department of Geography, University of Munich (LMU), Germany
Claudia.Binder@geographie.uni-muenchen.de

Abstract: The sustainable use of common-pool resources depends on users' behaviour with regards to appropriation and provision. Most knowledge about behaviour in such situations comes from experimental research. As experiments take place in confined environments, motivational drivers and actions in the field might differ. This paper analyses farmers' use of common property pastures in Grindelwald, Switzerland. Binary logistic regression is applied to survey data to explore the effect of farmers' attributes on livestock endowment, appropriation and provision behaviour. Furthermore, Q methodology is used to assess the impact of broader contextual variables on the sustainability of common property pastures. It is shown that the strongest associations exist between (a) socio-economic attributes and change in livestock endowment; (b) norms and appropriation behaviour; and (c) area and pay-off and provision behaviour. Relevant contextual variables are the economic value of the resource units, off-farm income opportunities, and the subsidy structure. We conclude that with increasing farm size farmers reduce the use and maintenance of common property. Additionally, we postulate that readiness to maintain a resource increases with appropriation activities and the net returns generated from appropriation.

1. Introduction

Natural resources like fishing grounds, forests, pastures, and water are often managed as common-pool resources. Common-pool resources are jointly managed resources, for which individuals' appropriation diminishes the resource stock and potential beneficiaries of which are difficult to exclude (Berkes et al. 1989). Additionally, most common-pool resources rely on provision activities for the supply of resource units and the upkeep of the resource system. Appropriation and provision activities comprise social dilemmas, in which users' short-term self-interest stands opposed to the interest of the group, that is to maximise appropriation and minimise provision activities (Gardner et al. 1990).

The behaviour of individuals in commons dilemmas affects the sustainability of all common-pool resources. Game theory provides the means to simulate both appropriation and provision behaviour in laboratory experiments, whereby the appropriation problem equals a common-pool resource game. As such, the appropriation of users diminishes the resource and hence reduces the stock and pay-offs of co-players (Keser and Gardner 1999; Cárdenas and Ostrom 2004; Osés-Eraso and Viladrich-Grau 2007; Ahn et al. 2010; Janssen et al. 2010). The provision problem matches a public good game. Public good experiments require players to invest in a common stock. The stock changes depending on the investments made and with it the individual's return on the investments (Isaac et al. 1994; Ledyard 1994; Fischbacher et al. 2001; Gächter and Thöni 2011). Recent attempts to validate findings from the laboratory with field experiments underline that users are sometimes able to overcome social dilemmas to achieve socially desirable outcomes (Cavalcanti et al. 2010; Rustagi et al. 2010; Prediger et al. 2011).

Whilst experiments provide important information about the factors facilitating cooperation, they offer limited explanations for the behaviour of real common pool resource users, mainly because the material constraints, preferences, and motives as they appear in the field are difficult to control for in experiments. This is due to the following reasons: Firstly, the underlying assumption of game theory that self-seeking players behave strictly rational to maximise pay-offs does not reflect reality (Smith 2010). Secondly, the behaviour of individuals in experimental settings is detached from personal characteristics (Levitt and List 2007; Anderies et al. 2011). Thirdly, subjects in laboratory experiments are usually students from Western

countries, whose personality traits might differ from those of common-pool resource users (Henrich et al. 2010). To complement experimental studies, more information is needed about the variables driving the behaviour of real common-pool resource users (Janssen and Ahn 2006; Poteete et al. 2010; Anderies et al. 2011). That information can then be integrated in experimental design to provide the common ground towards a more general behavioural theory of human actions in the use of common-pool resources beyond models of pay-off maximising individuals.

In doing so, this study analyses the use of common property pastures in Grindelwald, Switzerland. Common property pastures in Switzerland are located at higher altitudes, characterized by mountainous terrain. Therefore, they can only be used to graze cattle during the summer months. These pastures are typically managed and owned by public corporations. The sustainable use of common property pastures depends crucially on social-ecological interactions, namely appropriation (grazing intensity) and provision (maintenance of the ecological system and the respective infrastructure). Since both under- and overgrazing have adverse effects on the resource system, for example by reducing biodiversity or pasture productivity, total appropriation should remain within a sustainable yield. Furthermore, provision activities are needed to maintain or enhance the productivity of the resource system. Therefore, the sustainable use of common property pastures is analogous to common pool and public goods games, dependent upon the following actions of farmers:

- Change in livestock endowment: As livestock provides the means to harvest from common property pastures, farmers' livestock endowment determines potential appropriation and provision levels.
- Appropriation: The decision whether to send animals to the local common property pastures or have them graze in the valley.
- Provision: The work or capital farmers invest to maintain common property pastures and the related infrastructure.

To better understand the drivers behind individual's actions and the role of contextual variables for the use of common-pool resources, the study aims to answer the following questions:

a. What are the overall outcomes for change in livestock endowment, appropriation, and provision situations?
b. What are the individual attributes explaining behavioural differences?
c. How do broader contextual variables relate to the use of common property pastures?
d. What are the implications for the study of the commons and policy makers?

The paper is structured as follows: Firstly, we introduce the case study region and the institutions that influence and structure farmers' actions. Secondly, we describe the conceptual framework, expanding on microsituational and contextual variables, and the methods to study their impact on farmers' actions. Thirdly, we present the

regression models explaining change in livestock endowment, appropriation, and provision. Furthermore, we present the results from Q methodology, which show the impact of contextual variables on the sustainable use of common property pastures. Finally, we discuss the implications of the study for policy makers and further research.

2. The case study region

Grindelwald is a Swiss municipality in the canton of Bern covering 171 km², located in the heart of the European Alps (46° 37′ 32.98″ N, 8° 2′ 0.02″ E). With seven corporations self-governing the use of common property pastures, Grindelwald offers a natural lab-like setting for the study of appropriation and provision behaviour analogous to common pool and public good experiments (Table 1). Due to its natural beauty and snow sport facilities, Grindelwald is an internationally known tourism resort that attracts visitors all year round. Consequently, tourism is the most important source of income and offers diverse employment opportunities. Unlike other rural regions, the local population remains stable with about 3800 inhabitants. Besides tourism, agriculture, in particular dairy farming, manages to coexist with tourism, even if the number of farmers is steadily diminishing as a result of structural changes in the agricultural sector towards fewer, but larger sized farms. Since 1980, the number of farmers in Grindelwald has roughly halved from 242 to 123 in 2010. As a consequence, the average farm size has nearly doubled in terms of livestock and land holdings from about 5–6 to nearly 12 livestock units and hectares per household. Correspondingly, land use intensity on private grounds has been relatively stable in terms of livestock units per hectare, but has been significantly intensified in terms of cuts per year.

In addition to private land holdings, common property pastures provide an important source of animal feed. In the summer months, when farmers produce hay on their private lands for wintertime, the livestock grazes on common property pastures, looked after by herdsmen that produce artisan cheese from the milk. The herdsman is either the owner of the alp's huts himself or a seasonal employee. The fees farmers pay to the corporation for the care of the animals provides the

Table 1: Institutions for regulating appropriation and provision activities (Units in brackets; NST = a summered livestock unit).

Corporation Units	Maximum sustainable yield (NST)	Provision requirements (hours/NST)	Penalty for defection on provision (CHF/ hour)	Reimbursement of extra hours of provision (CHF/hour)
Grindel	251	8	25	22
Scheidegg	234	8	24	20
Wärgistal	167	8	25	25
Itramen	217	8	30	29
Bussalp	256	10	25	20
Bach	149	8	25	22
Holzmatten	74	8	25	25

herdsman's income. At the end of the season, the cheese stock is redistributed to the cattle owner according to the cows' milk yield.

2.1. Property arrangements

As Figure 1 shows, the productive area of Grindelwald is divided between 7 corporations ("Bergschaft"). The corporations separate their land into private property in the valley (inside the red dotted line) and common property in higher altitude regions (outside the red dotted line). The small corporation "Holzmatten" is a special case as its private lands are cut off from the common property. The large uninhabitable area to the southeast is the only municipal territory not assigned to a corporation, but instead is under the sovereignty of the canton of Bern.

2.2. Institutional arrangements

The corporations enforce institutions to regulate appropriation and provision activities. Ownership and leasehold of private land allows for appropriation of common property pastures (Naegeli-Oertle 1986; Mordasini and Tiefenbach 2006). All sections of land in the valley have rights attached to them that allow for appropriation in the corresponding corporation. Therefore, the location and the number of private plots formally restrict a farmer's appropriation activities. Since rights can be leased among locals at reasonable rates, appropriation is not restricted for locals, neither by the amount of rights nor by the exact location of private plots.
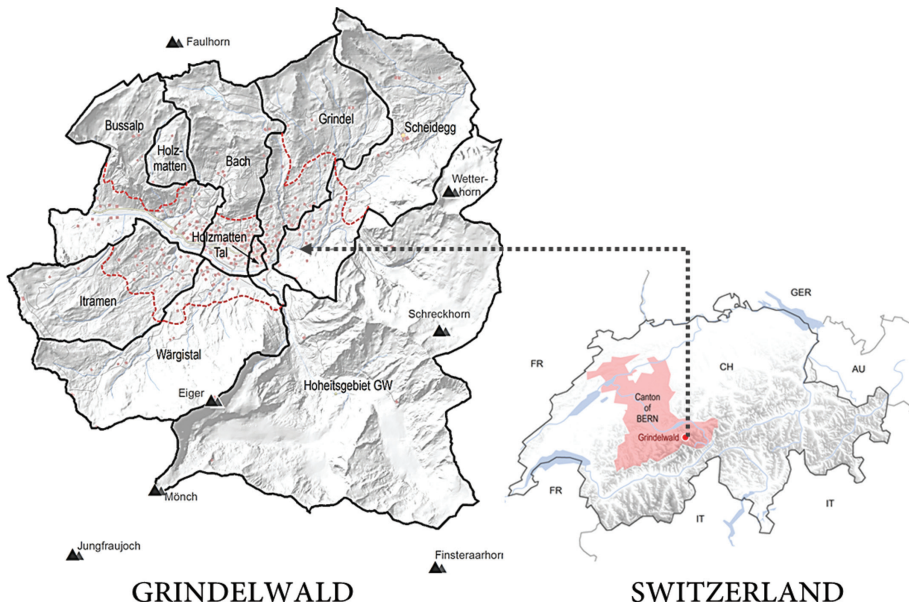

Figure 1: The case study region with the seven corporations (Source: Swisstopo).

In return for the benefits obtained from appropriation, farmers must carry out provision activities or face fines. Provision activities consist of tasks such as the cleaning of pastures from bush, shrubs and stones, the installation of fences and drinking troughs, the distribution of manure, and the maintenance of storage facilities (Mordasini and Tiefenbach 2006). As indicated in Table 1, corporations schedule the hours of provision activities required per appropriated unit, set out penalties for defection and reimburse for additional provision efforts if the budget allows for. Each corporation elects a monitor who sanctions defection on provision activities and organises additional provision activities. If defectors fail to settle fines within a year, they lose the right to appropriate from the common property pasture.

The maximum sustainable yield (MSY) is governed by agricultural policy through summering payments. The federal government subsidises each appropriated unit with CHF 320 per year, paid to the corporation. The subsidy must be reinvested to maintain the resource system and is incrementally reduced, if actual appropriation levels are above 10% or below 25% of the maximum sustainable yield as defined for the corporation. In Switzerland, the sustainable use of common property pastures is currently threatened by under- rather than by overgrazing which results in land abandonment and regrowth of forest and shrubs and consequently reduced bio- and landscape diversity. Summering payments therefore provide incentives for the corporation to keep grazing levels within a sustainable yield, including a lower and upper limit. The maximum sustainable yield is measured in appropriated units (NST). An appropriated unit corresponds to a livestock unit (GVE) summered for a hundred days. A livestock unit reflects an animal's weight and nutritional needs. Accordingly, a dairy cow represents one unit, young cattle of 1–2 years 0.4 units, cattle up to 1 year 0.2 units, sheep 0.25 units, and goat 0.2 units.

3. Methods

3.1. The Framework for analysing behaviour of common-pool resource users

This study uses the framework for analysing behaviour in commons dilemmas (Poteete et al. 2010). The framework build on the social-ecological systems framework proposed by Ostrom (2007, 2009), which compasses three levels of analysis: Firstly, the action situation with the users' behaviour; secondly, the microsituation with the behavioural drivers; thirdly, the broader social-ecological context, where the latter affects the outcome of the microsituation.

Figure 2 displays the framework focus on the action situation. Recent extensions of this framework highlight the adjacency of action situations (McGinnis 2011). As changes in livestock endowment determine potential appropriation and appropriation determines provision, the observed action situations are closely linked. The actions result in an overall intensity of use and maintenance of the common property pasture as the outcome. The microsituation refers to the users' actions driven by personal attributes (*U1...U10*). The broader social-ecological context determines the microsituation and consists of the second tier variables, which describe a social-ecological system
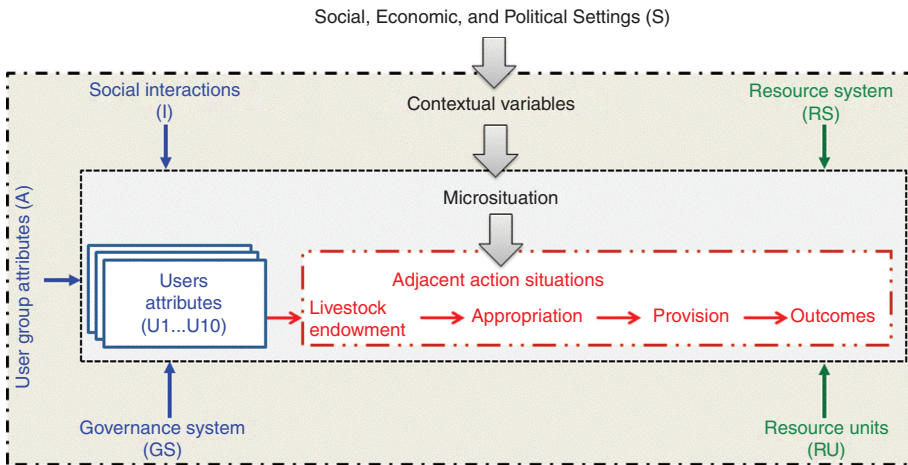
Figure 2: Conceptual model for analysing behaviour in adjacent action situations. Adapted and modified after Poteete et al. (2010, 220–239).

(Ostrom 2007). Consequently, contextual variables include external settings (*S*), the resource system (*RS*), the governance system (*GS*), the resource units (*RU*), users' attributes on the group (*A*) level, and social interactions (*I*) (Ostrom 2007; McGinnis 2011). As user attributes describe both group (*A*) and individual characteristics (*U*), they are part of the microsituation as well as of the broader context as group attributes.

3.2. Analysis of the microsituation

In the microsituation, users' attributes are the explanatory variables and the actions the dependent binary variables. Data was collected in a standardised survey carried out in the course of three weeks in summer 2011. Ninety-five questionnaires were collected from 125 registered local farmers, mostly at their home. The interviews lasted on average 105 minutes and were conducted in teams of two, with a graduate student leading the interview assisted by a bachelor student completing the questionnaire. We interviewed at least 50% of the farmers in each corporation. Only 6 of the interviewed farmers were female.

The dependent variables were cross-checked for reliability with census data and against information collected from the monitors in order to ensure data quality. Livestock endowment was compared as nominal and as binary measure. The survey data for appropriation in absolute numbers were extrapolated to population size and then compared with the census data. The measures for provision behaviour were also extrapolated and compared with the information from a survey conducted with monitors of the corporations (n=7). The main purpose of this survey was to gather data on land use change published in another study. In this survey, the monitors had to state the number of defectors for 2010 in their corporation. For measuring change in livestock endowment we referred to a timespan of ten years

(2000–2010) as it is constrained by fixed factors. As appropriation and provision are seasonal decision, we referred to the behaviour in the past season (2010).

3.2.1. Operationalization of explanatory variables

The explanatory variables consisted of second tier variables describing the users as proposed in the Social-Ecological Systems framework (Ostrom 2007, 2009; Poteete et al. 2010). Moreover, we added variable opportunity costs (U10) and operationalized the variables as follows:

U1- Number of users referred to the number of farmers in the corporation.

U2- Socioeconomic attributes include
   a) Age
   b) Marital status
   c) Successor: whether the farmer expected a family member to continue with the farm enterprise
   d) Area under cultivation
   e) Land use intensity for private plots
   f) Labour productivity of the farm enterprise

U3- History: a change in the farming strategy in the past ten years e.g. a switch in production standards or shift from dairy to mother cows.

U4- Location: geographic location of the farm. Since corporations with exposition North-East (Itramen, Wärgistal) are facing less demand for land from tourism, we expected agriculture to be more prosperous in that area.

U5a- Leadership referred to farmers holding a formal function within the corporation.

U5b- Entrepreneurship was measured as the pay-off per livestock unit resulting from the farmers' appropriation behaviour (equation 1).

$$\frac{\pi_i}{e_i} = x_i(\omega_i - c) + \alpha_i(e_i - x_i) - (MSY_{corp} - x_j)s\frac{x_i}{\sum x_j} \tag{1}$$

Farmers pay-off (π_i) per livestock unit (e_i) depended on their appropriation behaviour. For each livestock unit, the farmer decided to either send it to common property pastures (x_i), or have it graze on private land ($e_i - x_i$). Each appropriated unit (c) costs a fee of CHF 700 to compensate herdsman for the care and milking of the animal. The revenue of the appropriated unit (ω_i) is the farmer's revenue from cheese sales. The revenue from grazing a livestock unit on private land (α_i) equals the revenue of milk sales during the period. Since the corporation receives a subsidy (s) of CHF 320 per appropriated unit, the difference between maximum sustainable yield of the corporation (MSY_{corp}) and the actual appropriation levels in the corporation (x_j) results in foregone subsidies. We considered the forgone subsidies as costs that a farmer bears according to his share of the total appropriation in the corporation. ($x_i/\sum x_j$).

U6a- Norms measured the farmer's aversion against defection on communal work of joint-users.

U6b- Social capital measured the amount of voluntary labour available to the farmer. This included family and friends who do not live in the same household.

U7- Mental model referred to the identity of the individual regarding his profession. That is, whether the person considered his job title "Farmer" or not.

U8- Importance of resource reflected the household's dependence on agricultural income.

U9- Technology used referred to the production standard. Integrated production (*IP-SUISSE*) is the dominant production standard in the region and refers to a set of production requirements stricter than conventional, but more lenient than for organic farming.

U10- Opportunity costs measured the farmer's relinquished benefit from off-farm income when doing agricultural work (equation 2).

$$Opportunity\ cost = \frac{LA_i}{LO_i} * \frac{IO_i}{IA_i} \tag{2}$$

Whereas (LA_i) is the household's work hours allocated to agricultural activities divided by hours spent doing off-farm activities (LO_i), multiplied by the off-farm income (IO_i) over the agricultural income (IA_i).

3.2.2. Statistical procedure

We calculated binary logistic regression models to predict growth in livestock endowment, appropriation and provision behaviour based on the users' attributes. Binary logistic regression calculates the log of the odds for a dichotomous dependent variable by maximum likelihood (ML) estimation (Hosmer and Lemeshow 2000; Menard 2001) (equation 3):

$$Logit\ (Y) = \ln\left[\frac{P}{1-P}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k \tag{3}$$

Where:
P is the probability of the outcome for Y=1 (i.., growth in livestock endowment, full appropriation and provision)
β_0 is the constant in the model
$X_1...X_k$ represent the explanatory variables
$\beta_1...\beta_k$ represent the coefficients for the respective explanatory variables

To estimate the parameters of the model, we first calculated full models including all explanatory variables. As we had solely 89 data points for the variable labour

productivity (*A2e*) and 84 data points for the variable opportunity costs (*A10*), we omitted the two variables if not of significant explanatory power when calculating the reduced models. Thirdly, we estimated the parameters for the reduced models by maximum likelihood. The reduced models were selected by Bayesian Information criterion (BIC). Test statistics included for all models a non-significant Pearson Chi-squared, and significant Chi-squared tests. Lastly, we calculated standardised beta weights based on the mean of the predicted probability and the standard deviation of $x_1...x_k$ (King 2007). The standardised beta transformed the coefficients into "standard deviation units" that allowed for scale-free comparison of binary and nominal variables (Menard 2004). The analysis was performed with the software package SPSS, Version 20.

3.3. Analysis of the broader contextual variables

We then applied a Q method approach to analyse the impact of contextual variables on the ecological, economic, and social sustainability of the social-ecological system. Originating in psychology, this method has been applied to a variety of social-ecological problems aiming to develop detailed portraits about people's perspectives on a given problem (Swaffield and Fairweather 1996; Paula 2006; Swedeen 2006; Doody et al. 2009). As the local farmers were deemed to have the best knowledge about the way contextual variables affect the use of common property pastures, Q methodology was chosen to extract that knowledge by means of a five-step procedure.

i. Problem definition: Based on literature review and explorative interviews, we identified 34contextual variables that potentially affect the use of common property pastures. We identified 9 variables describing the external setting (*S*), 10 variables for the local governance system (*GS*), 3 for the resource system, 2 for the resource units (*RU*), 5 for interactions (*I*), and another 5 describing the group attributes of the users (*A*).

ii. Formulation of statements and definition of the sorting scheme: We used contextual variables instead of normative statements and decided that farmers should group the variables on a scale according to their perceived impact on the sustainable use of common property pastures. The scale ranged from +4 to −4, with the most positive impact at +4 and the least positive impact at −4 (Table 2).

iii. Selection of subjects: For our purpose, sampling included the people best informed and most affected by the problem under concern (Rajé 2007). Thus, we selected the seven monitors and four additional farmers for participation.

iv. The sorting procedure (Q sorting): Before sorting, we asked farmers to divide statements into three piles according to their impact on the use of common property pastures; one with variables considered to have a

Table 2: Q sorting scheme.

Q sorting scheme	Least positive impact								Most positive impact
Statement ranking	−4	−3	−2	−1	0	1	2	3	4
Number of statements	2	3	4	5	6	5	4	3	2

positive impact, one with variables considered to have a negative impact, and one with neutral variables. We simply asked farmers to evaluate whether the variables have a positive or negative or neutral impact on the use of common property pastures instead of mentioning sustainability. This pre-sorting mostly resulted in unequally distributed piles. Farmers then had to rank the statements on the scheme (Q sorting). During sorting, we asked farmers to comment on the reasoning for the placement which was recorded. At the end of sorting, farmers were given the opportunity to reflect on their choices and to reallocate variables. In order to qualitatively understand the impact of the variables on the different sustainability dimensions and on the functioning of the overall social-ecological system, we finally discussed sorting with the farmers. We then photographed the Q sorts and computed them later on.

v. Factor analysis and interpretation of results: We analysed the collected samples using the standard PQ Method software, Version 2.31. We calculated the mean z-scores for each statement and the corresponding rank to represent the aggregate view. Additionally we conducted a principal component analysis that generated 8 factors of which 4 had an Eigenvalue bigger than 1. As all subjects loaded significantly on one of the two factors with the highest Eigenvalues, we considered these two factors for Varimax rotation, which finally displayed the two most contrasting views (Fairweather and Swaffield 2001; Paula 2006).

4. Results

4.1. Descriptive statistics of the microsituation

Table 3 presents the measures for the dependent variables by corporation. Farmers with increasing livestock endowment outweighed farmers with decreasing endowment. The majority of farmers appropriated their entire endowment. Among the farmers with reduced appropriation strategy, nine farmers didn't appropriate at all and were therefore exempt from provision duties. The 86 farmers with provision duties showed strong tendencies towards full accomplishment of provision. On an aggregate level, all corporations achieved sustainable appropriation levels in terms of compliance with the range of state defined sustainable yields (75%−110% of optimal yield). The most intensive appropriation levels were observed in the

Table 3. Descriptive statistics for dependent variables listed per corporation.

Corporation	Livestock endowment		Appropriation		Provision	
	Reduced	Growing	Reduced	Full	Reduced	Full
Grindel	3	9	3	9	2	9
Scheidegg	7	8	7	8	2	12
Wärgistal	3	7	2	8	0	9
Itramen	7	11	10	8	0	18
Bussalp	9	12	10	11	1	19
Bach	6	4	3	7	1	8
Holzmatten	8	1	4	5	0	5
Total	43	52	39	56	6	80
(%)	(45%)	(55%)	(41%)	(59%)	(7%)	(93%)
Cronbachs-α	0.958		0.874		0.723	

corporation Scheidegg with 107% of maximum sustainable yield and lowest for Bach with 82% of maximum sustainable yield. Since no corporation showed a serious amount of defectors, overall provision activities are very close to the institutionally determined maximum. Therefore, both actions can be considered ecologically sustainable.

As indicated by the Cronbach's-α, survey data show very good to satisfying reliability for dependent variables if compared with census or respectively monitors information. Livestock endowment ideally matches census data if coded as binary. However, our sample shows a nominal increase in total livestock endowment by 9%, while the census shows a reduction of 8% from 2000 to 2010. Therefore, farmers with growing livestock endowment are slightly over-represented in the sample. The comparison of appropriation data with the census also shows good reliability with Cronbach's-α at 0.874. The provision data shows lower reliability with Cronbach's-α at 0.723, as monitors indicated 15 defectors, whilst our sample included six. The reason for the deviation is that our sample includes local farmers only while the monitors also referred to 8–10 external farmers, which, according to monitors, are more likely to defect on provision activities.

Table 4 shows the descriptive statistics for farmers' attributes considered in the regression models. Farmers were on average 51.6 years old (*U2a*) with a mean cultivated area (*U2c*) of nearly 12 hectares. Typically, farmers held one livestock unit per hectare (*U2d*). According to the farm size index (SAK), a farm of this size can be managed by one person. The mean value for labour productivity (*U2e*) indicates that it took in fact two persons to run the farm, including the work of partners and voluntary labourers. With regard to family structure, most farmers were married (*U2b*) and often counted on voluntary labour (*U6b*) provided by their own children, grandparents, or neighbours but rarely expected family succession (*U2f*). Importance of resource (*U8*) shows that most farming

Table 4: Descriptive statistics for explanatory variables.

Farmers' attributes	Description	N	Mean	SD
U1- Number of users	Number of farmers in the corporation to which the farmer belongs	94	21.45	4.73
U2- Socioeconomic attributes of users	a) Age of farmer – Nominal (years)	95	51.62	12.28
	b) Marital status – Binary variable. Value 1 if farmer is married	95	0.75	0.44
	c) Area under cultivation – Nominal (ha)	94	11.93	7.84
	d) Land use intensity for private plots – Nominal (GVE/ha)	95	0.98	0.37
	e) Labour productivity – Effective working hours / work time needed according to farm size index (SAK)	89	0.5	0.29
	f) Successor – Binary variable. Value 1 if farmer thinks that there will be a successor in the family willing to continue with the farm business.	95	0.27	0.45
U3- History of use	History – Binary variable. Value 1 if farmer has changed the farming strategy within past 10 years.	95	0.67	0.47
U4- Location	Location – Binary variable. Value 1 if the farmer is located exposition North-East.	94	0.31	0.46
U5- Leadership/ entrepreneurship	a) Leadership – Binary Variable. Value 1 if the farmer has a formal function within the corporation	95	0.32	0.47
	b) Pay-off per GVE during summering season – Nominal variable (CHF)	94	149.1	533.6
U6a- Norms	Norms – Binary variable. Value 1 if the farmer dislikes other farmers avoiding communal work and paying fines instead.	94	0.45	0.5
U6b- Social capital	Social capital – Percentage of voluntary labour available to the farmer when needed (excluding their partners).	95	64.16	56.43
U7- Mental models	Mental model – Binary variable. Value one if the farmer considers his job title to be "Farmer".	94	0.64	0.48
U8- Importance of resource	Importance of resource – Share of agricultural income in proportion to total household income	95	36.78	29.46
U9- Technology used	Technology – Binary variable. Value 1 if the farmer produces according to IP standards.	95	0.68	0.47
U10- Opportunity costs	Opportunity costs – Share of agricultural working hours in relation to total working hours divided by the share of agricultural income in proportion to total income.	84	2.92	3.26

households substantially relied on off-farm income and no household relied solely on agricultural income. With regard to their pay-off (*U5b*), farmers differed widely, as the function allows for negative values. Farmers that appropriated non-milked animals or used a substantial amount of the cheese for their own consumption did not cover the costs of their appropriation decisions. The variable importance of resources shows that farmers in the region have good off-farm income opportunities. On average, their earnings per hour off-farm work triple the earnings from agricultural work. The sample also includes 11 retired farmers that have no opportunity costs (*U10*) for farming activities.

4.2. Regression model for change in livestock endowment

Table 5 lists variables significantly associated with change in livestock endowment. Considering the Bayesian Information Criterion (BIC), the model with 4 variables offers the best fit to the data in relation to the variables included. The β-values reveal positive effects for marital status (*U2b*) and area (*U2c*), and negative effects for age (*U2a*) and norms (*U6a*) on the odds of increasing livestock endowment. The standardised β-values display the actual effect of the variables in the model, irrespective of scale.

As indicated by the standardised β, area is the strongest predictor for change in livestock endowment. With every additional hectare of cultivated area (*U2c*), the odds for livestock growth increased by 17.5%. This suggests that size conditions growth and those farmers with larger sized farms are more likely to attempt to realise economies of scale than colleagues with smaller landholdings.

Age proved to be the second best predictor for change in livestock endowment, as an additional year of life reduced the odds for livestock growth by 7.8%. This relationship might be partly linked to farmers' fitness and partly to policies. As age (*U2a*) is negatively correlated with labour productivity (*U2e*), decreasing physical abilities possibly forced some farmers' to reduce livestock endowment. Additionally, farmers receive substantial direct payments until retirement age. This suggests that farmers' willingness to invest in factors constraining livestock endowment such as barn capacity or land decreases as they approach retirement age. The main reason might be that without direct payments, such investments are likely to become untenable.

Table 5: Estimated and standardised β-coefficients for binary logistic regression models predicting change in livestock endowment. Standard errors (se) in brackets and significance levels p are indicated by asterisk (99%***, 95%**, 90%*).

Explanatory Variable	β (se)	βˢ
U2a- Age	−0.081 (0.026)	−0.230***
U2b- Marital status	1.602 (0.645)	0.163**
U2c- Area	0.161 (0.048)	0.288***
U6a- Norms	−1.354 (0.576)	−0.158**
Constant	2.358 (1.339)	
N	94	
Pseudo R² (NK)	0.514	
−2LL	82.6	
BIC	105.2	

Growth in livestock endowment was also associated with marital status (*U2b*). For married farmers, the odds for endowment growth increased 4 times. This suggests that partnership facilitates dealing with the extra workload resulting from additional livestock. Rather surprisingly, norms (*U6a*) which display positive attitude towards the fulfilment of provision activities decreased the odds for endowment growth by a factor of 0.24. This suggests that with growth in endowment, the concern for the maintenance of common property decreases.

4.3. Regression model for appropriation behaviour

Table 6 presents the variables significantly associated with appropriation behaviour. The β-values show a positive association of marital status (*U2b*) and norms (*U6a*) and negative association of area (*U2c*) and leadership (*U5a*) with full appropriation. As displayed by the standardised beta weights, norms (*U6a*) are the best predictor for appropriation behaviour followed by leadership (*U5a*), marital status (*U2b*), and area (*U2c*).

We found the strongest association to be between norms (*U6a*) and appropriation behaviour. Hence, farmers with aversion against defection on communal work had 2.4 times higher odds for appropriating all their livestock which points to self-interest. A farmer appropriating all his livestock is likely to be more concerned about the state of the resource and therefore also cares about joint-users fulfilling their provision activities. Leadership attributes (*U5a*) assigned to farmers with formal function in a corporation reduced the odds for full appropriation by a factor of 0.38. As farmers communicated, reduced

Table 6: Estimated and standardised β-coefficients for binary logistic regression models predicting appropriation. Standard error (se) in brackets, significance levels indicated by asterisk (99%***, 95%**, 90%*)

Explanatory Variable	β (se)	β^s
U2b- Marital status	0.916 (0.522)	0.096*
U2c- Area	−0.038 (0.032)	−0.073*
U5a- Leadership	−0.945 (0.524)	−0.106*
U6a- Norms	1.253 (0.484)	0.150***
Constant	−0.045 (0.599)	
N	93	
Pseudo R^2 (NK)	0.220	
−2LL	109.0	
BIC	131.6	

appropriation lessens workload. In this case, mostly younger cattle are kept in the valley to graze unproductive pastures for which mowing is labour intensive. Possible explanations would therefore be that leaders cultivated more marginal pastures or tended to have younger animals.

Socio-economic attributes such as marital status (*U2b*) and area (*U2c*) were also significantly associated with appropriation behaviour. Married farmers were 1.5 times more likely to appropriate their full endowment, while an additional hectare of area leads to a decrease in the odds of full appropriation by 3.7%. The reasoning for both variables again might point to the role of workload. When hay collection and provision duties can be split among couples during peak times, appropriation behaviour of married farmers might be less determined by labour scarcity. The need to reduce workload might also increase with area (*U2c*), leading farmers with larger land holdings to reduce appropriation and concentrate on private lands.

4.4. Regression model for provision behaviour

Table 7 displays the reduced model for provision behaviour. The models entail fewer cases, as farmers without appropriation were exempt from provision activities. The uneven distribution of the dependent variable explains larger standard errors. Stepwise reduction points to area (*U2c*), followed by pay-off (*A5b*), and importance of resource (*A8*) as the most important predictors.

The strongest association existed between area (*U2c*) and provision behaviour. That is an increase in land holding by an additional hectare reduced the odds of full provision by 19.2%. The negative effect of land holding on provision suggests that extra workload resulting from additional plots prevents farmers from accomplishing their provision duties. Regarding the beta coefficient, an

Table 7: Estimated and standardised β-coefficients for binary logistic regression models predicting provision behaviour. Standard error (se) in brackets, significance levels indicated by asterisk (99%***, 95%**, 90%*)

Explanatory Variable	β (se)	β^s
A2c- Area	−0.213 (0.116)	−0.127**
A5b-Pay-off	0.003 (0.001)	0.108**
A8-Importance of resource	0.048 (0.027)	0.103*
Constant	3.734 (1.223)	
N	86	
Pseudo R² (NK)	0.248	
−2LL	34.6	
BIC	52.4	

additional Swiss franc in pay-off (*U5b*) increased the odds of full provision by 0.3%. Although this seems negligible, the standardised coefficient illustrates that with a coarser scale, the effect would have become more pronounced. Moreover, importance of resource shows that an increase in agricultural income of 1% compared to non-agricultural income, increased the odds of full provision by 4.9%. The positive association of pay-off (*U5b*) and importance of resource (*A8*) with full provision suggests a strong positive relationship between the benefits obtained from a resource and farmers' willingness to maintain it.

4.5. The impact of contextual variables on the sustainable use of common property pastures

Table 8 shows the impact of contextual variables on the sustainable use of common property pastures in terms of ecological, economic, and social outcomes. The Mean value represents the overall sample, while Factor A and B represent the most distinguishing views. According to the overall sample, sustainability is promoted in particular through the functioning of the subsystems resource units (*RU*) and to a lesser extent by group attributes (*A*). The subsystem challenging sustainability includes the external settings (*S*), the resource system (*RS*), and interactions (*I*). The role of the governance system (*GS*) is neutral.

The mean value for the external settings reflects discontent with agricultural policies. Both government resource polices (*S5*) and market incentives (*S6*) achieve negative scores. The most problematic issues include dependence on direct payments, regulations for obtaining them and the milk price. In summary, farmers see government support and the relevant regulations as threatening entrepreneurial freedom and would instead appreciate stronger market incentives. Among government policies, only summering payments contribute to sustainability and provide financial resources to the corporation for the maintenance of the resource system. The mean value for income opportunities in the tourism sector shows the importance of off-farm income for farmers' livelihoods. Accordingly, tourism rather enables than competes with farming, even though in the resource system (*RS*) increasing demand for building sites, reduces available productive agricultural land. Within the governance system (*GS*), the local constitutional rules (*GS7*) are considered to have a positive impact, including the recent opening of common property pastures to non-local users. Thus, the presence of foreign cattle is not a desired development, but a necessary response to decreasing local livestock. Furthermore, the agricultural sector faces decreasing standing in municipal politics.

Resource units (*RU*) achieve the highest scores, as their economic value (*RU4*) provides incentives for the use of common property pastures. Particularly the added value in the production of alpine cheese compared to milk sales motivates appropriation. The main reason for the high added value of alpine cheese is sales opportunities resulting from the demand strengthened by the local tourism sector. Besides high scores for the resource units, users' group attributes (*A*) also achieved a slightly positive score. Surprisingly, interviewees consider the group

Table 8: Normalised factor scores for contextual variables on ordinal scale ranging from +4 indicating the most positive impact to −4 indicating the least positive impact of the variables on the sustainable use of common property pasture. The Mean values refer to the overall sample, while Factors A and B display the most distinguishing views. Asterisks mark the variables distinguishing Factors at a significance of 99%. Values for subsystems and second tier variables are calculated by means of the referring statements.

Contextual variables	Normalised scores		
	Mean	Factor A	Factor B
External Settings (S)	**−0.7**	**−0.7**	**−0.1**
S5- Government resource policies	−0.7	−0.2	0
Dependence on agricultural income*	−1	−3	4
Direct payments tied to livestock*	−1	2	−2
Direct payments tied to private land*	0	0	3
Ecological regulations for obtaining direct payments*	−3	0	−4
Rules for the obtainment of summering payments*	−1	−3	1
Summering payments*	2	3	−2
S6- Market incentives	−0.7	−1.7	−0.3
Off-farm income opportunities in the local tourism sector	4	3	2
Dependence upon direct payments*	−4	−4	0
Milk price	−2	−4	−3
Resource System (RS)	**−0.3**	**−0.7**	**−0.7**
RS3- Size of resource system	−0.5	−1	−1.5
Availability of agricultural area in the valley	−2	−1	−2
Area of the corporation	1	−1	−1
RS5- Productivity of system			
Quality of common property pastures	0	0	1
Governance System (GS)	**0**	**0.3**	**0.4**
GS3- Network structure	−0.7	1	1.3
Recognition of agriculture by local politics	−3	−1	−1
Reimbursements of railway operators to the corporations	0	2	2
Solidarity between the corporations	1	2	3
GS4- Property rights system	−0.7	−0.3	−0.7
Flexibility and lease of use rights*	0	−2	1
Amount of use rights in relation to the stock of animals present in the valley	−2	1	0
Attachment of use rights to private parcels in the valley*	0	0	−3
GS5- Operational rules	0.3	−0.3	−0.7
Hours of communal work to be conducted	2	1	1
Opening of the common property pastures for foreign cattle*	3	0	−2
Presence of foreign cattle on the common property pastures	−4	−2	−1
GS7- Constitutional rules			
Rules of the local constitution*	3	2	4
Resource Units (RU)	**3.5**	**4**	**1**
RU4- Economic value	3.5	4	1
Added value of alpine cheese*	4	4	2
Marketing and sales opportunities*	3	4	0

Table 8: Continued

Contextual variables	Normalised scores		
	Mean	Factor A	Factor B
Group attributes of Users (A)	**0.4**	**0.4**	**−1.2**
A1- *Number of users*	1	1	−1
Number of farmers*	2	1	−1
Share of locally born and raised farmers*	−1	0	−1
A5- *Leadership/entrepreneurship*	1	2	0
Farmers innovative abilities and entrepreneurship	1	1	0
Leadership within the corporation	1	3	0
A7- *Knowledge of SES*			
Know-how of the employees on the Alp*	−1	**−3**	−1
Interactions (I)	**−0.4**	**−1**	**0.6**
I3- *Deliberation process*	0	−2	0
Common values and goals for administering corporations*			
I4- *Conflicts among user*	−2	−2	3
Negotiability of conflicts on the local level*			
I5- *Investment activities*	1.5	0	1.5
The amount of resources invested into the infrastructure	2	1	2
Willingness to fulfil provision requirements*	1	−1	1
I7- *Self-organizing activities*			
Cohesion and solidarity among the farmers*	−3	−1	−3

of farmers to be large enough, although the number of farmers (*A1*) is constantly decreasing. Interactions (*I*) were valued slightly negatively. Farmers complained of solidarity among themselves (*I3*), negotiability of conflicts (*I4*), cohesion (*I7*), and, while infrastructural investments (*I5*) and willingness to fulfil provision activities achieved positive scores.

4.5.1. Disagreement regarding the impact of contextual variables
As indicated by Factors A and B in Table 8, we identified two groups of farmers with different perceptions regarding the role of contextual factors for the sustainable use of common property pastures. Factor A represents a liberal market-oriented view and Factor B represents a traditional view. Their views differ mostly with regard to the functioning of the government's resource policies (*S5*) and interactions (*I*). The liberal viewpoint is closer to the overall sample with an Eigenvalue of 2.89 and seven people loading on it. The traditionalist view achieves an Eigenvalue of 2 with four people loading on it.

    The liberal viewpoint displays preferences for market incentives (*S6*) resulting from interrelations with tourism accompanied by scepticism against agricultural policies. Accordingly, the tourism sector supports local demand for alpine products and off-farm income opportunities to reduce dependence on agricultural income and direct payments. Overall, the liberal viewpoint claims that an external setting (*S*), which offers more room for market forces and entrepreneurial freedom enhances

the sustainable use of common property pastures. The estimation of the economic value of resource units (*RS*) as incentives for the sustainable use of common property pastures underlines the market-oriented perspective. According to their perception, higher returns for alpine products determines farmers' willingness to use and maintain the Alps sustainably and was considered the best means to prevent land abandonment. In contrast, increasing governmental regulations cause higher transaction costs with governmental agencies, for example through controls, and furthermore requires unproductive investments to meet the prescribed standards, which are often considered bureaucratic burdens that interfere with sustainable traditional practices. In accordance with preferences for market incentives, the liberals show less concern over the presence of foreign cattle, but more concern over interactions (*I*) among farmers. Particularly common values (*I3*) and goals in negotiating affairs in the corporations and the negotiability of conflicts (*I4*) on the local level achieve negative scores. Such conflicts arise mostly over the organisation of sales activities or the management of the resource system in co-existence with tourism. The latter includes questions such as whether to allow tourist infrastructure such as ponds, artificial snow production or new trails and restaurants.

In contrast to the liberal view, the traditional view shows preferences for a closed agricultural system and livelihood focused on income from agriculture. The traditionalist viewpoint considers a dependence on agricultural income and direct payments tied to private plots to foster the sustainable use of common property pastures. Although the traditionalists are critical about the regulations for obtaining direct payments, they acknowledge that government support secures agricultural livelihoods. According to the traditional view, an external setting (*S*) that relies on heavy government support, enables agricultural livelihoods and thus promotes the sustainable use of common property pastures. Furthermore, traditionalists prefer a closed self-organised system as represented by the strong positive value of constitutional rules (*GS7*) and the possibility of leasing use rights among farmers. In terms of opening the system, traditionalists are concerned about the presence of foreign cattle and the number of farmers and their origin. They are concerned that the opening of the system might endanger the local cohesion and self-organisation.

5. Discussion

The behaviour of individuals in social dilemmas is a central puzzle in the study of the commons (Poteete et al. 2010; Anderies et al. 2011). Since information about behavioural drivers derives mostly from experimental research, this study aims to complement experimental findings with field observations from Grindelwald, Switzerland. In doing so, we estimated regression models from survey data to predict the behaviour of alpine farmers regarding change in livestock endowment, appropriation, and provision. Data showed that a slight majority of farmers (55%) increased endowment and applied full appropriation strategy (59%). Completion of provision activities was remarkably high (93%).

As summarised in Table 9, behaviour depended significantly on diverse user attributes. Socio-economic attributes, in particular age (*U2a*), marital status (*U2b*), and area (*U2c*), explained farmers' changes in livestock endowment. The role of age and marital status is best explained by their effect on work organisation, as youth and partnership allow the handling of larger endowments. Furthermore, the variable area suggests that farm size itself is the strongest predictor for endowment growth. The key role of area and also age in determining farm development is widely confirmed in the literature and indicates structural change towards fewer but larger sized farms (Baur 1999; Weiss 1999; Lauber et al. 2008). Other variables found to be associated with farm development such as presence of a successor (Potter and Lobley 1996; Mann 2003), opportunity costs, and labour productivity (Schmitt 1992), did not have a significant effect upon livestock endowment in the study region. Furthermore, the negative association of area with appropriation and particularly with provision behaviour suggests that farmers with larger sized farms concentrate labour on private property and reduce the use of common property. Likewise, farmers with larger land holdings are more likely to defect. As discussed, reduced appropriation reduces workload in two ways. Firstly, marginal private pastures are grazed by animals instead of labour intensive hay production. Secondly, lower appropriation reduces provision requirements.

Appropriation behaviour showed the strongest association with norms (*U6a*) – measured as farmers' aversion against defection on provision, assuming individuals with a full appropriation strategy are more concerned about the

Table 9: Direction of significant effects of individuals attributes on behavior in social dilemmas as calculated by binary logistic regression (99%***, 95%**, 90%*). Additionally, the effects of contextual variables on the sustainable use of common property pastures as calculated by Q Method are indicated by arrows (↙moderate negative; ↔neutral; ↗moderate positive; ↑positive)

Method	Regression Models			Q Method
Variables	Livestock endowment	Appropriation	Provision	Outcomes
U2a- Age	(−)***			
U2b- Marital status	(+)**	(+)*		
U2c- Area	(+)***	(−)*	(−)**	
U5a- Leadership		(−)*		
U5b- Pay-off			(+)**	
U6a- Norms	(−)**	(+)***		
U8- Importance of resource			(+)*	
S- External setting				↙
RS- Resource system				↙
GS- Governance system				↔
RU- Resource units				↑
A- Group attributes of users				↗
I- Interactions				↙

productivity of the resource and consequently hold stronger norms towards provision fulfilment. Self-interest might equally explain the association of pay-off (*U5b*) and the importance of resource with full provision behaviour. Hence, the willingness of individuals to maintain a common-pool resource increases the more an individual relies on the resource for his livelihood and the higher the generated pay-offs.

To assess the impact of contextual variables on the sustainable use of common property pastures, we applied Q methodology. Among the contextual variables, the value of resource units (RU4) was considered to have the most positive impact on the sustainability of common property pastures. As the economic value affects an individual's pay-off ability, we have reason to assume that a close positive relationship exists between the value of resource units and the fulfilment of provision activities. Tourism helps strengthening local demand and the economic value of resource units, and thus pay-offs. Furthermore, tourism allows for livelihoods with balanced agricultural and off-farm activities reducing the need to increase farm size, which is assumed to reduce use and maintenance of common property pastures. With regard to the perception of external settings (*S*), farmers differed significantly in their views. A liberalist viewpoint was identified that favours price incentives over governmental support, while the traditional view assumes that sustainability of common property pastures is promoted by strong governmental support securing agriculture-based livelihoods.

5.1. Implications for policy makers

The study provides further evidence that structural change towards fewer but larger sized farms results in decreasing use and maintenance of common property pastures (Gellrich et al. 2007). As average farm size increases, farmers reduce appropriation levels, resulting in an overall reduction of provision activities. Furthermore, the defection rate is likely to increase as farms grow bigger. To balance the reduced use resulting from structural change, we see three major policy options: (i) within the local governance system (*GS*), a further opening of the pastures and active acquisition of cattle from the lowlands; (ii) regarding external settings (*S*), stronger incentives for summering particularly of younger cattle; and (iii) policies for increasing the value of resource units. The further opening of pastures is likely to have some undesirable consequences. As the monitors stated, external users are more likely to defect on communal work and pay fines instead. This might lead to situations, where appropriators and maintenance providers become two separate groups, with external appropriators paying fees for defection on provision that might be used by the corporation to reimburse local farmers for provision. It is likely that both the quantity and quality of provision activities might then decrease as incentives, for provision are closely linked to appropriation levels. Furthermore, the Q method results for the governance system (*GS*) showed that farmers consider the presence of foreign cattle an undesirable, but necessary, as foreign cattle is less suitable to alpine conditions. Therefore, policies should

target incentives to foster the appropriation of local cattle with focus on younger cattle in particular, which are often left grazing in the valley. Furthermore, the maintenance of common property pastures depends on farmers' pay-offs, which are determined by the economic value of resource units. As a consequence, marketing tools for alpine dairy products should be considered as a policy option. A clear communication of the non-industrial production process and of the added cultural and ecological values potentially secures demand and prices for alpine products which are crucial for the sustainable use of common property pastures.

5.2 Implications for the study of the commons

5.2.1. Variables associates with appropriation and provision behaviour

Ostrom identifies six user attributes (*U1*, *U2*, *U5*, *U6*, *U7*, *U8*) that are potentially important for the sustainability of social-ecological systems (Ostrom 2009; Poteete et al. 2010). Although these variables relate to successful self-organisation of groups, our study expands on how the variables promote sustainable interaction of users with the ecological system. Along the lines of the framework, entrepreneurial attributes (*U5*), norms (*U6*) and importance of resource (*U8*) were central behavioural drivers in our study that relate to Ostrom's findings. According to Ostrom, presence of leaders and entrepreneurship in a group facilitates self-organisation; our study shows that entrepreneurship has a positive impact on fulfilment of provision duties, while leaders (defined as those who hold a formal function in a corporation) are more likely to apply reduced appropriating strategies. The latter is mostly context-specific, as leaders tend to be those with a long regional family tradition who own the ancient "Vorsassen" located on the border to common property; these private plots are generally less productive and difficult to mow and thus particularly suited for grazing younger animals. Furthermore, Ostrom shows that groups with shared moral and ethical norms face lower transaction costs for self-organisation. Our study reveals that with higher appropriation levels, users develop stronger norms for the maintenance of the resource which suggests that they show more commitment to leading self-organising and monitoring activities. Furthermore, users depending on a resource for their livelihood are more willing to invest in the maintenance of the resource, which is shown in the provision model. In contrast to the Ostrom framework, the variables number of users (*U1*) and mental models (*U7*) had no significant impact in our case. This is probably due to the heterogeneous group size of corporations and the fact that the mental model, which measured the farmers' identity, does not significantly affect farmers' actions. We expected that individuals, who define farming as their main occupation, are more likely to run growing enterprises, show higher appropriation and provision levels, which proved not to be the case. Recent studies propose an understanding of mental models as the inner representation of the external world (Jones et al. 2011). Q-methodology is a valid tool to elaborate on individuals' mental models. Unfortunately, our study design does not allow us to draw conclusions on how the perception of the functioning

of the social-ecological system (e.g. liberalist view) relates to actual behaviour. Nevertheless, mental models constitute a central part in the study of social-ecological interactions that can be equally addressed in experimental research (Lynam et al. 2012). Similarly, the variable opportunity costs of farming (*U10*) that we added to the framework did not significantly affect behaviour.

5.2.2. Implications for commonpool and public good experiments

The study provides implications for future experimental research exploring appropriation and provision problems. Most importantly, our findings suggest that appropriation and provision behaviour is closely linked through norms (*U6a*) and pay-offs (*U5b*). People with higher appropriation levels hold stronger norms regarding the provision fulfilment of joint users. Thus, we hypothesise that individuals with higher appropriation levels are more willing to invest in the monitoring and sanctioning of provision defectors in public good experiments. Experiments have shown that sanctioning possibilities increase corporation (Falk et al. 2002; Nikiforakis and Normann 2008), that individuals willingness to invest in sanctioning is best explained through inequality aversion (Fehr and Gächter 2000) and that even externals who do not benefit from public good provision make substantial investment for punishing defectors (Fehr and Fischbacher 2004). Nevertheless sanctioning has not been interpreted as an altruistic act to increase common welfare, but rather rooted in the desire to invoke costs on defectors (Bowles and Gintis 2002). Our results suggest that self-interest might be of central importance for sanctioning behaviour as those with highest appropriation rates hold the strongest norms regarding the corporation of joint users for the provision of public goods. Therefore, future experiments might test if individuals' investment levels are indeed positively associated with higher willingness to punish defectors in public goods games. Furthermore, the study suggests that people with higher pay-offs from appropriation will make higher investments into the public good. This finding relates to public good experiments, where investments increase with marginal returns (Isaac and Walker 1988; Isaac et al. 1994; Janssen and Ostrom 2006) but is contrasted by a study showing that individuals with higher income contribute less (Chan et al. 1996). Therefore, future experiments might consider linking common-pool experiments with public good experiments to test, if individuals with higher appropriation pay-off make larger investments into the public good.

5.2.3. Methodological challenges in linking behaviour to context

As this study observed behaviour for a single period, longitudinal studies are needed to observe the behaviour repeatedly and relate it to actions of joint users. Such studies will allow the inclusion of variables such as reciprocity, which is considered crucial for behaviour in experimental studies (Rustagi et al. 2010; Gächter and Thöni 2011) and whether predicted patterns of strategies towards concentration of either full or cero contribution (Janssen and Ahn 2006) can be equally observed in the field. Furthermore, additional studies on individuals'

behaviours are needed in the context of other common-pool resources to further theorise the interplay of microsituational and contextual variables and the way they determine behaviour. In our study, individuals are guided by robust institutions (Baur and Binder 2013). It might well be that our findings do not apply to a social-ecological context, where incentive structures are entirely different, in particular in settings, where over-exploitation and under-provision are dominant modes of behaviour. Therefore, it remains a methodological challenge to control for the impact of contextual variables on behaviour. Q methodology was used in this study to elaborate on the role of different contextual variables and on the different dimensions of sustainability of the SES. Given the notion of Q methodology that the number of distinct viewpoints on a given topic is limited (Van Exel and de Graaf 2005), we decided to extract knowledge from the people best informed using a rather small sample. The sharp distinction between the two views that we found as confirmed by the individuals' factor loadings increases confidence that the results from Q method best represent the farmers' views.

Unfortunately, the study design does not reveal how differences in the perception of contextual variables link to the observed behaviour on the individual level as this would require a larger sample of the q method to gather more data points for the individuals in order to make reliable predictions. Future studies adopting the same combination of methods would potentially benefit from including not only resource users, but also external experts on the topic from governmental, NGO or science for sampling. Experts might provide different perspectives that would allow distinguishing between farmers and experts opinions more clearly.

6. Conclusion

This study offers explanations about the way personal attributes affect individuals' use of common-pool resources. It thus elaborates on the general framework of studying social-ecological systems and laboratory experiments, which simulate appropriation and provision problems. Our findings suggest that socio-economic attributes (*U2*) determine the endowment of resource users and provision activities. Norms (*U6a*) and pay-off (*U5b*) determined appropriation and provision behaviour. The analysis shows that individuals, who appropriate intensely, hold stronger norms towards maintaining the resource stock and as a result would be probably more willing to invest in the punishment of free-riders. In turn, it was shown that the higher an individual's economic benefit generated from appropriation, the less likely a user is to defect on externally assigned provision duties for maintaining the resource stock and the physical infrastructure. In summary, the study reveals that those individuals who use a resource intensively and benefit most from it also have the biggest interest in maintaining resource productivity in the long run, and thus apply and enforce pro-social behaviour. The analysis of contextual variables suggests that this mechanism is accelerated with increasing value of resource units for

the management of common property pastures. This raises two questions for experimental research that would require linking appropriation to provision situations: (i) Are individuals with higher appropriation rates also more willing to invest in the sanctioning of provision defectors in public good situations in order to sustain or increase their appropriation pay-offs? (ii) Does an increase in an individual's pay-offs from appropriation result in higher investments into the public good? If so, self-interest can be indeed considered a motivational driver leading to pro-social behaviour. Nevertheless, behaviour remains context-specific, which limits the extent to which these findings can be generalised. Behaviour is thus likely to vary with factors such as the quality of institutions, the type, and prices of the resource used, and the overall condition of the social-ecological system; the control for contextual factors and their effect on the associations of personal attributes with behaviour in field studies and experimental research consequently remains a central methodological challenge for the study of the commons.

Literature cited

Ahn, T. K., E. Ostrom, and J. Walker. 2010. A Common-pool Resource Experiment with Postgraduate Subjects from 41 Countries. *Ecological Economics* 69(12):2624–2633.

Anderies, J. M., M. A. Janssen, F. Bousquet, J.-C. Cardenas, D. Castillo, M.-C. Lopez, R. Tobias, B. Vollan, and A. Wutich. 2011. The Challenge of Understanding Decisions in Experimental Studies of Common Pool Resource Governance. *Ecological Economics* 70(9):1571–1579.

Baur, P. T. 1999. Agrarstrukturwandel in der Schweiz, Diss. Techn. Wiss. ETH Zürich, Nr. 13240 1999. Ref.: P. Rieder; Korref.: R. Schubert.

Baur, I. and C. R. Binder. 2013. Adapting to Socioeconomic Developments by Changing Rules in the Governance of Common Property Pastures in the Swiss Alps. *Ecology and Society* 18(4):60.

Berkes, F., D. Feeny, B. J. McCay, and J. M. Acheson. 1989. The Benefits of the Commons. *Nature* 340(6229):91–93.

Bowles, S. and H. Gintis. 2002. Social Capital And Community Governance*. *The Economic Journal* 112(483):F419–F436.

Cárdenas, J.-C. and E. Ostrom. 2004. What do People Bring into the Game? Experiments in the Field about Cooperation in the Commons. *Agricultural Systems* 82(3):307–326.

Cavalcanti, C., F. Schläpfer, and B. Schmid. 2010. Public Participation and Willingness to Cooperate in Common-pool Resource Management: A Field Experiment with Fishing Communities in Brazil. *Ecological Economics* 69(3):613–622.

Chan, K. S., S. Mestelman, R. Moir, and R. A. Muller. 1996. The Voluntary Provision of Public Goods Under Varying Income Distributions. *Canadian Journal of Economics* 29(1):54–69.

Doody, D. G., P. Kearney, J. Barry, R. Moles, and B. O'Regan. 2009. Evaluation of the Q-method as a Method of Public Participation in the Selection of Sustainable Development Indicators. *Ecological Indicators* 9(6):1129–1137.

Fairweather, J. R. and S. R. Swaffield. 2001. Visitor Experiences of Kaikoura, New Zealand: An Interpretative Study Using Photographs of Landscapes and Q Method. *Tourism Management* 22(3):219–228.

Falk, A., E. Fehr, and U. Fischbacher. 2002. Appropriating the Commons: A Theoretical Explanation. In *The drama of the Commons,* Eds. E. Ostrom, N. D. Thomas Dietz, P. C. Stern, S. Stonich, and U. Weber, 157–191. Washington, DC: National Academy Press.

Fehr, E. and U. Fischbacher. 2004. Third-party Punishment and Social Norms. *Evolution and Human Behavior* 25(2):63–87.

Fehr, E. and S. Gächter. 2000. Cooperation and Punishment in Public Goods Experiments. *The American Economic Review* 90(4):980–994.

Fischbacher, U., S. Gächter, and E. Fehr. 2001. Are People Conditionally Cooperative? Evidence from a Public Goods Experiment. *Economics Letters* 71(3):397–404.

Gächter, S. and C. Thöni. 2011. Micromotives, Microstructure, and Macrobehavior: The Case of Voluntary Cooperation. *Journal of Mathematical Sociology* 35(1–3):26–65.

Gardner, R., E. Ostrom, and J. M. Walker. 1990. The Nature of Common-pool Resource Problems. *Rationality and Society* 2(3):335–358.

Gellrich, M., P. Baur, B. Koch, and N. E. Zimmermann. 2007. Agricultural Land Abandonment and Natural Forest Re-growth in the Swiss Mountains: A Spatially Explicit Economic Analysis. *Agriculture, Ecosystems & Environment* 118(1):93–108.

Henrich, J., S. J. Heine, and A. Norenzayan. 2010. Beyond WEIRD: Towards a Broad-based Behavioral Science. *Behavioral and Brain Sciences* (33):111–135.

Hosmer, D. W. and S. Lemeshow. 2000. *Applied Logistic Regression*. Hoboken, NJ: John Wiley& Sons.

Isaac, R. M. and J. M. Walker. 1988. Group Size Effects in Public Goods Provision: The Voluntary Contributions Mechanism. *The Quarterly Journal of Economics* 103(1):179–199.

Isaac, R. M., J. M. Walker, and A. W. Williams. 1994. Group Size and the Voluntary Provision of Public Goods: Experimental Evidence Utilizing Large Groups. *Journal of Public Economics* 54(1):1–36.

Janssen, M. A. and T.-K. Ahn. 2006. Learning, Signaling, and Social Preferences in Public-good Games. *Ecology and Society* 11(2):21.

Janssen, M. A. and E. Ostrom. 2006. Empirically Based, Agent-based Models. *Ecology and Society* 11(2):37.

Janssen, M. A., R. Holahan, A. Lee, and E. Ostrom. 2010. Lab Experiments for the Study of Social-ecological Systems. *Science* 328(5978):613–617.

Jones, N. A., H. Ross, T. Lynam, P. Perez, and A. Leitch. 2011. Mental Models: An Interdisciplinary Synthesis of Theory and Methods. *Ecology and Society* 16(1):46.

Keser, C. and R. Gardner. 1999. Strategic Behavior of Experienced Subjects in a Common Pool Resource Game. *International Journal of Game Theory* 28(2):241–252.

King, J. E. 2007. Standardized coefficients in logistic regression. Paper Presented at the Annual Meeting of the Southwest Educational Research Association. San Antonio, TX. Online document. http://www.ccitonline.org/jking/homepage/standardized_paper.doc.

Lauber, S., I. Seidl, R. Böni, and F. Herzog. 2008. Sömmerungsgebiet vor vielfältigen Herausforderungen. *Agrarforschung* 15(11–12):548–553.

Ledyard, J. O. 1994. Public Goods: A Survey of Experimental Research. In *Handbook of Experimental Research*, eds. A. Roth and J. Kagel. Princeton: Princeton University Press.

Levitt, S. D. and J. A. List. 2007. What do Laboratory Experiments Measuring Social Preferences Reveal About the Real World? *The Journal of Economic Perspectives* 21(2):153–174.

Lynam, T., R. Mathevet, M. Etienne, S. Stone-Jovicich, A. Leitch, N. Jones, H. Ross, D. Du Toit, S. Pollard, H. Biggs, and P. Perez. 2012. Waypoints on a Journey of Discovery: Mental Models in Human-Environment Interactions. *Ecology and Society* 17(3):23.

Mann, S. 2003. Bestimmungsgründe des landwirtschaftlichen Strukturwandels. *Agrarforschung* 10(1):32–36.

McGinnis, M. D. 2011. Networks of Adjacent Action Situations in Polycentric Governance. *Policy Studies Journal* 39(1):51–78.

Menard, S. 2001. *Applied Logistic Regression Analysis* (Vol. 2). Thousand Oaks, CA: Sage Publications, Incorporated.

Menard, S. 2004. Six Approaches to Calculating Standardized Logistic Regression Coefficients. *The American Statistician* 58(3):218–223.

Mordasini A. G. and M. Tiefenbach. 2006. *Bergschaften in Grindelwald – Alppflege zwischen Tradition und Moderne*. Grindelwald: Sutter Druck AG.

Naegeli-Oertle, R. 1986. *Die Berglandwirtschaft und Alpwirtschaft in Grindelwald*. Vol. 21, *Schlussbericht zum Schweizerischen MAB-Programm*.

Nikiforakis, N. and H.-T. Normann. 2008. A Comparative Statics Analysis of Punishment in Public-good Experiments. *Experimental Economics* 11(4):358–369.

Osés-Eraso, N. and M. Viladrich-Grau. 2007. Appropriation and Concern for Resource Scarcity in the Commons: An Experimental Study. *Ecological Economics* 63(2–3):435–445.

Ostrom, E. 2007. A Diagnostic Approach for Going Beyond Panaceas. *Proceedings of the National Academy of Sciences* 104(39):15181–15187.

Ostrom, E. 2009. A General Framework for Analyzing Sustainability of Social-ecological Systems. *Science* 325(5939):419–422.

Paula, S. 2006. Post-normal Science in Practice: A Q Study of the Potential for Sustainable Forestry in Washington State, USA. *Ecological Economics* 57(2):190–208.

Poteete, A. R., M. A. Janssen, and E. Ostrom. 2010. *Working Together Collective Action, the Commons, and Multiple Methods in Practice*. Princeton, NJ; Oxford: Princeton University Press.

Potter, C. and M. Lobley. 1996. The Farm Family Life Cycle, Succession Paths and Environmental Change in Britain's Countryside. *Journal of Agricultural Economics* 47(1–4):172–190.

Prediger, S., B. Vollan, and M. Frölich. 2011. The Impact of Culture and Ecology on Cooperation in a Common-pool Resource Experiment. *Ecological Economics* 70(9):1599–1608.

Rajé, F. 2007. Using Q Methodology to Develop more Perceptive Insights on Transport and Social Inclusion. *Transport Policy* 14(6):467–477.

Rustagi, D., S. Engel, and M. Kosfeld. 2010. Conditional Cooperation and Costly Monitoring Explain Success in Forest Commons Management. *Science* 330(6006):961–965.

Schmitt, G. 1992. Der Zusammenhang zwischen Organisationsform und Betriebsgröße in der Landwirtschaft: Eine institutionenökonomische Erklärung und agrarpolitische Implikationen. *Berichte über Landwirtschaft* 70(4):505–528.

Smith, V. L. 2010. Theory and Experiment: What are the Questions? *Journal of Economic Behavior & Organization* 73(1):3–15.

Swaffield, S. R. and J. R. Fairweather. 1996. Investigation of Attitudes Towards the Effects of Land Use Change Using Image Editing and Q Sort Method. *Landscape and Urban Planning* 35(4):213–230.

Swedeen, P. 2006. Post-normal Science in Practice: A Q Study of the Potential for Sustainable Forestry in Washington State, USA. *Ecological Economics* 57(2):190–208.

Van Exel, J. and G. de Graaf. 2005. Q Methodology: A Sneak Preview. *Online document. http://qmethod.org/articles/vanExel.pdf*.

Weiss, C. R. 1999. Farm Growth and Survival: Econometric Evidence for Individual Farms in Upper Austria. *American Journal of Agricultural Economics* 81(1):103–116.