ASSESSING PARTICIPATORY MAPPING AND MULTI CRITERIA EVALUATION FOR LAND USE CHANGE ANALYSIS

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Zusammenfassung

Der massive Landnutzungswandel im Berggebiet beschäftigt Forschung und Praxis: Beispielsweise die Abnahme des Bergackerbaus im Münstertal um 90 % seit 1990 sowie dessen Förderung unter der neuen Agrarpolitik seit 2014 oder die prognostizierte Abnahme der Rebflächen im Gebiet des Naturparks Pfyn-Finges um 17-51 % bis 2040. Es stellt sich die Frage, ob diese Entwicklungen im Konflikt mit Anstrengungen zum Erhalt der Biodiversität, der Landschaftsästhetik oder auch des sozialen Gefüges stehen. Um hierzu einen Beitrag zu leisten, erforschten wir Methoden, welche helfen den Landnutzungswandel zu verstehen und zu prognostizieren. Anhand von real existierenden, aktuellen Themen wurde so ein methodischer Beitrag geleistet und gleichzeitig konnten interessante inhaltliche Ergebnisse produziert werden.

In dieser Arbeit wurden zwei Methoden erforscht, welche diese Entwicklung räumlich aufzeigen und prognostizieren sollen. Eine untersuchte Methode war, die Bewirtschafter ihre Einschätzung direkt auf Luftbildern einzeichnen zu lassen (partizipatives Kartieren). Eine zweite basierte auf einer multikriteriellen Analyse mit nicht-lokalen Experten. Diese Methoden sind räumlich explizit, zeigen also auf, an welchen Orten sich der Ackerbau, respektive Weinbau verändern wird. Sowohl im Münstertal als auch im Gebiet des Naturparks Pfyn-Finges wurden neben dem partizipativen Kartieren auch Interviews durchgeführt und ein Fragebogen verteilt. Damit konnte aufgezeigt werden wo ein Landnutzungswandel zu erwarten ist und wie dieser von den Bauern und Winzern wahrgenommen wird.

Doch können die Bewirtschafter den Landnutzungswandel überhaupt vorhersagen und wenn ja, mit welcher Genauigkeit? Und wie viele Teilnehmer bräuchte es für eine solche Vorhersage? Dieser Frage wurde in einer Fallstudie im Val Müstair nachgegangen. Dabei wurde nicht nur der Zustand unter der neuen Agrarpolitik erfragt, sondern auch wie denn der Zustand 1990 gewesen sei, also zu einer Zeit als es noch deutlich mehr Ackerbau gab. Diese von den Landwirten beigesteuerten Informationen wurden mit einem rekonstruierten Zustand von 1990, sowie Beobachtungen aus den Jahren 2014 und 2015 verglichen. In der Umfrage wurden jeweils drei Massstäbe (1:5 000, 1:12 5000 und 1:25 000) verwendet.

Die Auswertung der Studie im Val Müstair zeigte, dass die Bewirtschafter den historischen Zustand genauer und kompletter als die Prognose einzeichnen konnten. Auch zeigte sich, dass dies auf der Skala mit dem grössten Detaillierungsgrad am besten ging. Durch die statistische Methode des Jackknifing konnte herausgefunden werden, mit wie vielen Teilnehmern im Durchschnitt ein ähnliches Resultat wie dasjenige der ganzen Gruppe erreicht worden wäre. Es zeigte sich, dass für die Erfassung des Zustands im Jahr 1990 auf der detailreichsten Skala 5 der 15 Landwirte und für die Prognose 9 der 15

Teilnehmer ausgereicht hätten. Auf der gröbsten Skala hätte man hingegen 7 und 11 Teilnehmer für den historischen, respektive den prognostischen Zustand, gebraucht. Demnach benötigen detailliertere Skalen weniger Teilnehmer für dieselbe Datenqualität und diese fällt grösser aus bei einem vergangenen Zustand als bei einer Prognose.

Aber wäre es nicht glaubwürdiger und genauer, man würde die Landschaftsentwicklung mit einem Modell vorhersagen? Die Fallstudie Pfyn-Finges diente der Beanwortung dieser Frage. Es wurden einerseits 33 Winzer mit der Methode der partizipativen Kartierung befragt und andererseits wurde mit 13 nicht lokalen Experten ein multikriterielles Modell erstellt. Für die Befragung wurden den Winzern folgende zwei Fragen gestellt: Erstens, welche Flächen werden in 25 Jahren nicht mehr Weinreben sein und zweitens, welche Flächen werden sicher noch Weinreben sein? Die Differenz dieser Meinungen ergab dann die Prognose. Für das multikriterielle Modell wurden Experten aus Forschung, Verwaltung und Privatwirtschaft gebeten, die wichtigsten Einflussfaktoren für die Umnutzung von Rebparzellen einzuschätzen. Diese Informationen wurden danach in einem Computerprogramm zusammengeführt und es wurde berechnet, mit welcher Wahrscheinlichkeit eine Fläche in 25 Jahren noch weiter bewirtschaftet wird. 25 Jahre entspricht dabei ungefähr der Generation eines Rebstockes: Innerhalb von 25 Jahren wird eine Rebfläche also neu bepflanzt, was meist eine wichtige Entscheidung darstellt, da diese mit hohen Kosten verbunden ist.

Es zeigte sich, dass es Regionen gibt, in welchen sowohl das partizipative Kartieren als auch das multikriterielle Modell zu ähnlichen Ergebnissen kommen. Im Bereich des extrapolierten Trends zur Abnahme der Rebfläche (ca. 17-50 % Abnahme), stimmen die beiden Methoden deutlich besser überein, als dies nach Zufall zu erwarten gewesen wäre. In einem Evaluations-Workshop attestierten die Winzer und die nicht-lokalen Experten der multikriteriellen Analyse eine bessere räumliche Auflösung, der kartenbasierten Befragung hingegen eine höhere Plausibilität. Beide Methoden schnitten aber deutlich besser als ein Zufallsmodell ab und sind somit für Prognosen der Landschaftsentwicklung geeignet. Diese Ergebnisse wurden zusätzlich mit Interviewdaten kombiniert und es zeigte sich, dass gewisse Weinberge möglicherweise umgenutzt werden, welche von den Winzern einen grossen kulturellen Wert zugeschrieben bekamen.

Summary

The drastic change of land use in the mountains is a hot topic in both research and practice: for instance, the decline of arable farming in the Val Müstair, by approximately 90 % since 1990, and its support under the new agricultural policy from 2014 or the predicted decline of vineyards in the natural park Pfyn-Finges of about 17–51 % by 2040. Does this development conflict with efforts supporting biodiversity, landscape aesthetics or social cohesion? Within this frame, we researched methods that help to develop understanding and accordingly forecast land use changes. Based on real and pressing issues, this thesis delivers methodological contributions, whilst at the same time also delivering interesting content-based insights.

This thesis researches two methods in mind of assessing and forecasting the spatial distribution of the named development: one method was asking farmers to deliver their assessment directly on airborne images (participatory mapping); the second method bases on a Multi Criteria Evaluation with non-local experts. Both methods are spatially explicit and therefore show in which locations there are changes expected concerning arable farming or grape-growing, respectively. As well as in the Val Müstair, as in the area of the natural Park of Pfyn-Finges, we not only performed participatory mapping but also interviews and distributed a questionnaire. In so doing, we established where to expect a land use change and how such a change would be perceived by farmers and grape-growers/wine-makers.

Are farmers actually able to forecast land use changes and, if so, with what accuracy? And how many participants does one need for such a forecast? These questions were investigated in the case study of the Val Müstair. There, not only a forecast for the arable farmland under the new agricultural policy was sought, but also the situation in the year 1990 when there was much more arable farming. For the participatory mapping, three scales were used (1:5 000, 1:12 500 und 1:25 000). The results then were compared to a reconstructed scenario from the year 1990 and to observations made in the years 2014 and 2015.

The results of the study in the Val Müstair showed that the farmers were able to map the historical state more correctly and completely than the prognosis. The best results were yielded on the scale with the highest level of detail. The statistical method of the Jackknifing, allowed inferring the number of participants, which on average would have yielded a result similar to the one of the whole group. On the most detailed scale, 5 of the 15 participants for the historical state, and 9 out of the 15 participants for the prognosis would have been adequate. On the coarsest scale, it would have required 7 and 11 participants for mapping the historic and the prognosis situation, respectively. Hence, more detailed scales require fewer participants for the same data quality, which was bigger for the historic state than for the prognosis.

Nonetheless, would it not be more plausible and more accurate to forecast land use change with a model? The case study in Pfyn-Finges served to answer this question. On the one hand, 33 grape-growers/wine-makers were interviewed with the method of participatory mapping, whilst on the other hand, 13 non-local experts were included in building a Multi Criteria Evaluation. For the participatory mapping, grape-growers/wine-makers were asked to two questions: first, in 25 years, which areas are no longer vineyards?; and second, which areas surely will remain as vineyards? The difference between the two opinions yielded the prognosis. For the Multi Criteria Evaluation, experts from research, administration and industry were invited to compare the most important factors for converting a vineyard. From the list of the nine most important factors, the distance to the road and the size of the cultivation unit were considered to have the greatest weight. This information then was combined in a computer program, with the probability of a piece of land remaining a vineyard in 25 years calculated. A period of 25 years corresponds roughly to the generation of a vine: within 25 years, a vineyard will be re-planted, thus posing an important question as it is connected to high costs.

The results of this study showed the regions in which participatory mapping, as well as the Multi Criteria Evaluation, yields similar results. The methods correspond much more to one another than to a random model within the interval concerning the decrease of vineyards (approximately 17–50 % less). In an evaluation workshop, grape-growers/wine-makers and the non-local experts judged the Multi Criteria Evaluation to have a better resolution and the participatory mapping to have a higher plausibility. Both methods performed much better than a random model, and thus are considered suitable for the prognosis of land use development. These results further were combined with interview data, which showed that some vineyards are possibly converted, to which a high cultural value is ascribed.

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ESS – Ecosystem Sercices
MCE – Multi Criteria Evaluation
PA – Place Attachment
PGIS – Participatory GIS
PM – Participatory Mapping
PPGIS – Public Participatory GIS
SOP – Sense Of Place

1 Introduction

1.1 Motivation

Agriculture is the largest land use of the world, covering approximately 38 % of the earth's terrestrial surface *(Foley et al. 2011)*. Cropland and grasslands are said to produce a flow of approximately 28 trillion USD in ecosystem services, which amounts to roughly 22 % of the global flow *(Costanza et al. 2014)*. It therefore makes sense to study changes in agricultural land use. Globalisation and economic development exert stress ecological and human systems as responsible for inducing land use change *(Beilin et al. 2014)*. In such a changing environment, agriculturally usable genetic resources, as an example, may be threatened *(Cardinale et al. 2012; MEA 2005)*. Prognoses of land use change help to develop policies and identify smart solutions to counter existing stressors. In this thesis, we[1] aim at advancing methods that assist in predicting and understanding such changes. The work will be organised around two case studies in Switzerland, namely through consideration to changes in arable land in the Val Müstair, a valley in the south-eastern Swiss Alps, and changes in viticulture in Pfyn-Finges in the south-western Swiss Alp (Canton of Valais).

In the Val Müstair, the drastic decline of arable land from 1990 to 2013 considerably influenced the landscape and menaces local culinary traditions. This is best illustrated by a practical example. A bakery in the Val Müstair produces traditional bread made from rye (70 %) and wheat (30 %). The bread gained the status of a 'Slow Food Presidio'[2], acknowledging its high local cultural value whilst at the same time requiring the ingredients to be sourced locally. As a 'Slow Food Presidio', it garnered much more popularity and opened opportunities for the bakery to sell its bread in larger supermarkets and for the farmer to have a guaranteed buyer. However, if there was to be a decline in the amount of rye planted in the Val Müstair, this interaction, at some point, would no longer be possible as the production of the bread requires local technological, social and natural resources. Luckily, however, through the enactment of a new Federal Agrarian Policy in Switzerland in 2014, the support biodiversity and the conservation of cultural heritage has become a political objective. Since then, the area devoted to arable farming has once again increased. But nonetheless, do the effects of this policy negatively influence other targets? Is it possible to predict which plots farmers are most likely to revive arable farming? And if so, how easily can this be done?

[1] We decided to use the pronoun we throughout this thesis, to credit the influence of many collaborations in most parts of the work

[2] A "Slow Food Presidio" is a high-quality product, supported by the "Slow Food Foundation" (www.fondazioneslowfood.com) as way to safeguard traditional practices, unique ecosystems and local varieties

In the 20th Century, the Canton of Valais experienced a boom of viticulture, which peaked in the early 2000s and since has reversed. Pfyn-Finges is a nature park within this canton, and now is facing decreasing importance of vineyards (c.f. Section 3.2 'Pfyn-Finges'). But the question is posed: How does this influence cultural values associated with grape-production, and is there some form of threat to culinary or biological heritage? Is it possible to forecast the land use change and hence support conservation of cultural landscape and/or might the land use change even be used as a chance to support biodiversity?

Forecasts in land use change require the integration of different sources of knowledge *(Cacciapaglia et al. 2012; Moller & Berkes 2004)*. An understanding of social and natural aspects often is deemed necessary in terms of maintaining ecosystem services, as explained in greater detail in Section 2.1.1). In-depth knowledge of the social ecological system *(Ostrom 2009)* is fundamental in terms of predicting when ecological functions are perceived as an ecosystem service and when they become a perceived disservice *(Galluzzi et al. 2011)*. Through examining methods in line with assessing land use change in these highly dynamic regions, we therefore are able to make a contribution to better understanding the social ecological dynamics in those regions and accordingly to giving guidance on researching land use change in general. We place particular focus on the quality of such a forecast as this is deemed to be of utmost importance in the management of natural resources *(Moller & Berkes 2004)*.

Methods used for land use forecasting aim at fostering the exchange between science and practice, aiming at a common language *(Herweg et al. 2010)*. There is a plethora of methods targeting at this integration *(c.f. Bergmann et al. 2010; Gerber & Hoffmann 2009)*. This thesis focuses on two methods: firstly, participatory mapping as a well-known method involving a diverse group of stakeholders in planning processes *(Brabham 2009)*, as described in more detail in Section 2.2.3 ('Public Participation through GIS'), which is viewed as a method for soliciting geospatial data directly from participants; and secondly, the use of Multi Criteria Evaluation (MCE), which is widely applied in relation to similar problems, as introduced in Section 2.3.2 'Related Applications of MCE', where MCE is recognised as a rule-based approach, asking participants for their judgements. Both methods yield spatially explicit results; therefore, they can be represented in maps. Maps can be seen as a medium of communication with explicit spatial reference *(Monmonier 1993)*. Nevertheless, most of the applications of MCE forecasting land use change are of rather low accuracy *(Pontius et al. 2008)*, and hence a comparison between the two completely different methods represents a challenge, with the aim of reaching a better understanding of the strengths and weaknesses of each method. Geographic space further is considered a promising candidate to function as a ground to integrate and complement social and natural sciences, even though there has been little research done so far on this topic *(Beeco & Brown 2013)*. Finally, it is up to the stakeholders to decide on the validity of either method *(Lynam et al. 2007)*.

One should bear in mind that the domain of the public involved and the level of interaction must not be a static decision, and varies throughout the process *(Stauffacher et al. 2008)*. Imagine, for example, a project involving the planning of a new agricultural policy aiming at providing ecosystem services in an agricultural landscape: the involved stakeholders and the level of involvement likely changes over time, with PM positioned as a suitable method of communication amongst stakeholders at various phases of the work. In the beginning, one might, for example, involve only policymakers in defining the scope and resources of the new policy. Ensuring clarity in regards the general aims and range of action, a larger set of stakeholders forms a planning board to define the domains of action of the new policy. Members of the planning board are representatives of, for example, farmers associations, non-governmental organisations and research institutions. In this example, they define priority areas, such as environmental education, biodiversity conservation, safeguarding the cultural heritage and sustainable tourism. Then, taking the heritage as an example, in a test area, the general public is invited to indicate landscape features within agricultural land of high cultural value at the present time. Parallel to surveying the general public, local farmers are asked to indicate areas and features for cultural heritage conservation with the least negative impacts on their work. The landscapes with the highest density of landscape features and least negative impacts on the work of farmers when conserving the landscape then are identified and presented in a public hearing. After jointly amending and prioritising the proposed areas for conservation, the final plan is fed back to the planning board. They then assess conflicting goals between the proposed heritage conservation areas with other domains of action, as, for example, biodiversity conservation. Throughout the described process, maps facilitate communication and further aid in specifying and generating ideas, and serving for data collection and data dissemination. The various methods centred on collecting spatial data at the very beginning of such a described process have been investigated, with their qualities evaluated.

Notably, we did not investigate large spatial extents or include large numbers of participant; rather, we believe in the value of well-chosen, knowledgeable experts, as theoretically underlined in Section 2.4 'Data Quality and Sampling'. Further, to our knowledge, studies using participatory mapping typically only seek to establish the *presence* of features. We deem the *absence* of features to be equally important, and hence mapped both expected persistence and disappearance of land use classes. Finally, we believe in the richness of data by adding qualitative data and in-depth studies of smaller spatial extents as one contribution to the advancement of science *(Flyvbjerg 2006)*.

In summary, this thesis follows the rationale of transdisciplinary socio-ecological research, makes use of methods and concepts originating from geographical information science (GIScience) and social sciences research, and bases on theory of public participation and sampling. Contributions are made to the fields of natural resources management, participatory planning, GIScience, as well as to sampling strategies overall. Insights are generated regarding the perceptions of land use change from a local perspective. This thesis, however, does not seek to investigate the biophysical conditions for land use change, and therefore only touches on the drivers for land use changes.

1.2 Research Questions

The research design is shown in Figure 1-1. We shortly introduce each of the research questions. In participatory mapping, there are several research gaps to be addressed, including the effect of scale, the accuracy of the data gathered and the sample required in order to reach this degree of accuracy *(Brown & Kyttä 2014; Brown 2012a; Sieber 2006)*. In particular consideration to scale, there are large differences found in the literature, as described in Section 2.2.3 'Public Participation through GIS', which we address in our work. Further, we investigate whether or not we can infer the reliability of the data by looking at characteristics of the data itself, similar to work done in ethnography, described in Section 2.4.1 'Sampling Strategies and Saturation'. Therefore, we pose the first research question:

1. How can the required sample size in participatory mapping be assessed using land use change as an example? How does scale influence the data quality?

As a contrasting method, we performed a Multi Criteria Evaluation on the same area of research. Multi Criteria Evaluation studies are not as dependent on local knowledge as participatory mapping. They often lack, however, a thorough uncertainty analysis. Further, there is little guidance on methods to include a group of decision-makers for generating value functions *(Malczewski & Rinner 2015)*. Further, just as in participatory mapping, there exists little work where methods have been validated, as explained in Section 2.4.2 'Validation, Verification and Data Quality'. We assess the validity of our results by feeding them back to the local experts and scientific experts, allowing them to evaluate the outcome of a forecast made by participatory mapping, as opposed to one yielded by a Multi Criteria Evaluation. Subsequently, we compared the outcome of the two methods for agreement and disagreement, which led to the second research question of this thesis:

2. How do the results of participatory mapping differ from those originating from a Multi Criteria Evaluation? Which results are more valid? And how do the annotations in participatory mapping contrast with and complement the results from the Multi Criteria Evaluation and the participatory mapping?

Finally, through semi-standardised interviews, we assess the perception of land use change and associated cultural values. As other studies have proven, a combination of perceptions and observations delivers valuable insights in terms of social-ecological systems behaviour *(Aritia et al. 2015; González-Puente et al. 2014)*. Particular focus is directed towards the effects of participatory mapping. Does it, for example, influence attitudes? There is little research centred on how researchers using participatory mapping change people's perceptions, even though it is assumed to have an effect *(Brown 2012b; Sieber 2006)*. Nevertheless, perceptions and the resulting social values, norms and perceived behaviour control provide an important basis for shaping people's behaviour, as described in Section 2.1.4 'The Effect of Social Values on Behaviour'.

For the area of the Pfyn-Finges case study, we further have collected spatial annotations, which are said to be an important step in terms of better understanding the data collected *(Brown et al. 2015b; Cox et al. 2014)*. Hence, we can use these annotations to contrast results from the participatory mapping and the Multi Criteria Evaluation exercises, respectively, and accordingly gain more explicit knowledge pertaining to the perceived land use change drivers and effects. We therefore address the following set of research questions in relation to the values and perceptions concerning land use change:

3. What type of social values do participants express with regards land use change? And does participatory mapping influence the perception of social norms, attitudes and perceived behaviour control?

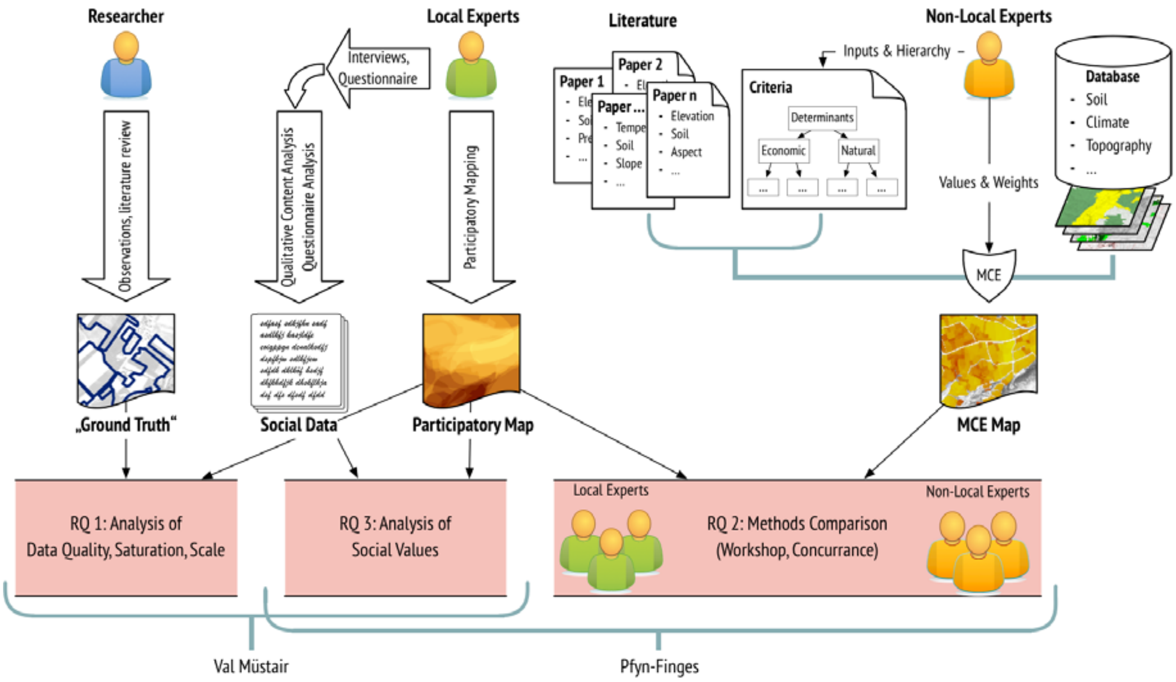


Figure 1-1: Sketch of the research-design used in this thesis

2 Related Work

The chapter reviews literature from various fields relevant to the thesis, such as public participation, participatory mapping, ecosystem services, social values, sense of place, resilience, sampling strategies, Multi Criteria Evaluation and knowledge integration in transdisciplinary research. The review begins with attention to concepts and studies on human environment systems, with particular focus on cultural and social values. Subsequently, the role of public participation and the possibilities in mind of assessing tangible and intangible items through participatory mapping is illustrated on a range of published studies. This then leads to questions pertaining to adequate sampling strategies and the assessments of the resulting data quality, such as its validity and the correspondence to the 'truth'. The review concludes with a section on Multi Criteria Evaluation techniques, as a contrasting and more expert driven approach.

2.1 Coupled Human and Ecological Systems

2.1.1 Ecosystem Services (ESS)

Ecosystem services are understood as *«the benefits people obtain from ecosystems» (MEA 2003: 3)*, thus linking people and ecosystems. Example ecosystem services from a forest can be timber, protection from avalanches and relaxing walks, which are classified as provisioning, regulating and cultural services, respectively *(MEA 2003: 3)*. From a conceptual point of view, the ecosystem services cascade *(TEEB 2010)* recently attracted attention *(Potschin & Haines-Young 2011)*. The cascade adheres the following reasoning: there is a successive transformation of biophysical processes (e.g., species' adaptation to the environment) to ecosystem services (e.g., genetic resources within the resulting biological diversity) to human well-being (e.g., health through the development of medicine based on genetic resources). However, there needs to be a demand for a biophysical process in order to turn it into a service *(Kareiva et al. 2011)*. Applied to the example of genetic resources, this means that, as long as nobody makes use of the genetic resources, such as, for example, with the development of medicine, the engineering of crops or becoming inspired by species' richness, biodiversity does not deliver those services.

Over time, the total of ecosystem services varies due to changes in the demand and/or supply of ecosystem services. They can change, for example, due to policy intervention *(Paetzold et al. 2010)* or otherwise as a direct result of the adaptation of society to existing ecosystems services *(Willemen et al. 2012)*. Within the ecosystem services framework, land use change therefore interact with ecosystem services, and subsequently we highlight connections to the conservation of plant genetic resources and to cultural ecosystem services *(Brush 2004: 71–74; Lenné & Wood 2011)*.

Plant Genetic Resources for Food and Agriculture (PGRFA)

Plant Genetic Resources for Food and Agriculture (PGRFA) are a subset of genetic resources stored in biodiversity, limited to those that are of possible or actual use for food production and agriculture (cultivars, landraces, ecotypes, weedy races and wild relatives) *(Galluzzi et al. 2010)*. PGRFA are genetically close to crops, meaning a transfer from traits found in PGRFA to crops therefore is possible *(Stolton et al. 2006)*.

PGR are important for food production and hence for human wellbeing for various reasons. First, in order to adapt and improve plants in a changing environment, breeders and farmers are contingent upon crop diversity *(FAO 2010; Rerkasem & Pinedo-Vasquez 2007)*, as, for instance, PGRs are an important basis for breeding crops resistant to pathogens. Japanese researchers, for example, used a resistance gene against snow mould found in a wheat variety cultivated in the Val Müstair *(Kleijer 1988 in: Kleijer et al. 2012)*. Second, diversity allows the use of more niches and thus increases and stabilises productivity *(Cardinale et al. 2012; Hajjar et al. 2008)*. The vulnerability of few cultivated species, for example, accounted for a decrease in almond production in Lebanon *(FAO 2010)*. Third, PGRs facilitate the adaptation to different environments and therefore are needed for a resilient agroecosystem in a changing world *(Galluzzi et al. 2011)*. Thus, PGRs are essential for achieving long-term sustainability and meeting short-term goals *(Brown & Hodgkin 2007)*.

The conservation of PGRFA not only depends on cultural factors, but also contributes to them *(Bardsley & Thomas 2004)*. The literature mentions several conceptual, biological links from PGRFA to ecosystem services *(Hajjar et al. 2008)*. However, there are also social benefits, such as the retention of a cultural heritage in the form of a cultural landscape *(Bardsley & Thomas 2004; Geiger et al. 2012)*, the conservation of knowledge and therefore the diversity of responses to crisis *(Barthel et al. 2013)*, and a larger variety in tastes *(Narloch et al. 2011; Negri 2003)*. Furthermore, the genetic material is preserved in a changing environment, allowing it to show its adaption potential *(Brush 2004)*.

The feeling for social cohesion and identification is a leading factor preventing the loss of agricultural practices *(Beilin et al. 2014)*, which indicates that social factors and cultural identity need to be included in order to advance in PGRFA conservation *(Leclerc & Coppens d'Eeckenbrugge 2012; Nabhan et al. 2012)*. González-Puente ***et al***. *(2014)* attribute cultural values to be a major moderator for driving forces in land use change. In Switzerland, the farmers' association 'Gran Alpin' markets and supports the growth of local and rare varieties. For the associated farmers, a sense of 'cultural identity' is said to be crucial for planting the grains *(Bardsley & Bardsley 2014)*. Generally, if it is about continuation of a land use, the driving forces are culture, tradition and local knowledge *(Bosshard & Glasenapp 2012)*. Such behaviour can be very well understood through the stewardship of farmers and the degree to which they have a moral concern regarding the conservation of those practices *(Raymond et al. 2013)*. The Theory of Planned Behaviour, described in Section 2.1.4 'The Effect of Social Values on Behaviour', represents a psychological theory of the interaction between social norms on behaviour.

However, farmers usually care little about the uniqueness and social importance of the specifically planted genetic material *(Brush 2004)*, even though such decisions can have inter- and intragenerational consequences *(Jarvis et al. 2007)*. Thus, there are global policy incentives for the conservation of PGRFA, especially for food security reasons *(FAO 2011)*, and protected areas in mountainous regions are particularly suitable for such conservation efforts *(Stolton et al. 2006)*.

Protected areas in the mountains may comprise niches where traditional and rare varieties are competitive to modern breeds *(Brush 2004)*. Furthermore, particularly biosphere reserves aim at the conservation of cultivated diversity *(FAO 2010; Lange 2011)*. Doing so overcomes the separation of biological and cultural diversity and, by more closely connecting them, a greater persistence of both types of diversity is achieved *(Cocks & Wiersum 2014)*.

Social and ecological resilience interact *(Ceroni et al. 2007)*. For example, if the conservation of a variety depends on a single person or a single field, the cultivation of this variety is neither socially nor ecologically resilient *(Negri 2003)*. A driving force in this context is land use change: for example, the abandonment of land and the associated loss of local knowledge adversely impacts the conservation of PGRs *(Bosshard & Glasenapp 2012; Galluzzi et al. 2010; Simmons 1996)*, as those factors are closely interwoven. Nowadays, the conservation of PGRs in the mountainous regions of Switzerland depends on maintaining a social system with their associated infrastructure, way of life and markets *(Bardsley & Bardsley 2014; Bardsley & Thomas 2004; Barthel et al. 2013; Maillefer 2013)*. We therefore consider it important to investigate changes and dynamics in such social ecological systems, and particularly in relation to land use change.

Cultural Ecosystem Services

Amongst all of the ESS, the cultural ESS has gained in importance *(Guo et al. 2010; Hernández-Morcillo et al. 2013)* but often lacks proper implementation in management and decision-making *(Milcu et al. 2013)*. Cultural ecosystem services are intangible services, such as, for example, cultural heritage and spiritual experience, education, recreation, and aesthetic values *(EEA 2013; MEA 2003; Staub et al. 2011)*. As they are intangible, they often depend more so on the observer rather than on the ecosystem and thus are more difficult to measure *(Burkhard et al. 2012)*.

Cultural ecosystem services are not just 'there'; culturally valued landscapes are contingent on the two co-producing factors, namely the humans that value and the landscape that is valued. It is particularity owing to cultural ecosystem services, such as sense of place, that they only can be consumed as long as humans constantly re-ascribe them to the ecosystem (Figure 2-1). If, for example, humans cease to identify themselves with a region, the regional identity dies *(Paasi 1986; Relph 1976)*. What applies to regional identity also applies to other cultural ecosystem services. Landscape aesthetics, for example, depend on visible patterns, in addition to social norms, which shape the perception of the patterns *(Gobster et al. 2007)*. Moreover, it is a doubtful task seeking to conserve cultural values as they exist today by conserving the physical environment *(Stephenson 2008)*.

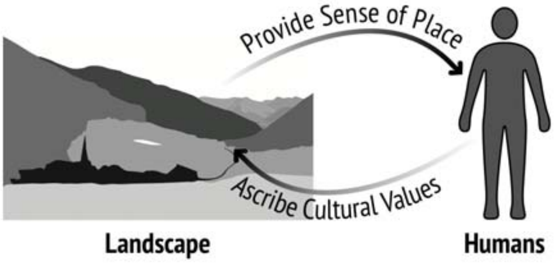


Figure 2-1: Co-production of the cultural ecosystem service Sense of Place

The proposed method of paying more attention to the social system for ESS assessments is the inclusion of stakeholders in the decision-making process *(Seppelt et al. 2012; Termorshuizen & Opdam 2009)*. For instance, especially for the valuation of different services and thereafter the setting of development priorities requires an interaction with society *(Balmford et al. 2010; Perrings et al. 2010; Sherrouse et al. 2011; Termorshuizen & Opdam 2009)*. In so doing, the inclusion of demand and supply of ESS is considered from the very beginning of a study *(Lamarque et al. 2011; Palomo et al. 2013)*. Following this line, the path ahead could be an ecosystem services impact assessment, similar to the procedure proposed by *Willemen et al. (2012)*. One possible method for such an integrative procedure is participatory mapping *(Hernández-Morcillo et al. 2013)*. Through this method, one can incorporate social values in spatial planning, as subsequently discussed in Section 2.2.3 'Public Participation through GIS'.

2.1.2 Sense of Place and Place Attachment

Places are more than areas in the physical world: places are connected to feelings and emotions (sense of place), identities (place identity), and affection (place attachment). They are locales of everyday activities and social interactions *(Castree 2009; Lewicka 2011; Massey 2002)*. Places encompass physical and social dimensions in which personal experiences occur *(Eyles 1985; Stedman 2002)*. Consequently, heritage, tradition and culture also are embodied in a place *(Lyon 2014)*. Places have different functions, such as providing security, self-actualisation and continuity *(Scannell & Gifford 2010)*. As places provide humans with such crucial functions, it is not surprising that people get attached to places *(Stedman 2002)*.

People develop a sense of place (SOP) and place attachment (PA), respectively, through their engagement with places *(Hauge 2007; Riley 1992)*, as shown in Figure 2-2. SOP and PA are very much interrelated *(Stedman 2002)*, with SOP acting on a cognitive level and PA rather acting on an affective level *(Mihaylov & Perkins 2014)*. SOP can be understood as the feeling of identity and belonging evoked through interaction with the place and understanding of the place *(Hummon 1992; Vorkinn & Riese 2001)*. PA can be seen as an emotion evoked by and directed to a place, shaping the behaviour of people *(Lewicka 2005)*. For example, place attachment is said to provoke a motivation *«to protect, preserve or improve the community» (Mihaylov & Perkins 2014: 61)*. In this analytical framework, SOP signifies the feelings stimulated by the landscape whereas PA denotes the bond between the land and the people.

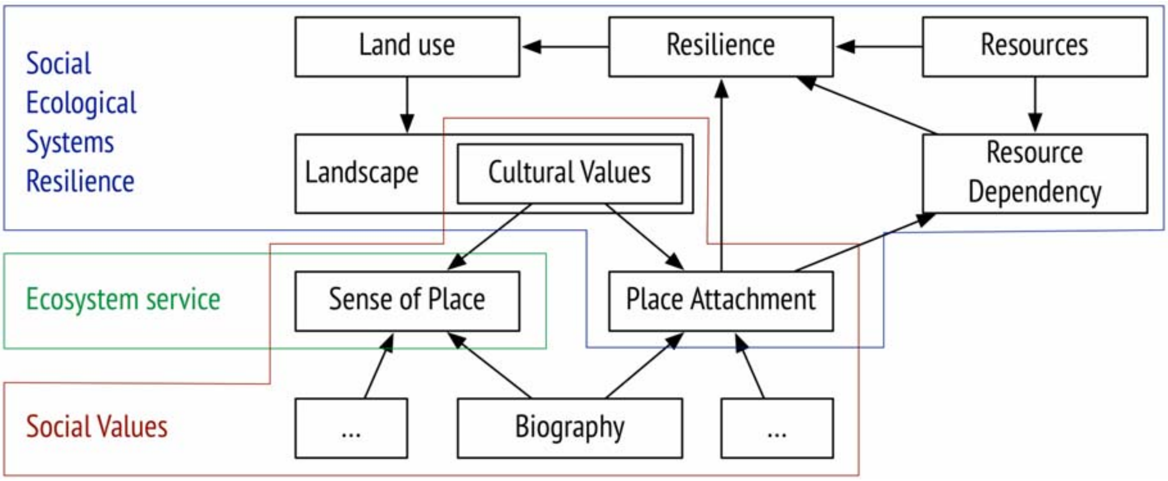


Figure 2-2: Main interactions of the different constructs used with culturally valued landscapes in the centre
Source: Own figure, based on the references mentioned in the text

SOP is explicitly mentioned in several classifications of ecosystem services *(EEA 2013; MEA 2003; Staub et al. 2011)*. As an ecosystem service, SOP belongs to the class of cultural ecosystem services, understood as a 'spiritual experience' *(Crossman et al. 2013)*. PA, on the other hand, is explicitly mentioned in resilience assessments *(Mihaylov & Perkins 2014; Norris et al. 2008)*. As PA and SOP are very much interrelated, their distinction makes sense if analysing the social ecological system dynamics and their effects on ecosystem services at the same time.

SOP and PA both are highly individual; however, certain predictors of PA and SOP might be shared amongst people with, for example, similar biographies. PA and SOP thereafter also can be socially clustered *(Riley 1992)*: for example, early investigations have shown that there is a socially shared understanding of a region *(Paasi 1986)*. This understanding is created through places that connect a community, such as through common events, for example. We expect groups with similar interactions and experiences regarding a place to have similar attitudes *(Vorkinn & Riese 2001)* and attachments *(Kaplan & Kaplan 1989)*.

2.1.3 Cultural Values

Whilst PA and SOP may be understood as individual component of valuing a place, cultural values may be considered as the socially shared component *(Scannell & Gifford 2010)*. According to the ***Cultural Values Model*** *(Stephenson 2008)*, cultural values are created through the interaction between relationships, forms and practices. In this model, ***relationships*** denote valued human and natural interactions, which, for example, lead to SOP and PA; one can imagine, for example, a vineyard that is inherited from grandparents and therefore reifies a human relationship. Physical appearances, such as landforms, vegetation and anthropogenic structures are referred to as ***forms***, such as in the case of terraces, for example, upon which the previously mentioned vineyard is situated. The ***practices*** value involves both, natural processes, such as the growth of grapes, and various human activities, such as harvesting grapes by hand. In this example, the cultural value of a vineyard for its owner is built up by having inherited a piece of land that is situated on a visually prominent terrace and that is a place where people work with the grapes. Whilst the cultural value is enriched through the described processes, it also becomes embedded within the landscape. The presently re-created cultural value amalgamates with the values created in the past and that are already embedded in the landscape *(Stephenson 2008)*. Therefore, the cultural values of a community with a high degree of PA are not expected to change quickly.

2.1.4 The Effect of Social Values on Behaviour

PA influences behaviour and is said to increase participation in community activities *(Carrus et al. 2014; Lewicka 2011)* and resistance to changes when a place-dimension is adversely affected *(Bonaiuto et al. 2002; Carrus et al. 2014; Devine-Wright 2009; Mihaylov & Perkins 2014; Vorkinn & Riese 2001)*. If a landscape changes, such as through the installation of a power line, for example, and the change is coherent with people's understanding of the place, there is little opposition to be expected; however, if the powerline disrupts how people understand the place, a protective behaviour against the powerline is likely *(Devine-Wright 2012; Relph 1976)*. The perception of landscape qualities therefore is centred on determining the acceptance of land use changes *(Gobster et al. 2007; Lindemann-Matthies et al. 2010)*. Within two biosphere reserves in Poland, cultural heritage and land use structures were assessed as particularly important *(Sowińska-Świerkosz & Chmielewski 2014)*, indicating that cultural heritage should be accounted for in land use management in assuring the acceptance of management strategies.

Another strong behavioural factor is that of social norms. Thus, Schwartz *(1973)* developed the ***Norm-activation Behaviour Model*** in line with awareness of consequences and the ascription of responsibility. According to this theory, social norms form personal norms, which then translate into behaviour under the condition that both the ascription of responsibilities and the awareness of consequences are high. Of Schwarz's theory, the ***Theory of Planned Behaviour (TPB)*** has been seen to emerge as a widely used approach *(Ajzen 1991; Fishbein & Ajzen 2010)*. The theory connects attitudes, social norm, and

Perceived Behavioural Control (PBC). These constructs together form the behavioural intention, which, under favourable circumstances, translates to behaviour. Figure 2-3 depicts the TPB graphically and Table 2-1 gives explanatory information concerning the factors in Figure 2-3.

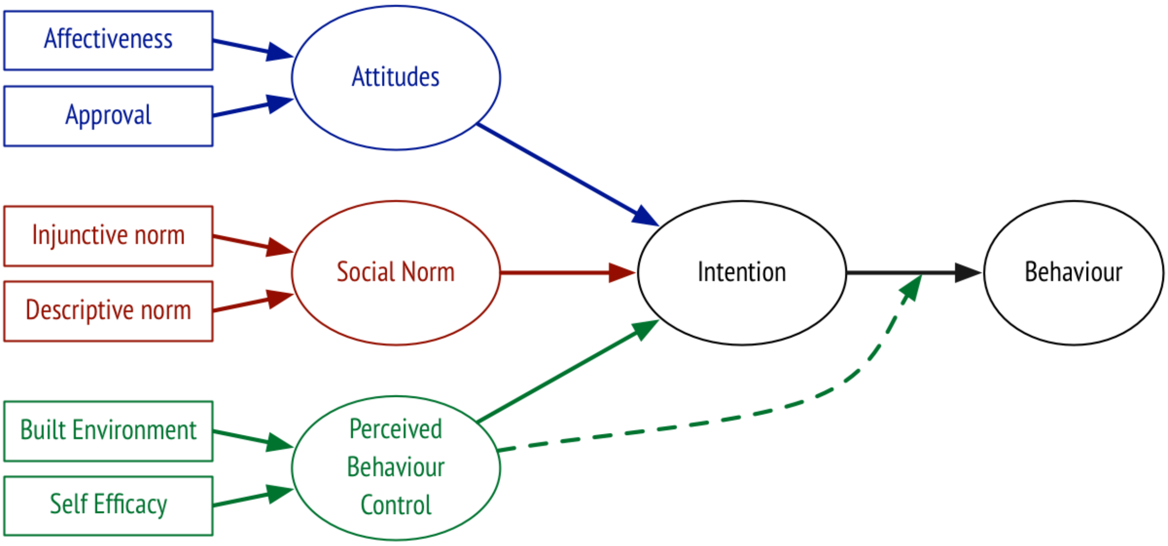


Figure 2-3: Theory of Planned Behaviour with the different constructs used
After *(Fishbein & Ajzen 2010)*

Table 2-1: Descriptions of the constructs in the Theory of Planned Behaviour
Based on *(Fishbein & Ajzen 2010)*

Construct	*Definition*	*Explanations*
Attitudes	Sentiments towards the action.	The arousal due to an action. PA and other personal values belong to this category.
Social Norm	Perceived social pressure	**Injunctive Norm:** Socially shared norms of conduct, which are inferred from society. **Descriptive Norm:** Observed actions from people that are important to oneself.
Perceived Behavioural Control	Perceived capability to perform an action	The perceived ability to perform an action. PBC is both, a moderator on the Intention-Behaviour relationship and a predictor of the Intention.
Intention	Intention to perform an action	Usually expressed as a will to perform an action in the future.

2.1.5 The Perception of Land Use Changes

Ariti *et al. (2015)*, in a recent study, discovered that most farmers perceived land cover changes correctly, i.e. as observed on remote sensed images. More specifically, if the changes were greater than 10 %, all the farmers correctly remembered the direction of changes (in- vs decrease), which happened even 30–40 years ago, with similar values for more recent changes. Smaller changes, however, were classified ambiguously. In a study by González-Puente ***et al.*** *(2014)*, inhabitants not always correctly reported land cover change that occurred in the past 60 years. In particular, the increase of built-up area was not reported correctly, while most inhabitants correctly reported the decrease in cropland.

The valuation of land use functions and the severity of land use changes decide upon the attitude regarding land use transformations *(Hunziker et al. 2008)*. Research by Lindemann-Matthies et al. *(2010)* on landscape preferences in the Swiss mountains has shown that urban people seem to value landscapes with species-rich grasslands most, with the age of the participants being a moderating factor for the perception of aesthetics; Older people valued landscapes with high diversity and a proportion of arable land more, than younger people. A second study showed that farmers valued a landscape containing arable land more than non-farmers *(Junge et al. 2011)*. This suggests that older farmers are more likely to negatively evaluate a decline in arable land than younger urban people.

2.2 Public Participation and the Role of GIS

2.2.1 Public Participation

There are many reasons behind public participation in environmental decision-making, with the most prominent being a higher acceptance of decisions *(Dietz & Stern 2008; Reed 2008)*. Particularly in knowledge-intensive fields, a participatory process is deemed important in the development of creative solutions that are better adopted by the target audience *(Brabham 2009; Okali et al. 1994)*. Besides of a higher acceptance, the interaction of organisers with the participants is said to build capacity and trust on both sides, and to increase the quality of the decisions, which together are the key reasons for participation *(Dietz & Stern 2008; Lane & Husemann 2008; Meyfroidt 2013; Reed 2008)*. High-quality participation is characterised by a great breadth of involved participants, transparency of decisions, and a high level of interaction and trust amongst all participating parties *(Dietz & Stern 2008)*. Blackstock ***et al.*** *(2007)* developed a set of 22 criteria to evaluate participation, including legitimacy of the outcome, conflict resolution, social learning and the cultural context in which participation takes place. Some of these criteria, such as cultural context, do not allow the ranking of better and worse participation, but rather allow a more in-depth understanding of the process. The outcome of a participatory process, such as a lower or higher acceptance of a presented solution, does not indicate a better or worse participatory process, as the aim of the process is to interact. Lei and Hilton *(2013)*, for example, were satisfied with the process they launched, despite the fact it led to more opposition, as opinions were formed through the process. However, the ways in which participation influences behaviour, particularly from the perspective of the theories discussed previously, remains poorly researched.

Arnstein *(1969)* published the very famous 'Ladder of Citizenship Participation', and sarcastically presented different levels of participation, similar to the levels shown in Figure 2-4. On the lower rungs of the ladder (the lower two levels in Figure 2-4), the process only pretends to let people participate but either is ‘nonparticipation’, such as by educating or manipulating people, for example, or otherwise represents a sort of ‘tokenism’ by involving participants for a predefined and usually undisclosed goal. Since its publication, Arnstein’s adder has been disputed for its ranking of higher levels of participation, such as empowerment, as better than, for example, information. However, choosing an appropriate level of participation, and corresponding to the actual sharing of power and information, helps in reducing frustrations on both sides, the ones organising the participatory process and the participants *(Dietz & Stern 2008: 15)*. The present best practice is concerned with choosing the level of involvement according to the actual power to be delegated, whether on a lower or higher rung of the ladder *(Blackstock et al. 2007; Lynam et al. 2007; Schlossberg & Shuford 2005; Sieber 2006)*.

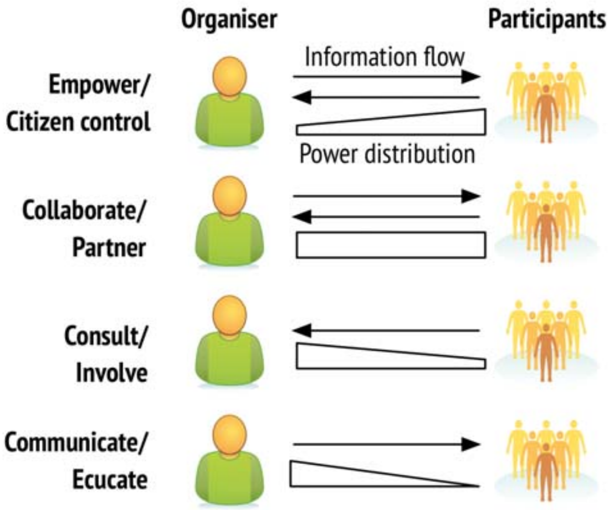


Figure 2-4: Different levels of participation and the respective exchange of information and the sharing of power
After *(Arnstein 1969; IAP2 2007; Reed 2008; Stauffacher et al. 2008)*

However, a match between the preferred level of participation and the actual level is difficult to achieve: Brown and Chin *(2013)* observed that a higher degree of involvement of the participants in the process correlated with an increasing demand to have influence on the decisions. In the same study, participants perceived a planning process to be mainly consultative, i.e. the participants providing inputs, while actually they wished to collaborate on the planning; therefore, some participants experienced frustration as they invested much time in the planning process, expecting to collaborate, but actually were only viewed by the organisers as consultants. Figure 2-5 displays some example projects involving different domains of the public at different levels of participation.

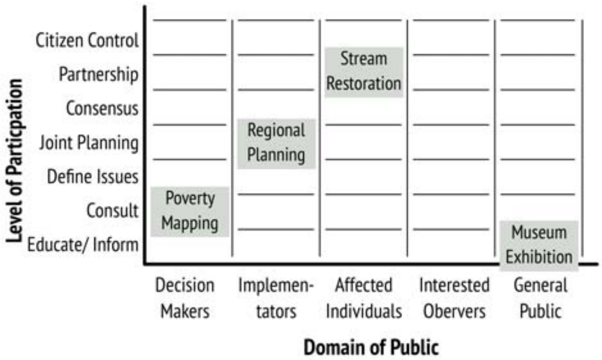


Figure 2-5: Example tasks for different domains of the public in combination with different levels of participation
Source: After Schlossberg and Shuford *(2005)*

2.2.2 The Integration of Scientific and Non-scientific Knowledge

Comparing local ecological knowledge and scientific insights requires insight into the particularities regarding scientific and local ecological knowledge. Scientific knowledge production follows a very formalised procedure, mostly producing written reports, whilst what we would refer to as 'local knowledge' is generated informally, in a heuristic trial-and-error manner, mostly resulting in tacit or oral knowledge *(Payton et al. 2003; Raymond et al. 2010)*. Data gathered on a participatory basis is commonly recognised as 'local knowledge' *(Corburn 2003)*, where such different epistemologies make them work in different contexts, without making any of the two types of knowledge lesser connected to their context and to the personal preference of the investigator *(Agrawal 1995)*. 'Local knowledge' is not usually verified and of a small spatial and topical coverage, but likely covering a long time scale with particular highlighting of extreme events *(Berkes et al. 1995; Moller & Berkes 2004)*. Scientific knowledge is mostly detached from the concrete, generalised and only accessible using the view of a certain 'thought style' *(Fleck 1935)*. Therefore, local and scientific knowledge may contain very distinct observations, which only make sense within the respective 'thought collective' *(Fleck 1935; Lach 2014)*.

A ***transdisciplinary research project*** involves people from outside academia contributing to a problem with societal relevance *(Herweg et al. 2010)*. In transdisciplinary research, the interaction with outside-academia actors can be characterised in analogy to those in public participation and can vary over the course of the project *(Enengel et al. 2012; Herweg et al. 2010; Stauffacher et al. 2008)*. The aims of such an endeavour usually are an increased trust and interest in the results, whilst increasing the relevance of the recommendations *(Herweg et al. 2010)*. However, this requires much experience and time *(Neßhöver et al. 2013)*. Despite the process being a core element, data generated in such a process should be valid and useful *(Lynam et al. 2007)*.

Homogenising both types of knowledge is a complicated, if not impossible, endeavour; therefore, the aim could be to harmonise the two, seeking to establish a connection between them *(Davenport & Prusak 1998)*. Local knowledge might be 'richer' in context and therefore could complement scientific knowledge *(Chalmers & Fabricius 2007)*. However, there is a lack of studies concerning the quality and specialities of the data gained through participatory mapping. Geographical space can be seen as an integrative platform *(Payton et al. 2003)*, which makes it particularly interesting for participatory research. We therefore will investigate the specificities of mapped data in greater detail.

2.2.3 Public Participation through GIS

As mentioned above, the collection of geospatial data in a participatory manner is referred to as Participatory Mapping (PM) *(Tulloch 2008)*. PM is a core method in data collection in Public Participatory GIS (PPGIS) and Participatory GIS (PGIS) and for gathering Volunteered Geographic Information (VGI). VGI is usually characterised by passive sampling *(Brown & Kyttä 2014)*, meaning that the control over the data collection by the project leader is limited as participants are not approached directly. As the focus of this thesis is centred on the interactions between participants, the data and the outcome of the PM, subsequently, focus is directed towards studies applying an ***active sampling*** strategy, namely PGIS and PPGIS studies. The term Public Participatory GIS (PPGIS) is commonly used for studies taking place in industrialised countries, whilst the term Participatory GIS (PGIS) more often is used for empowering research in developing countries *(Brown & Kyttä 2014)*. However, the definitions of the two terms remain partly nebulous *(Tulloch 2008)* and are not important for this thesis.

Maps are a powerful, flexible and robust way of exchanging and integrating information with a spatial component *(Monmonier 1993; Payton et al. 2003; Schlossberg & Shuford 2005)* and particular social phenomena *(Beeco & Brown 2013)*. Eventually, it may be that PM might be suitable in capturing interactions amongst spatial objects; however, this is disputed *(Lynam et al. 2007)*. Early uses of PM were close to sketch-mapping without the provision of a geographical reference for mapping. This allowed participants to provide information even if their understanding of space was non-Euclidian *(Mascarenhas & Kumar 1991; Wartmann 2016: 135–136)*. Nowadays, PM applications are mostly based on a geographical reference, which is recognised as allowing easy comparison with other data used in natural resources management *(Morse 2012)*.

The degree of participation required for a PM study depends on the aims of the particular study. Using maps as a medium for participation in decision-making might allow the formerly 'silent' to speak out; at the same time however, it might hinder others due to low map-reading competence or technical inabilities, for example *(Carver 2003)*. The inclusiveness of the method must not be of great concern as long as the aim of the PM is reached, should the validity and generalisability of the data be assured, for instance. This might be the case if the aim of PM is to augment and complement expert views *(Brown et al. 2013; Jankowski 2009)*, or otherwise if PM is the only source of spatially explicit knowledge and information and the desired people can participate *(Fagerholm et al. 2012)*. However, in other ways, PM is more than a simple research tool aimed at increasing the voice of the public in participatory decision-making *(Jankowski & Nyerges 2003; Sieber 2004)* or on building a trustful relationship with a community and jointly define the research agenda *(Stewart et al. 2008)*. In such an instance, the PM needs to be much more inclusive, allowing everyone who wishes to contribute to do so. Therefore, PM itself does not guarantee a participatory process on a particular level of the previously introduced intensities of participation *(Arnstein 1969; Schlossberg & Shuford 2005)*. In this thesis, focus is predominantly placed on the ***collection*** of geospatial data in a participatory way, and thus we subsequently use the term PM.

The Mapping Methods in PM

There are many ways by which PM methods can be characterised, amongst them the type of mapped features (points, polygons or predefined areas), the setting (self-administered surveys, facilitated workshops or face-to-face interviews) and mapping medium (paper-based vs digital). Nevertheless, there is a combination of characteristics that is more common than others: self-administered surveys mostly use point features to be mapped as they seem to be less cognitively challenging to participants *(Brown & Fagerholm 2014; Brown 2012b)*. In workshops and face-to-face interviews, the methodology may be much more diverse. In the following, polygon and point-mapping are compared, along with the corresponding aggregation methods.

Most studies carried out to date are based on mapping point features. In a recent review of studies applying PM to mapping ecosystem services, three studies were concerned with seeking out polygonal features, with 25 studies mapping point features and two studies using predefined polygons or a hectare raster respectively *(Brown & Fagerholm 2014)*. Usually, PM studies allow the participant to freely define the area on which they would like to focus, with the notable exception of the study by Hall ***et al.*** *(2009)*, who required that participants tessellate the entire study area. There are a few studies with predefined polygons, for which the participants then have to give a value, such as cultural ecosystem values *(Plieninger et al. 2013)* or the importance of urban green spaces *(Tyrväinen et al. 2007)*. Such an approach makes it easier to link the results to a management unit *(Tyrväinen et al. 2007)*; however, the introduced tessellation pretends crisp boundaries and regions, which, in reality, do not exist as such *(McCall 2006)*. Further, as with all tessellations of space, such approaches may suffer from the Modifiable Areal Unit Problem (MAUP), as highlighted by Sieber *(2006)*. A third set of studies use PM to comment on and evaluate existing spatial information, such as sites for wind energy *(Simão et al. 2009)* or adaption strategies to climate change *(Eikelboom & Janssen 2013)*. Few studies have combined PM with transect walks to refine the boundaries drawn by the participants *(Payton et al. 2003)*.

Mapping point or polygonal features does not allow mapping vague concepts, but their aggregation does usually incorporate some vagueness as they do not yield crisp boundaries, as explained below. Nevertheless, attempting to incorporate the inherent spatial fuzziness while mapping the features, some studies provided a fuzzy 'spray-can' tool, which allows to gradually add certainty to information objects by leaving areas semi-transparent or add denser colour *(Cacciapaglia et al. 2012; Carver et al. 2009)*. However, this tool was not tested on its ability to represent the participant's perception of fuzziness.

In any case, the appropriate level of fuzziness depends on the aim of the PM. There is a broad set of possible applications of PM with different requirements regarding certainty and ambiguity of the outcome data, as shown in Figure 2-6. Above all, the maximum positional accuracy of PM seems to depend on the scale of the map *(Brown & Kyttä 2014; Brown 2012a; McCall 2006)*. Without reaching positional accuracy, the results cannot be certain. Literatures suggests that, when seeking to reach high levels of certainty, large-scale base maps need to be used. McCall *(2006)* suggests a range of 1:5 000 to 1:20 000, whilst Mather *et al. (1998)* recommend even larger scales, spanning between 1:1 250 and 1:2 500 for PM. Nonetheless, despite these recommendations, the average scale used in similar studies is recognised as being around 1:260 000 (c.f. Table 2-2), which is more than a magnitude smaller than those proposed in the literature. Although some concerns were raised regarding the effect of scale on data accuracy in PM *(Carver 2003; Sieber 2006)*, few studies have been undertaken in mind of investigating this. Brown *(2012a)* identified no correlation between map scale and mapping accuracy when comparing points marked at a scale of 1:100 000 and those mapped at a larger scale, which, however, is much smaller than the scale range proposed previously.

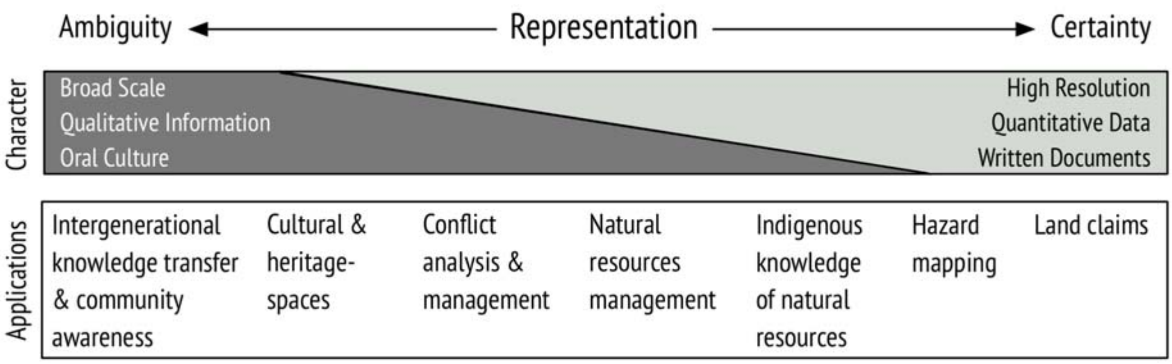


Figure 2-6: Spectrum of PM applications, ranging from representing features with highest certainty to ambiguous features
Source: Own graphic, based on McCall *(2006: 118)*

Polygonal data most often is aggregated by counting the number of overlaps (c.f. Table 2-2), whereas point data, on the other hand, often is aggregated using kernel density estimation (KDE) *(Brown & Fagerholm 2014)*. KDE is a geostatistical procedure to interpolate the density of points. Some studies then isolate 'hotspots' of opinion convergence by applying a certain threshold to the KDE, such as the upper third *(Alessa et al. 2008; Brown & Weber 2012; Cox et al. 2014; Whitehead et al. 2014)*. Studies using polygonal data follow a similar reasoning, such as taking the 10 % of the area where most polygons overlap *(Darvill & Lindo 2015)*. Eventually, statistically significant 'hotspots' are assessed using Getis-Ord Gi* *(Brown et al. 2014; Karimi et al. 2015)*. To then compare hotspots between different methods or features, one could either use a percentage used as a threshold for isolating hotspots and accept varying acreage for comparison or select the same acreage and accept varying values for the threshold *(Karimi et al. 2015)*.

Table 2-2: Selection of PM-studies with individuals mapping polygon features

Study Subject	*Purpose*	*Sample*	*Scale*	*Aggregation*	*Reference*
Perception of Downtown	Investigation of vague concepts. Participants delineated what they understood as 'downtown'.	39	1:170 000	Point density shading (similar to polygon overlaps)	*(Montello et al. 2003)*
Social Values	Integrate social values to park planning. PM combined with interviews.	15	1:72 000	Polygon overlaps	*(Black & Liljeblad 2006)*
Landscape Values	Elicit landscape values, development preferences and special places.	18–42	1:125 000	Union of polygons	*(Brown & Pullar 2012)*
Coastal ecosystem services	Assessing monetary and non-monetary values and threats.	17–25	1:400 000	Polygon overlaps	*(Klain & Chan 2012)*
Agricultural services	Mapping and collecting local knowledge concerning agricultural services.	26	1:300 000	Polygon overlaps	*(Debolini et al. 2013)*
Access priority	Mapping priority fishing grounds amongst fishers for spatial planning.	103	Not disclosed	Polygon overlaps weighted by fleet and area size	*(Yates & Schoeman 2013)*
Ecosystem services for conservation	Mapping of tangible and intangible ecosystem services.	31	1:500 000	Polygon overlaps	*(Darvill & Lindo 2015)*

Few studies collect PM data with other attributes from the participants, such as psychometric survey data *(Jorgensen & Stedman 2011)* or qualitative interview data from interviews *(Black & Liljeblad 2006; Cacciapaglia et al. 2012; Hall et al. 2009)*, despite the fact the reasoning behind mapping decisions or more detailed values associated with a given spatial feature were demanded in a couple of studies *(Brown & Pullar 2012; Brown et al. 2015a; Cacciapaglia et al. 2012; Debolini et al. 2013)*.

The Mapping Content: From intangible to tangible items

The mapping context itself varies greatly, with some studies focusing on issues not directly observable (latent variables), such as, for example 'Sense of Place'. Other studies focus on the preferences of use or development, which can be subsumed under 'tenure and resource use mapping', or even on more tangible properties, such as a biological reality, which then can be classified as 'local ecological knowledge' *(McLain et al. 2013)*. Each of the different approaches will be described in this section.

The measurement of intangible social values, such as place attachment or sense of place, is difficult as it requires an operationalisation of those vague concepts *(Brown & Raymond 2007)*. In order to make the concept to be mapped more manageable, studies have combined psychometric with PM data *(Brown & Raymond 2007; Lowery & Morse 2013)* or otherwise have sought to link additional spatial features, such as waterways and landscape fragmentation to PM data *(Jorgensen & Stedman 2011)*. Other studies focused on more easily understandable intangible items, such as the services farmers can provide and those they can utilise within society *(Debolini et al. 2013)* or perceived threats to social values *(Scolozzi et al. 2014)*. However, such studies lack the possibility to cross-validate the results with some sort of 'ground truth' *(Brown et al. 2012a)*, and merely represent a snapshot of relations that are likely to be highly dynamic, as discussed in Section 2.1.2 'Sense of Place and Place Attachment'. Furthermore, to the best of our knowledge, at the current time, there is no study seeking to delineate areas without sense of place or place attachment; therefore, most studies infer the absence of mapped values to actually *represent* an absence of mapped values. Doing so neglects the possibility of forgetting or not knowing about these regions, and hence does not account for ipsative constraints *(Tanner 1999)*.

Numerous studies combine biological and social values and/or development preferences. One of the aims of such an approach is centred on better integrating participatorily mapped perceptions and social values within established top–down planning processes *(Brown & Weber 2012)*. Therefore, these studies link intangible values to better observable, tangible values, which are likely included in the existing planning process. Those studies, for example, map perceived biological values and overlay those with biological primary production or habitat mappings *(Alessa et al. 2008; Cox et al. 2014)*, ask about natural and cultural ecosystem services *(Brown et al. 2012a; Darvill & Lindo 2015; Fagerholm et al. 2012; Palomo et al. 2013; Raymond et al. 2009)*, or otherwise investigate the relation of monetary and non-monetary values *(Klain & Chan 2012)*. A couple of studies draw a direct contrast between areas of high cultural value, elicited through PM, with areas of high biological value, derived from other sources (e.g., expert statements, biological models). Such a comparison then facilitates the inference of possible acceptance of conservation measures *(Brown et al. 2004, 2015b; Karimi et al. 2015; Whitehead et al. 2014)*.

Such studies, connecting biophysical and cultural values, provide relevant insights into the clustering, distribution and overlap of cultural and natural, intangible and tangible values. Intangible values, especially those applied in mind of social interaction, seem to be more densely clustered than more tangible values, such as wood collection or cultivation, as shown throughout the course of several studies *(Alessa et al. 2008; Fagerholm et al. 2012)*. Further, there seems to be less collocation between intangible and tangible values than within the two groups *(Nielsen-Pincus 2011)*. However, those studies lack the inclusion of the reasoning of the participants when providing PM data. The expressed reasoning is particularly important for intangible values when considering there is evidence that seem to be more easily expressed in spoken words than in mapped features *(Klain & Chan 2012)*. Several studies have requested the assessment of the reasoning of participants during mapping *(Brown et al. 2015b; Cox et al. 2014)*.

A third set of studies focuses on the mapping of a biological reality, using the participants of the PM as domain experts in some aspects of local ecological knowledge. In those applications, the quality of the data is of the greatest concern in the creation and incorporation of trust into the method *(Brown & Kyttä 2014; Brown 2012b)*. Depending on the study, data quality is operationalised differently and incorporates validity, spatial accuracy, correctness, and/or completeness (these terms are explained in greater detail in Section 2.4 'Data Quality and Sampling'). Padmanaba *et al. (2013)* used PM to map the occurrence of six animal and two plant species by a total of 52 participants, which regularly went for hunting or gathering plants. They conclude that PM could be a cost-effective method for such data collection, assuming their data to be valid, but admitted that the evaluation of PM data with various other datasets was missing, which did not allow the calculation of spatial accuracy, correctness or completeness. Brown *et al. (2015b)* empirically evaluate the completeness and positional accuracy of PM areas of conservation priority by comparing the results of PM with those from a zonation software. In their study, the conclusion is drawn that the conservation priority areas identified by the software are generally also found through PM data. However, this study lacks reporting of the amount of false positives, i.e. the correctness of the data, by calculating areas that were identified by PM but not by the zonation software to be a conservation priority. In a study by Brown *(2012a)*, a total of 260 participants mapped native vegetation, which then was compared to the native vegetation derived from a satellite image. Considering spatial accuracy, only 6 % of the points had no native vegetation whilst 45 % had 90–100 % native vegetation within a 1000 m buffer around the mapped points, as opposed to randomly distributed points, which would yield 22 % of the points with no vegetation and 33 % with 90–100 % native vegetation within the buffer. However, this study does not calculate the share of native vegetation that was not identified with the PM, i.e. the completeness of the data. However, as with correctness, i.e. the share of correctly identified native vegetation, the assessment of completeness is not straightforward as it compares mapped points with polygons of native vegetation. Vergara-Asenjo *et al. (2015)* mapped primary forests with indigenous communities, and further validated the results on some random points and some given plots. In comparison to the digital image classification of remotely sensed data, PM showed the highest overall correctness and completeness, considering both areas of a given land use correctly identified as such (true positives) and areas of another land use not classified as the given land use (true negatives). One therefore can infer that a considerable overlap between features mapped by PM and by other methods is likely; a complete overlap, however, is highly unlikely *(Alessa et al. 2008; Karimi et al. 2015)*. PM and other methods are likely to both, complement and correspond to each other *(Brown et al. 2015b)*.

2.3 Multi Criteria Evaluation (MCE)

2.3.1 The MCE Procedure

Multi Criteria Evaluation (MCE) represents a structured way of formalising a decision problem and accordingly comparing alternatives with one another *(Carver 1991)*. MCE can help to rank alternatives according to their attributes (multi attribute decision-making) when having a single objective or it can help to find the optimal values for attributes when having several objectives (multi objective decision-making) *(Malczewski 1999)*. We subsequently focus on ***multi attribute decision-making*** as our aim is to rank land patches in line with their likelihood to experience land use change based on their attributes. A multi objective problem, as a contrasting example, would be to find the land use configuration that delivers the most ecosystem services (with each ESS representing a potentially conflicting objective). A spatial MCE connects an MCE with spatial data by incorporating the spatial distribution of the attribute values. Most spatial MCEs follow the multi-attribute approach *(Malczewski 2006)*.

Although spatial MCEs were intended to increase participation in spatial decision-making from the very beginning *(Carver 1991)*, this often is not the case due to several reasons. First, the mere existence of an MCE states that there is a problem to be solved: for instance, if there is an MCE for the siting of a powerline, the public participation could never contest the project itself by selecting, transforming and weighting the criteria. Second, an MCE does not necessarily incorporate all the aspects important to the public, e.g., because they are not measurable *(Towers 1997)*.

MCE traditionally comprises the following six steps *(Malczewski 1999)*:

1. Selecting criteria
2. Standardising the criteria values to value scores
3. Weighting the value scores
4. Aggregating the weighted value scores
5. Sensitivity analysis of the results
6. Validation of the results (as explained in Section 2.4.2 'Validation, Verification and Data Quality')

Step 1: Selecting criteria: In a multi-attribute MCE, the objective is given, for example, to identify the most suitable parcel for growing wine. The aim then is to rank the alternatives based on their suitability; therefore, one first selects the decisive criteria for the ranking. For example, slope, soil suitability, and insolation. The selection of the criteria determines what an MCE can include, and is a normative decision *(Towers 1997)*. If, for example, landscape beauty is not included as a criterion, the MCE then cannot incorporate it, and people who value landscape beauty can never incorporate their opinion in the MCE. The criteria further needs to be measurable or otherwise be decomposed into measurable items, and they should be independent of one another in order to avoid double counting *(Malczewski 1999)*.

Step 2: Standardisation: Subsequently, one needs to translate the measured values to a comparable unit (e.g., monetary units or a dimensionless utility) in a comparable range (often 0 to 1) *(Winterfeldt & Edwards 1986)*. There are various ways of so doing, mostly by applying a transforming function, e.g., by reclassifying classes of measured values into utility values or by applying a continuous function *(Beinat 1997; Brans & Mareschal 2005)*. In order to calculate the value function, the bi-section technique is a prominent representative. Through this approach, one is asked to indicate the level of a measured value that corresponds to half of the utility, then with the level of 0.25 and 0.75 utility and finally the level of highest and lowest utility. The intermediate values then are linearly interpolated *(Kalelkar & Brooks 1978)*. However, for so doing, the functions must be monotonically decreasing or increasing, possibly requiring that the measured values be first transformed *(Winterfeldt & Edwards 1986)*. Other approaches include the use of differently shaped value functions *(Keeney 1992)*, e.g., trapezoidal functions *(Morgan 1998: 243)* or the transfer of measured values to fuzzy sets through fuzzy membership functions *(Malczewski 1999)*. The function might vary over the study area; that is, in different parts of the study area, the same slope transfers to a higher or lower utility, and either a spatially varying function is defined or a function is used that works for the entire area of research *(Hepner 1984)*. Aggregating value functions from the inputs of several participants is difficult, and further advances in group MCE-methods are still to be accomplished *(Malczewski & Rinner 2015)*.

Step 3: Weighting the value scores: As a third step, the criteria are weighted. This means that each criterion is assigned a certain importance with regards all other criteria. Typically, all the weights sum up to one. There are different ways of eliciting the weights, amongst them ranking, rating, trade-off analysis and pairwise comparison. One of the more widespread and scientifically sound weighting methods is the Analytic Hierarchy Process (AHP) *(Malczewski 2006)*. In the AHP, the criteria are ordered in a hierarchical tree, hence its name, and on each level of the tree, pairwise comparisons between each of the criteria belonging to the same branch are performed *(Saaty 1995)*. Hence, one compares Criterion A to Criterion B and to Criterion C, and Criterion B to Criterion C. As a consequence, there are possible inconsistencies if, for example, one judges Criterion A to be less important than Criterion B and at the same time to be more important than Criterion C. In such a case, Criterion C logically would be less important than Criterion B, but one may judge it to be more important. Therefore, recent research have developed alternatives to the classical linear scale for the comparison, which are more robust concerning inconsistencies and better correspond to verbal expressions *(Franek & Kresta 2014; Salo & Hämäläinen 1997; Siraj et al. 2015)*. Further, proposals have been made to expand the method for multiple contributors *(Goepel 2013; Ishizaka & Labib 2011)* and assess differences between the contributed preferences using Sammon maps *(Condon et al. 2003)*.

Step 4: Aggregating value scores: The fourth step aims at aggregating the weighted value scores. In the simplest technique, the layers are converted to binary maps, indicating suitable and unsuitable areas per criterion, and then are combined in a Boolean way, intersecting suitable and unsuitable areas. However, this Boolean approach does not allow a ranking of alternatives; there are various different ways of calculating ranked alternatives, amongst them the Weighted Linear Combination (WLC) and Ordered Weighted Averaging (OWA) methods *(Yager 1988)*. In the case of the WLC, the weighted and standardised criteria are added by summation, which is the most common way of achieving aggregation *(Malczewski 1999)*. OWA includes a statement centred on the degree of substitutability amongst the criteria: for example, by selecting only the lowest value, higher values cannot substitute lower ones, or by selecting only the highest value, lower ones do not affect the overall score. If one assumes complete substitutability amongst the criteria, the OWA solution equals the WLC by giving the lowest and highest values the same weight. More elaborate and complex approaches involve fuzzy aggregation *(Malczewski 1999: 231–232)*, logic scoring of preference *(Dujmovic et al. 2009)*, and Dempster-Shafer combination *(Comber et al. 2010)*.

Step 5: Sensitivity analysis: After having calculated the results, the effects of uncertainty should be analysed through the completion of a sensitivity analysis *(Malczewski 1999)*. Most studies completely neglect to assess sensitivity *(Malczewski 2006)*, and if they do, they investigate the effect of one factor at a time *(Malczewski & Rinner 2015)*, such as by setting the value of a criterion to 0 or to 1, for example, which allows one to establish the consistency of the results, following the reasoning 'what would have happened, if the measurement or the weighting of this criteria would be completely different'. Such an approach does not consider any possible interactions between criteria, their valuation, weighting and measurement uncertainty *(Ligmann-Zielinska & Jankowski 2014)*. However, there also are methods centred on assessing sensitivity by including the variation of all the criteria simultaneously, as explained subsequently.

There are two basic ways of assessing the complete uncertainty in a Multi Criteria Evaluation: analytical calculation and probabilistic methods *(Malczewski & Rinner 2015; Malczewski 1999)*; the former is based on the formulae for error propagation from general error theory, where the total uncertainty is a combination of the uncertainties associated with the individual variable (expressed by the standard deviations of the error of each variable). Whilst being computationally less demanding, in the analytical method, the covariance between the criteria often is neglected. If, for example, high values of one criterion correlate with the low values of another, they compensate each other. If this systematically happens, i.e. if the criteria have a high covariance, the result has a lower variation than one would expect if considering the variations of the criteria one after another. Because the number of covariance instances rises to the square of the number of criteria, it is difficult to analytically incorporate the covariances for a larger number of criteria. Additionally, general error theory assumes errors are normally distributed with the variables continuously differentiable. The probabilistic approach uses Monte Carlo simulation *(Gómez-Delgado & Tarantola 2006)* or similar methods, such as bootstrapping *(Malczewski & Rinner 2015)*. In MCE, there is no clear guidance and comparison between the analytical uncertainty analysis, which is faster but does not incorporate the covariances, with the uncertainty analysis based on the Monte Carlo simulation, which accounts for the covariances. When considering the greater versatility and the less constraining assumptions, Monte Carlo methods today have become the predominant approach to computing error propagation in practical applications—even more so since computing power is ever increasing.

2.3.2 Related Applications of MCEs

MCEs often are used in predictions of land use and land use change *(Veldkamp & Lambin 2001)*. One may, for example, use a spatial MCE that spatially allocates land use change to subsequently quantify the overall change in a non-spatial land use prognosis *(Pontius et al. 2004; Verbrug et al. 2002)*. Schneider and Pontius *(Schneider & Pontius 2001)*, for example, calculate the suitability for deforestation with a spatially explicit MCE and accordingly combine the MCE with a prognosis of the total area deforested modelled through linear extrapolation. The plots with the highest suitability for deforestation then are used to spatially allocate the modelled total deforestation area. This combination benefits from both sides, as MCEs are well-known in their ability to calculate land use suitability within a given area *(Eastman et al. 1998; Qiu et al. 2014)*, whilst the drivers of land use change often are dominated by processes on a spatially coarser level, such as through politics or economy *(Murray-Rust et al. 2011; Veldkamp & Lambin 2001)*.

The quality of the predictions by such models varies. In a larger study on land use change models, Pontius *et al.* *(2008)* compared 13 land use predictions by different models with actual data. They calculated the figure of merit, which is equal to the Jaccard-Coefficient, as well as the producers' and users' accuracy, which allows the calculation of the F1-value, as used and described later on in this thesis (see Section 4.3 'Evaluation of the Results'). Both range 0–1, with higher values corresponding to higher data quality. On average, the models in the study of Pontius *et al.* *(2008)* yield an F1-value of 34 % and a Jaccard-Coefficient of 24 %, respectively. Only one model reached a Jaccard-Coefficient greater than 50 %, indicating that more than half of the predicted pixels were actually correct. Considering the limited predictive power of the models, there is room for the further development of land use change prediction. Such research is important but should also seek to reduce the complexity of the approach and include more stakeholders as this would increase the overall acceptance associated with quantitative models *(Sohl & Claggett 2013)*.

Regarding the case studies of this thesis, there are a couple of applications using MCE to assess the suitability for viticulture. Tonietto and Carbonneau *(2004)* use an MCE to classify worldwide grape-growing regions based on climate. Jones *et al. (2004)* calculate viticulture suitability in the Umpqua valley in Oregon US based on soil, topography and climate. Irimia and Patriche *(2010)* do the same, but in Moldavia and based on solar radiation, insolation, slope and aspect. The study with the greater resolution and the most thorough evaluation was performed by Yau *et al. (2014)* in north-western USA. On a 10 m resolution, they included topography, soil parameters and climate. They then evaluated the results of MCE in interviews and on-site visits, drawing the conclusion that the used available water holding capacity (a soil parameter) in particular is not congruent with people's perceptions, and hence has been judged as problematic as it might invalidate the results. However, none of the presented studies on viticulture made all the steps outlined previously transparent. For example, weighting and standardising often were carried out in a single step, with none of the studies including a sensitivity analysis. Further, the weighting and standardisation of the criteria values often were done in an incomprehensible way. Therefore, we intend to make a contribution by presenting the first methodologically sound MCE, involving multiple experts on vineyards.

2.4 Data Quality and Sampling

2.4.1 Sampling Strategies and Saturation

In order to better understand sampling strategies in PM studies, a brief overview of sampling strategies in other disciplines is provided. The way in which sampling is carried out corresponds to the character and aims of the study: if the study aims at exploring and understanding the views of people, qualitative methods often are used, such as narrative interviews or participatory observations *(DeLyser & Sui 2014)*. However, if the aim rather is centred on measuring the effects or properties of a population, researchers often use quantitative methods, such as questionnaires or measurements *(Johnson & Onwuegbuzie 2004; Marshall 1996)*. In this terminology, quantitative methods generate scaled data, e.g., numbers and ranks, which in turn can be turned into a numerical output, whilst qualitative methods yield insights that cannot be ranked or counted, and are mostly disseminated in text form.

Sampling in qualitative research, usually follows three broad approaches, convenience, purpose and/or theory building *(Marshall 1996)*. ***Convenient sampling*** entails to approach the most accessible participants, and will not be discussed further, as it is not a scientifically sound approach. ***Purposeful or Judgement sampling*** starts with assumptions from the researcher about influential variables and then seeks to sample i.e. maximal variation, critical cases or conforming and disconfirming cases *(Marshall 1996; Patton 2015)*. ***Theoretical sampling*** is the most inductive sampling approach, as the sampling criteria unfold throughout the research. The already analysed data and iteratively developed hypothesis and theories are considered for sampling further cases *(Patton 2015; Strauss 2004)*.

As PM might be either understood as rather qualitative or as rather quantitative, there are different sampling strategies found in the literature. Including a probabilistic, random sampling of households with the possibility of volunteers to join *(Brown et al. 2013)*, semi-probabilistic sampling of decision-makers *(Raymond et al. 2009)* or community leaders *(Fagerholm et al. 2012)*, sampling aiming for highest diversity amongst participants *(Klain & Chan 2012)*, or sampling for the domain experts *(Debolini et al. 2013)*, eventually combined with snowball sampling *(Morse et al. 2014)*. Each of these sampling strategies has its merits. Whatever strategy is used, the key point is that it is capable of reflecting the aims of the study.

Brown *(2012b)* provides a rough guidance to adjusting the sampling strategy based on the task to be mapped. He proposes sample participants with more expertise for more cognitively challenging tasks. In this logic, mapping place-based activities requires less expertise than mapping environmental impacts. Carver *(2003)* proposes the inclusion of people who would be affected by the outcome of the PM. However, little guidance can be given concerning the minimum number of informants required.

Whilst there is a clear foundation of the required sample size in quantitative science, qualitative methods provide less guidance besides the concept of ***theoretical saturation*** *(Mason 2010; Strauss 2004)*. This concept defines that enough interviews are performed when further interviews do not yield additional information, thus making it crucial to define an 'information unit' *(Francis et al. 2010)*. Often, theoretical saturation is measured in a cyclical, iterative process, checking each interview for additional information *(Marshall 1996)*. In a typical study, the first 6 interviews add the most information, with additional interviews adding fewer new insights *(Guest et al. 2006; Mason 2010)*. In quantitative analysis, on the other hand, the necessary sample size is determined by the strengths of the effect analysed, the level of significance and the power level *(Cohen 1992)*.

However, if the aim is not reach ***theoretical saturation***, but to gather for instance cultural knowledge, such as in ethnography, the concept of theoretical saturation provides little guidance. There, the aim might be focused on gathering the most consensual representation of a cultural feature, such as whether a certain place is sacred. In ethnographic research, Romney ***et al.*** *(1986)* calculated the required number of informants depending on the average 'cultural competence' of those informants. The 'cultural competence' describes whether or not this informant has proven to answer questions similar to the answers of other participants. Hence, it is of importance that the participants share some agreed domain knowledge for reaching saturation *(Guest et al. 2006)*. Figure 2-7 details some saturation curves from Romney ***et al.*** *(1986)* with 95 % confidence: for example, if one would like to have 90 % of the questions answered with 95 % confidence, one would need between 13 and 4 informants with low or high 'cultural competence', respectively. Unfortunately, one does not know the 'cultural competence' of the informants prior to data collection and probably not even afterwards. However, this indicates that small samples of well-informed participants yield more reliable data than a larger sample of less competent informants. In the study by Chalmers and Fabricius *(2007)*, a smaller sample of local experts yielded more consistent information than a larger one consisting of random respondents; in other words: *«a small number of specially chosen informants can yield more valid and generalizable information than a larger group of general informants»* *(Johnson 1990: 26)*. This indicates that increasing a sample by adding less knowledgeable informants actually might prove to be counterproductive for yielding a better result.

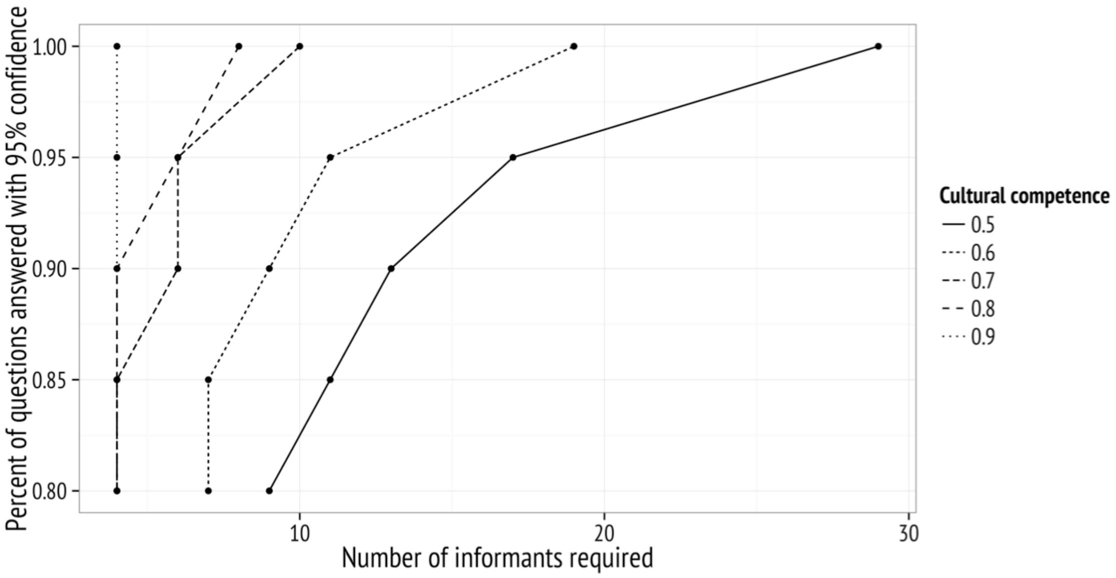


Figure 2-7: Required sample size for cultural research depending on the 'cultural competence' of the participants and the required confidence level
Own graph, data taken from *Romney et al. (1986: 326)*

The desired level of attribute and spatial detail greatly influences the required sample size in PM. Further, the required sample size and a corresponding saturation-criterion that should be achieved are not well-defined in PM. An attempt to do so needs to include the spatial variability of the phenomenon to be sampled *(Rohrbach & Laube 2014)*, besides the topical variety *(Padmanaba et al. 2013)*. Recalling Romney *et al.* *(1986)*, the 'cultural competence' of informants about a given location is important to estimate the confidence in the information for that given location.

However, using only experts in the field does not necessarily seem to yield a high level of consensus among the participants: in a study on habitat-mapping by six professional environmental consultants, Cherrill and McClean *(1999)* found a mean agreement of only 25.6 % amongst the surveys. However, when aggregating habitat classes, an agreement of 56.4 % was reached; therefore, data quality in PM depends on the spatial and topical resolution.

In some contexts, even local knowledge is not necessary. In the geo-wiki project[3], participants map global land cover based on satellite images. When evaluating the quality of mapped cropland, the

[3] http://geo-wiki.org

participatory data yielded an accuracy of 78.8 % and a completeness of 68.5 %. Indicating, that 78.8 % of all land, which was classified as cropland by the participants, was indeed cropland, and of the total cropland, the participants identified 68.5 % as such *(See et al. 2013)*. Not making use of an active sample but rather drawing on OpenStreetMap data, Haklay *et al. (2010)* found that, if there are more than five participants mapping, streets were less than 8 m off from the reference data. Using Flicker tags, Hollenstein and Purves *(2010)* showed, that 83 % and 86 % of the tags were correctly placed inside Regent's Park and Hyde Park, respectively.

The sampling strategy, the mapping content and the mapping methodology have a reported influence on the necessary sample size. Participants who are familiar with the study area, do not necessarily engage more with the study *(Brown et al. 2012b)*, although familiarity with the site is a necessity in terms of providing meaningful information *(Sherrouse et al. 2011; Di Zio & Pacinelli 2011)*. Mapping vaguer concepts, such as aesthetic versus economic values, seems to require larger samples *(Brown & Fagerholm 2014; Brown & Pullar 2012)*. Mapping polygons rather than points requires between 15 and 28 times fewer participants than using points for the same feature *(Brown & Pullar 2012)*. Distributing the questionnaire over the internet reduces the mapping effort and the response rate compared to the distribution of a paper version *(Brown et al. 2012b; Pocewicz et al. 2012)*. Therefore, a PM study using polygons concerning a concrete subject, with domain experts in the field and a narrow geographical scale, requires the lowest number of subjects, whilst a PM involving a random sample on a vague content, using points on a large geographical scale, requires many participants.

There are few studies investigating the sample size required in PM. Morse *et al. (2014)* define saturation in PM as the point at which the data covers 90 % of the data from a geometric union of all mapped data. The application of a union in aggregation is similar to the procedure adopted by Brown and Pullar *(2012)*. This, however, does not account for the density of overlapping polygons. Morse *et al. (2014)* state the need to handle these areas with different numbers of overlapping opinions (hotspots), and accordingly stress the limitations of the simple union. Accounting for 'hotspots' whilst assessing the saturation of the spatial data is still a research gap.

2.4.2 Validation, Verification and Data Quality

Validation of a model does not only make it credible but also checks whether or not accuracy is acceptable for the intended purpose *(Rykiel 1996)*. This means that valid data does not need to be fully correct but just 'correct enough'. This poses two requirements: there needs to be a defined purpose of the model and the operationalisation of data quality, which may be different for different stakeholder groups and model aspects (e.g., outcome, process) *(Ligtenberg et al. 2010)*. *Verification*, on the other hand, checks whether the model is formally correct and the results are calculated as expected *(Kaye-Blake et al. 2010)*. Whilst predictive models cannot be verified, they surely can be validated.

Figure 2-8 shows a general typology of imperfection, distinguishing between imprecision and inaccuracy *(Worboys & Duckham 2004)*. Inaccuracy is the lack of correlation between observations and reality (or more precisely: observations believed to be true) and imprecision is the lack of specificity, such as positional precision, or the lack of detail in an observation. Should boundaries be vague because, for example, one uses vague concepts, such as 'high-quality soil', there is always imprecision as one cannot delineate the exact boundary between what is defined as being high- and low-quality soil *(Duckham & Sharp 2005)*. Because there are borderline cases of soil being of both high and low quality, depending on the perspective, one can neither directly assess accuracy nor precision in such situations, as those concepts require crisp boundaries. Rough sets, for example, address this problem *(Pawlak 1982)*; rough sets basically divide the boundary into two boundaries (an upper and a lower bound), which yields three distinct sets for separating 'high-quality soil'. Hence, three sets will be created: one that certainly contains high-quality soil, a set that certainly contains low-quality soil, and a set of undefined soil.

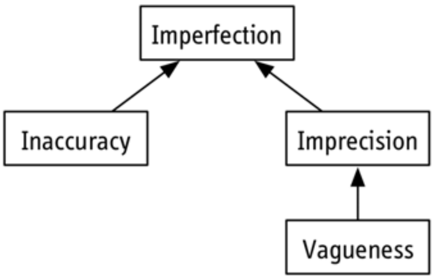


Figure 2-8: Classes of imperfection according to Worboys and Duckham ***(2004)***

In Section 2.2.3 'Public Participation through GIS', we presented four studies that assessed the overall data quality of PM data. Such data quality usually is assessed through the analysis of omissions and errors. Nevertheless, data quality is operationalised differently from one field to the next. In specific consideration to this study, we draw on the literature in GIScience, land use classification in remote-sensing, and information-retrieval (see Section 2.4 'Data Quality and Sampling'). However, other than in land use classification, PM data using polygons most often does not tessellate the whole study area; hence, there is no information the area participants did not mark. Measures including non-classified areas therefore are not suitable for assessing data quality, as this area increases with the amount of 'white space' considered in and around the study area. PM studies using points further face the task of extrapolating the point data to areal units, which requires the selection of a method and the eventual setting of further parameters. However, to the best of our knowledge, there is no study thoroughly validating data from a PM survey, establishing whether the data quality is suitable for the intended use.

2.5 Summary of Research Gaps

The following list summarises the research gaps addressed within this thesis. Additionally, the corresponding section, elaborating on the specific research gap, is referenced to.

- It is unknown which social values nowadays are perceived by the people in the areas of research and how they interact with selected ecosystem services
  (Section 2.1 'Coupled Human and Ecological Systems')
- The influence of PM on social values and possibly on behaviour, remains poorly researched
  (Section 2.2 'Public Participation and the Role of GIS')
- In PM, there is little known about the reasoning of the participants when mapping
  (Section 2.2.3 'Public Participation through GIS')
- It is not clear how much PM and other methods complement and concur with each other
  (Section 2.2.3)
- There is no thorough assessment of PM concerning correctness, completeness and validity
  (Section 2.2.3)
- There is a large range of applied scales and number of participants in PM. Guidelines are not yet clear
  (Section 2.2.3)
- There are methods missing for the aggregation of different expert's opinions concerning the standardisation of the criteria values
  (Section 2.3 'Multi Criteria Evaluation (MCE)')
- Accounting for 'hotspots' whilst assessing the required number of participants in PM has not been done so far
  (Section 2.4.1 'Sampling Strategies and Saturation')

3 Case Studies Descriptions

3.1 Val Müstair

The Val Müstair is an alpine valley in eastern Switzerland, ranging in altitude from about 1 200 m to over 2 400 m (a.s.l.), as shown in Figure 3-1. The valley borders Italy. The Swiss part extends over 20 000 ha, with 46 % of it covered by unproductive areas, such as rocks and glaciers. Another 27 % are forests or shrubs, and a further 22 % is classified as alpine meadows. Pastures account for approximately 4 % of the valley's surface and arable land for about 0.1 %. The remaining 1 % is a built area.

The valley gained the status of a UNESCO Biosphere reserve, to protect and develop its rich culture, scenic landscapes and provide societal cohesion and economic development *(Anon 2009)*. As a biosphere reserve, it is predestined for synergy building between conservation and human needs, aiming at conserving natural landscapes whilst using them *(Higgins-Zogib et al. 2010; Lange 2011)*. Therefore, land use transformations do and should occur; however, they should lead to sustainable development *(Dudley et al. 2010)*.

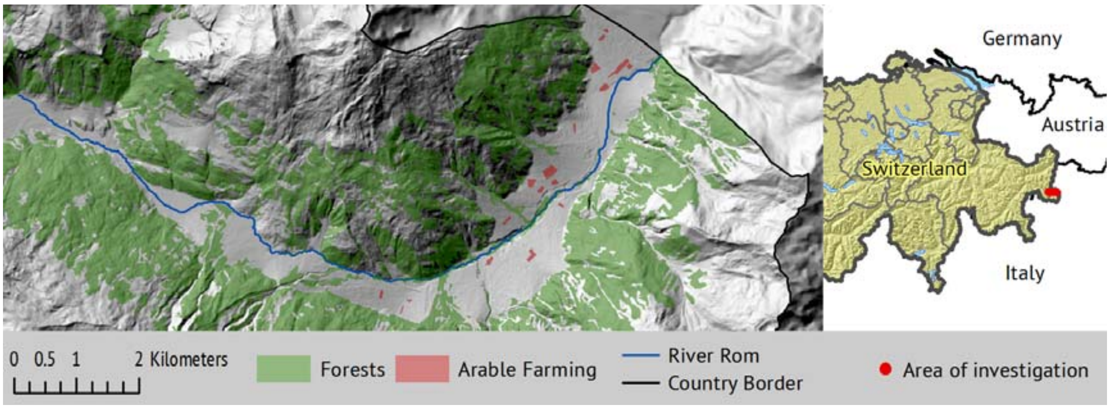


Figure 3-1: Arable farming in the Val Müstair research area in the year 2013

Figure 3-2: Impression from the Val Müstair with some cropland

The recent land use change, with the steep decline of arable farming, as visible in Figure 3-3, is typical for Swiss alpine regions. Since 1990, the area used for arable farming in the valley declined by approximately 85 % to a remaining area of a total of 15 ha, making room for pastures. Since 2014, the main crops planted are fodder maize, wheat, rye, barley, oats and potatoes. The number of farms declined from 85 in 1990 to 51 in 2014, with 39 nowadays producing organic food; many stopped doing arable farming. In 1990, 51 farms (60 % of the total) had arable land, with only 7 (13 % of the total) remained in 2014 *(Swiss Federal Statistical Office 2015)*.

The development of the arable farmland in the Val Müstair, as shown in Figure 3-3, exhibits two periods of drastic decline. The first one was after the Second World War, when the so-called 'Plan Wahlen' ended. The 'Plan Wahlen' was a political programme centred on increasing the production of agricultural goods in Switzerland, with the goal of increasing nutritional autarky in wartimes. This was thought to be achieved through the shift towards more intensive arable farming on grasslands and formerly unproductive land, increasing the cropland from the pre-war 183 000 hectares to 500 000 hectares *(Tanner 2010)*. Following the Second World War, agricultural policy was still production-oriented; however, the support for arable farming declined, and price premiums were reduced *(Ruef & Ladurner 1998)*. Hence, the area dedicated to arable farming declined to an estimated 110 hectares. The second important breakpoint was in 1990, when the dairy in the Val Müstair decided to produce only organic cheese, with the consequence that the milk produced by farmers also had to be organic. As the Swiss 'Knospe' (engl. bud) label for organic farms requires all activities on the farm to be organic *(Bio Suisse 2010)*, not only the milk production but also arable farming had to be converted to organic production. Many farmers faced problems in this transition, particularly with weeds, which no longer could be controlled using herbicides. Additionally, the political basis changed again: the federal agrarian policy was less directed towards intensive, production-oriented agriculture, such as arable farming, but more towards the extensive use of meadows for grazing and milk-production *(Ruef & Ladurner 1998)*. Together, these two changes made the area used for arable farming decline to about 14 hectares in 2011.

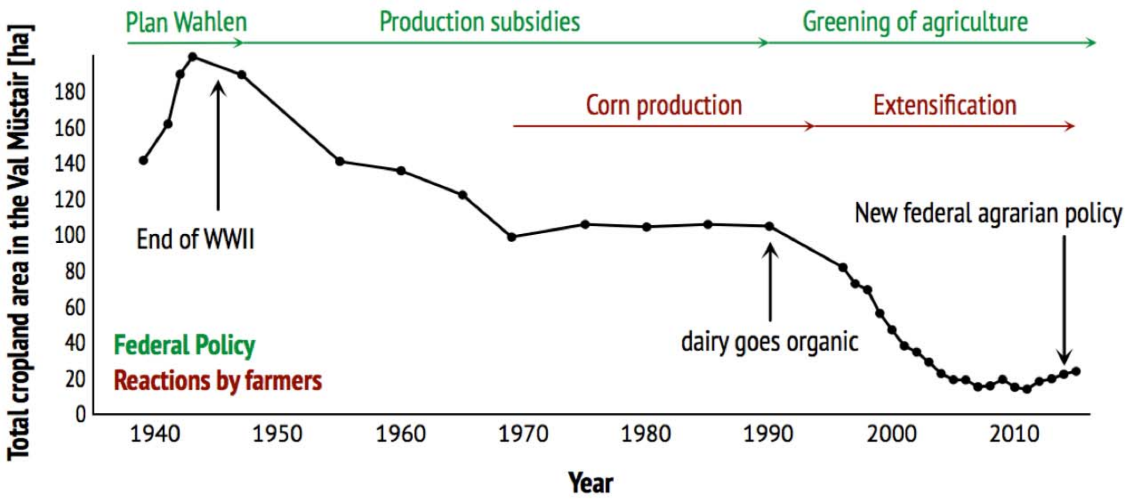


Figure 3-3: Annotated graph of the arable farming surface in the Val Müstair from 1940 to 2013
Based on *Ruef & Ladurner (1998)* and *Swiss Federal Statistical Office (2015)*

In 2014, the federal agricultural policy received a major redesign through the inclusion of regionalised landscape quality payments *(Richner 2011)*. In this respect, the Val Müstair, together with further two communities, developed their own landscape quality concept *(Abderhalden & Pedotti 2014)*, which was enacted at the end of July, 2014. The concept budgeted payments for up to 52 hectares of arable farming as a contribution to the landscape; however, not only did the landscape benefit from this development but also, in the vicinity of arable farmland, biologists found rare weeds and the skylark, a particular bird, which positioned them as valuable in terms of increasing biodiversity *(Andres et al. 2009)*.

3.2 Pfyn-Finges

Pfyn-Finges is since 2013 a regional park in southern Switzerland, in the alpine Canton of Valais, as shown in Figure 3-4. In Pfyn-Finges, viticulture is an important land use covering approximately 4 % of the total area, whilst arable farming accounts for only about 3 %. Most of the study area is covered by forests (43 %), unproductive land (27 %), meadows (18 %) and built-up area (6 %) *(Swiss Federal Statistical Office 2010)*. The steep landscape, dominated by dry-stone walls, as visible in Figure 3-5, requires much manual labour for cultivation; therefore—and as a result of the high salaries in Switzerland—prices for grape-production are higher than in surrounding countries. Nevertheless, the wine industry has been thriving for almost a century now.

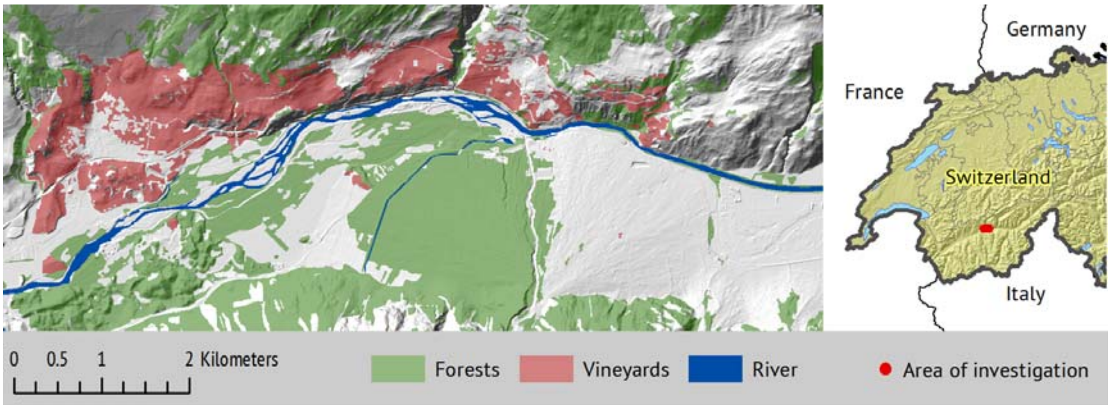


Figure 3-4: Vineyards in the Pfyn-Finges study area in the year 2013

Figure 3-5: Impression from the Pfyn-Finges area of investigation

Throughout the period of industrialisation, big industries, such as 'Alusuisse' (producing aluminum), settled in the valley floor, giving people employment. Whilst working shifts in the factories, many of the workers kept small parcels of land for cultivation as a part-time occupation *(Rieder 1996)*. Due to this period of part-time grape-growing/wine-production, many people came to feel strongly attached to the wineries and accordingly encounter tradition and heritage in the practice of vine cultivation and the landscape full of vineyards. However, many grape-growers/wine-makers experienced trouble in finding successors for their parcels *(Domeniconi et al. 2010; Schlegel 1973; Vallat 2010)*; more specifically, the part-time wine farmers were said to have had a particular connection to their land and were rather reluctant to change when compared with full-time grape farmers *(Emery 2001)*. Whilst still allowing for diversity in occupations (part-time vs. full-time), the present aim of the inter-trade organisation of the wineries is to professionalise this branch of economy, support entrepreneurship, and accordingly increase the control and traceability of the wine-production industry *(Branchenverband der Walliser Weine 2015)*.

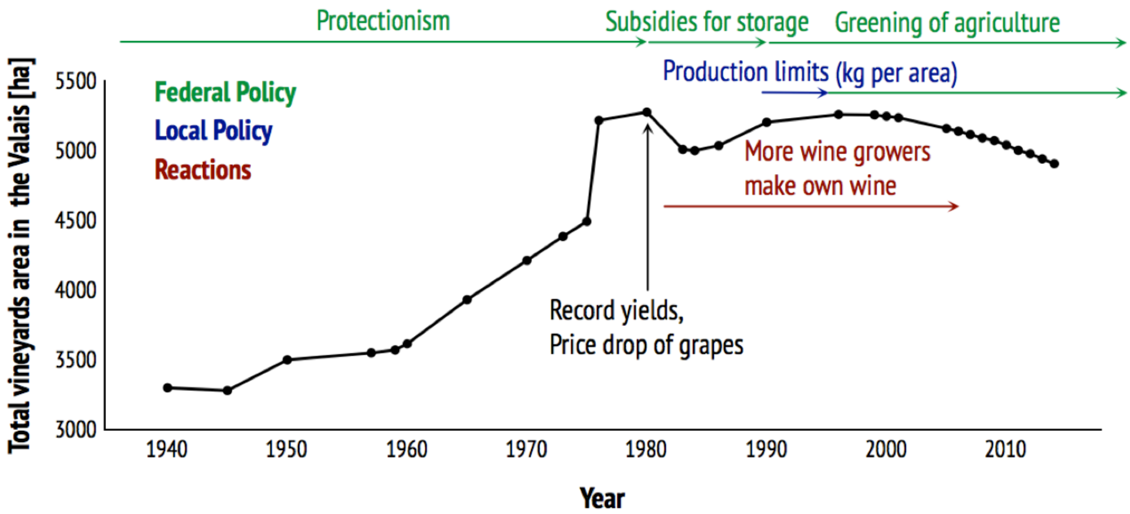


Figure 3-6: Annotated graph of the vineyard surface in the Canton of Valais from 1940 to 2013
Graph based on *Carruzzo-Frey & Dubuis (2010), Rieder et al. (1992) and Weinernteberícht (2004-2014)*

Figure 3-6 details the extent to which vineyards have increased after the Second World War, peaking at around 1980. This increase reflects the increasing price paid for grapes in a well-protected, production-oriented economy. Finally, the grape prices peaked in 1981, after two record yields *(Carruzzo-Frey & Dubuis 2010)*. The government then subsidised the storage of the overproduction and thus possibly saved the wine economy from crashing, but also prolonged the flooding of the market with cheap wine *(Rieder et al. 1992)*. In the area of study, due to the comparatively higher quality of grapes, the decline of area devoted for viticulture was not visible in the region for a long time *(Mounir 2008)*. However, since 2006, there has been some decline observed in the region. Figure 3-7 shows the area used for vine production over the past 11 years.

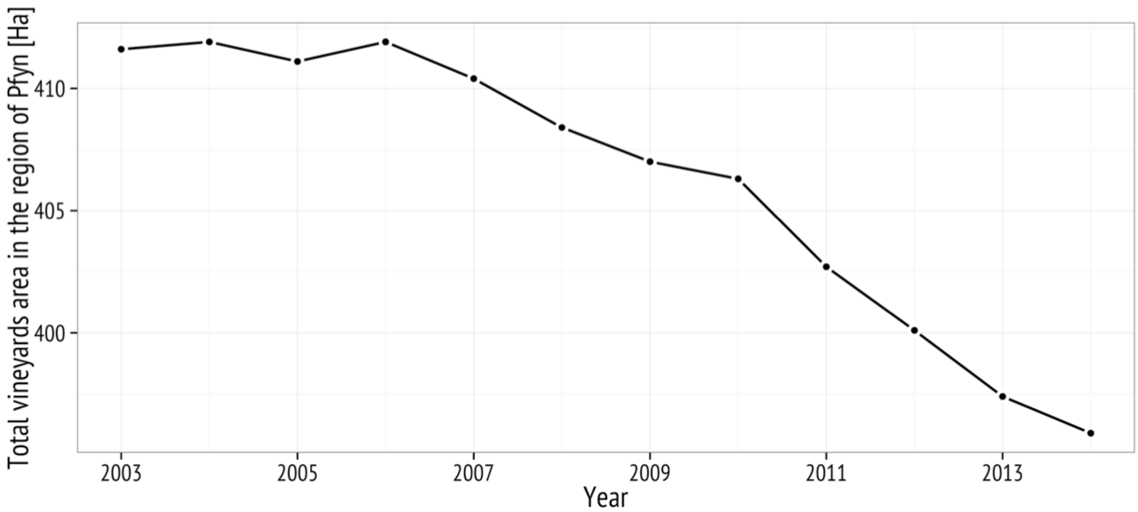


Figure 3-7: Development of the extent of vineyards within Pfyn-Finges
Graph based on *Weinernteberícht (2004-2014)*

In the late-1980s and 1990s, several initiatives were started that aimed at increasing prices through higher quality wine: for example, the introduction of the label of protected origin (AOC), 'Grand Cru' selections, and the limitation of the production to approximately 1 kg of grapes per square meter *(Carruzzo-Frey & Dubuis 2010; Mounir 2008)*. Moreover, the more lucrative specialties gained importance and, nowadays, Switzerland—and, in particular, the Valais—features a rich set of grape and wine varieties that are recognised as unique *(Anderson & Aryal 2013)*. At an individual level, many wine farmers stopped selling their grapes for a low price and began to vinify themselves as the wine itself still yielded a relatively good premium compared to the grapes. Meanwhile, in the 1990s, the government began to direct the agricultural subsidies towards the greening of the agriculture rather than towards a production-oriented agriculture. This placed some stress on the system.

Since 1995, the area dedicated to vineyards in the entire Canton of Valais decreased by approximately 10 % to slightly less than 5000 ha. The more inaccessible places, which do not yield the highest quality, were the first to be abandoned *(Carruzzo-Frey & Dubuis 2010; Koder 2014)*. On the other hand, the prime goal of the new strategy of the inter-trade organisation of the wineries in the Valais is concerned with keeping approximately 5000 ha of viticulture in production in order to maintain a critical mass of wineries *(Branchenverband der Walliser Weine 2015)*.

4 Methods

4.1 Research Design

There are several methods that are and can be used for analysing several aspects within this research, as illustrated in Figure 4-1. For example, the collection and processing of PM data, the sampling strategy, and the collection and analysis of the questionnaires and interviews was analogue in both areas of research; however, the methods concerning MCEs and bootstrapping are limited to the area of Pfyn-Finges. The creation of spatially explicit land use scenarios and Jackknifing, however, are only relevant for the Val Müstair case study.

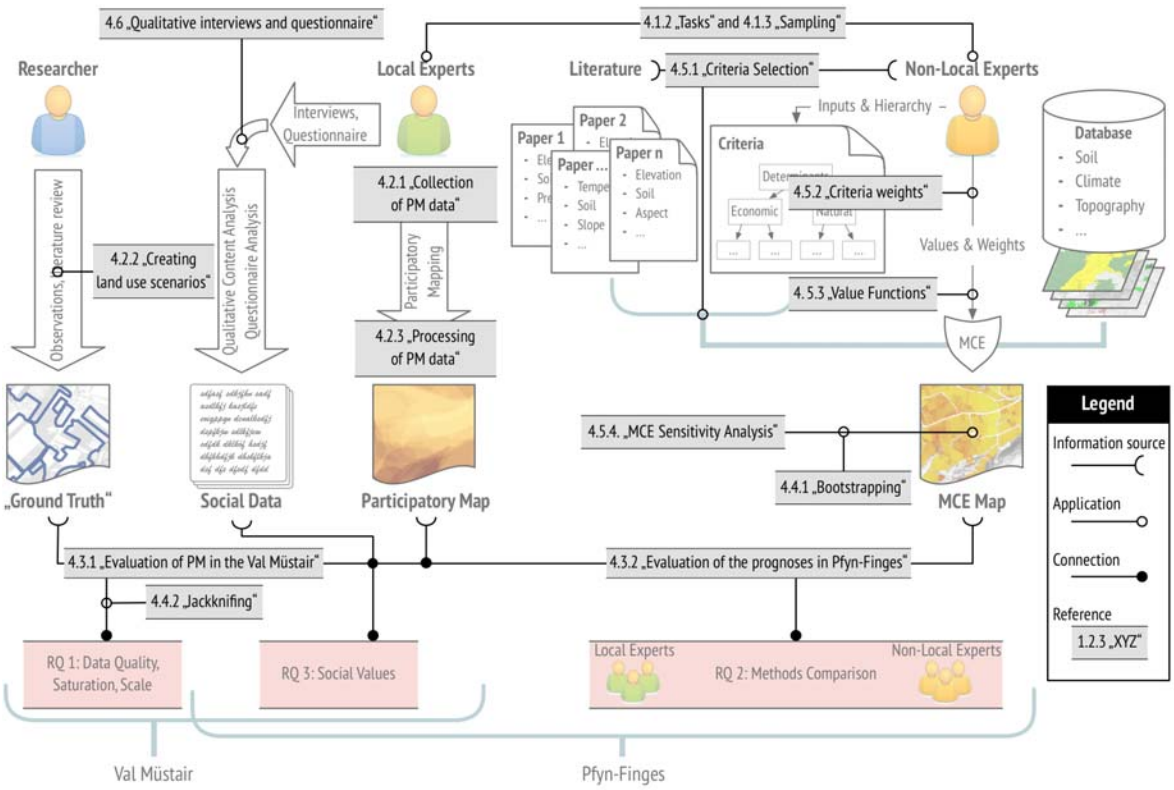


Figure 4-1: Overview of the methods Sections and their connection to the research design
The numbers in the boxes refer to the corresponding Section within the Methods Chapter. The figure is similar to Figure 1-1, which in a reduced form is showed greyed out underneath

4.1.1 Preliminary Studies

Both studies were shaped in close interaction with local actors, as proposed in other transdisciplinary research *(Couix & Hazard 2013; Enengel et al. 2012)*. In the Val Müstair, exploratory talks with 'Arinas environment AG', a company very much involved in the development of the new agricultural policy, as well as with local farmers, helped with the design of the research questions and associated mapping tasks. In Pfyn-Finges, the administration of the nature park and a key wine farmer were involved in developing the content of the research.

The participatory mapping tool, as shown in Figure 4-2, as well as the questionnaire and the interview questions, firstly were tested with two farmers from outside the study area. The structure of the evaluation workshop (4.3.2 'Evaluation of the Prognoses in Pfyn-Finges') was developed and tested in a university course on moderation skills.

4.1.2 Tasks

Local Experts

The local experts were asked to complete three tasks: first, a qualitative, semi-structure interview; second, two tick-box questionnaires; and third, various participatory mapping exercises. The interviews were performed as expert interviews *(Gläser & Laudel 2006; Meuser & Nagel 1991)*, and were seen to last between 15 and 60 minutes, with eventual continuation throughout the rest of the encounter, which, in total, lasted between 1 and 2 hours. The focus of the interviews was centred on the biography of the people, their perceptions of present and future land use change, and the importance of local varieties. Following the completion of the interviews, the participants were given the first tick-box questionnaire (as shown in Appendix A: 'Pre Questionnaires'), concerning biographical and operational data, estimations, values and attitudes related to arable farming or grape-growing/wine-production, respectively.

Throughout the introductory mapping task, the participants marked their own land at the present time. In the Val Müstair, the participants were subsequently asked to mark the regions in the valley, which, in their opinion, were used for arable farming in 1990, then the areas which, according to their judgment, will be used for arable farming under the imminent agrarian policy. As the final mapping task, they were asked to mark the areas they themselves will consider using once the new agrarian policy has been enacted. In the Pfyn-Finges study area, after marking the land they cultivate themselves, the participants were asked to mark land they think will not be used for viticulture in 25 years' time and, subsequently, land they think will remain in use for viticulture in 25 years' time. Each task was completed on a different transparency overlay, which was stored in a folder after the completion of the task. Hence, the participants could not directly compare the present answer with answers they gave in previous tasks unless they explicitly requested to go back to a particular sheet.

After having completed all mapping tasks, the participants were given a second tick-box questionnaire, which equalled the first one in relation to estimations, values and attitudes, but which did not include biographical and operational data. The second questionnaire, however, included a small section for evaluation of the PM (as shown in Appendix B: 'Post Questionnaires'). Finally, the participants received a small present.

Non-Local Experts

The non-local experts were approached firstly in mind of designing and selecting the criteria (described in Section 4.5.1 'Criteria Selection'), and later in order to provide value ranges and weights for each criterion (described in Section 4.5.2 'Criteria Weights'). This was done through a questionnaire spanning over two A4 pages. The questionnaire was developed in French and German, and sent to participants via email. The document was accompanied with a description of the methodology and an example of the core steps of the MCE, along with the aim, in an effort to communicate to the participants how their input would be further processed (see Appendix C: 'MCE-Questionnaires'). However, most were met in person (as described in the following section), meaning the questionnaire and implications of their involvement could be discussed directly.

4.1.3 Sampling

Throughout the course of the research, we applied a purposeful sampling of study participants *(Patton 2015: 264–307)*, aiming at people with a wealth of knowledge in the domain under examination, as theoretically undermined in Section 2.4.1 ('Sampling Strategies and Saturation'). This strategy was combined with snowball sampling, seeking out further reference to people that might be of interest in the study. This sampling design also has been applied in similar studies *(McLain et al. 2013)*.

Val Müstair

The sampling of study participants was initiated through contact with the regional farmer advisor, who proposed an initial set of participants, which was complemented by connections made on an exploratory visit of the study area and by recommendations by other farmers. Finally, 23 farmers were contacted, 18 of whom participated in the study. Due to time constraints or a lack of motivation, some participants did not participate in all activities. Consequently, depending on the particular scale and task analysed, the spatial data is based on 15–16 farmers, whilst the qualitative data includes all 18 participants.

Of the 18 farmers, 5 practice conventional (non-organic) farming. On average, they cultivate 25 ha of land. The farmers were seen to have a median age of 50 years, and have been farming since they were 24 years old, on average. Of the complete sample, 4 farmers were practicing arable farming in 2012, with 3 acting as organic farmers. One of the participants was female, whilst all others were male. We believe that this sample, within the farming community of the Val Müstair of totally 51 farms, as explained in Section 3.1 ('Case Studies Descriptions'), represents the farmers with the most knowledge about arable farming in the study area.

Pfyn-Finges

Local participants: In this study area, we targeted part- and full-time wine farmers, wine-producers, and people who grow grapes as a hobby. Therefore, approximately 150 candidate participants are active in the area. A first set of participants was recruited in cooperation with a local expert. Additional participants were selected randomly and contacted by telephone, whilst others were approached directly in the field. Eventually, 32 interviews were conducted with a total of 35 participants; three of the interviews were conducted with two participants at the same time. Five of the participants were female. In 4 of the 32 interviews, participants refused to map areas that were likely to cease to be vineyards in 25 years, and 8 participants did not map areas they believed would still be used as vineyards.

Participants were, on average, 51 years old (min = 37, max = 78), with an average of more than 28 years' experience in viticulture. On average, they cultivate approximately 5 hectares of vineyards. In total, 12 interviews were carried out with full-time commercial wine farmers, 11 with part-time commercial wine farmers, and another 9 who performed wine farming as a hobby. We aimed at stratified sampling within the study area proportional to the number of grape-growers/wine-makers present, with the sample judged to representatively cover the thematic and spatial extent of the study area.

Non-local experts: We sampled experts from research stations, consulting companies, universities, a large grape-growers/wine-makers trade association and governmental organisations. The number of grape-growing/wine-production experts with specific knowledge about the relevant factors for wine-production within the area of research is limited. The participants therefore were approached directly by the author. Of the 15 experts contacted, 13 agreed to an interview. A total of 12 interviews took place face-to-face, whilst one participant answered via email. On average, the participants had more than 24 years' experience in viticulture.

4.2 Spatial Data Collection and Processing

4.2.1 Collecting Participatory Mapping Data

For the participatory mapping sessions, we used a pen-and-paper approach. As basemap, we used aerial images of the year 2006 for the Val Müstair and of 2010 for the area of Pfyn-Finges. The images were shot by the Swiss Federal Office of Topography 'Swisstopo' with a resolution of 0.25 m to 0.5 m, and overlaid with contour lines. The areal images were covered with a transparency layer for drawing, which was clamped to a board, as shown in Figure 4-2; this is similar to the setup proposed by Mather ***et al.*** *(1998)*. In the Val Müstair, we provided the participants with maps of the following three different scales, as proposed by Cacciapaglia ***et al.*** *(2012)*: 1:5 000, 1:12 500, 1:25 000. For Pfyn-Finges, only the 1:5 000 scale was used. Scales ranging from 1:5 000 to 1:20 000 are proposed by McCall *(2006)* for PM; although this might sound like a narrow range, it means 1–16 printed maps of equal size to cover the same region. The cartographic scales used in this study therefore are much larger than those usually observed in the literature (c.f. Table 2-2), but seemed reasonable, as our aim was centred on gathering data with high accuracy and validity.

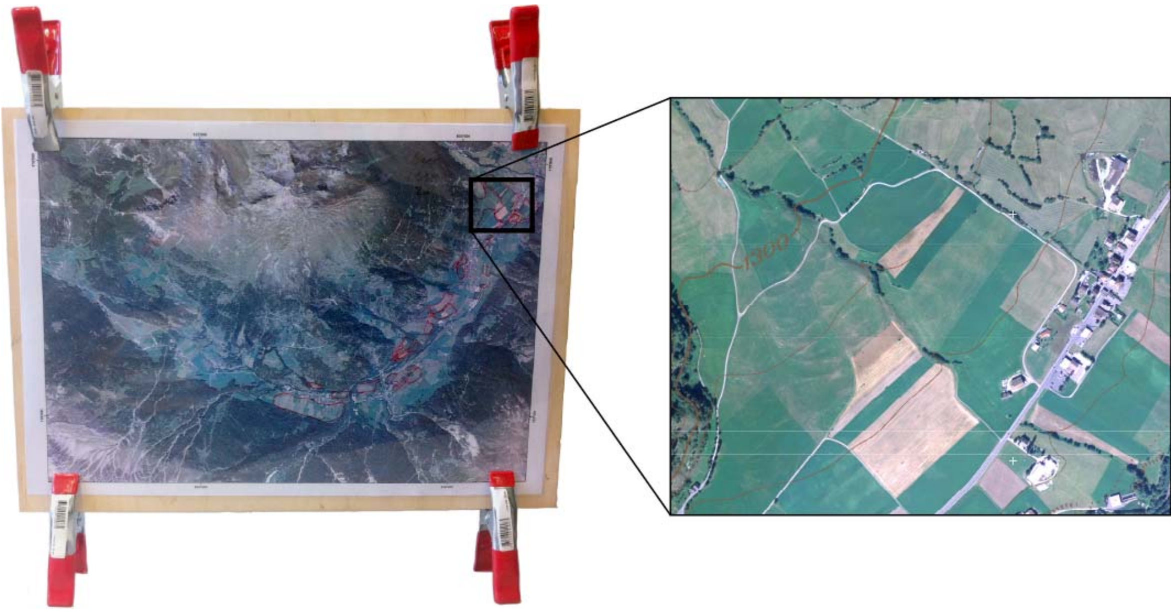


Figure 4-2: Tool used for participatory mapping
The left part of the figure shows a photograph of the tool with mapped data, with a detail of the aerial image to the right.

The paper size was A3 (297 × 420 mm), which allowed the whole of Val Müstair to fit on a single sheet for the 1:25 000 scale. For Pfyn-Finges, there were nine sheets at the scale of 1:5 000 and three additional ones at the scale of 1:15 000, for orientation purposes. For mapping in the Val Müstair, we always started with the coarsest resolution (1:25 000) in order to provide participants with an overview, and continued with finer resolutions. In Pfyn-Finges, participants usually were familiar with the 1:5 000 scale but were provided with the coarser resolution images when needed. The PM was carried out face-to-face for a duration of between one and two hours, and was combined with a survey and qualitative interviews. The entire session was tape-recorded and, in Pfyn-Finges, the polygons were annotated with timestamps of the recording whenever possible and whenever deemed appropriate. This later on allowed for the joining of the transcribed sections of the interview with the particular polygon—a procedure similar to that described in Black and Liljebad *(2006)* or by Hall ***et al.*** *(2009)*.

Once completed, the transparent sheets were scanned and georeferenced, and the mapped areas digitised using a combination of image-processing and ESRI ArcGIS ArcScan tools. We also recorded the time invested in collecting, digitising and analysing the PM data. Spatial analysis was completed with ArcGIS, FME and R, whilst statistical analysis and graphics were completed solely in R.

4.2.2 Creating Land Use Scenarios

For the Val Müstair, two spatially explicit land use scenarios were created: one for situation under the new federal agricultural policy (1), and another for the year 1990 (2), as shown in Figure 4-3. The situation under the new agricultural policy was assessed by field inspections in the years 2014 and 2015. The field inspections were done in the fall of each year, and based on visual inspections and GPS-tracks surrounding the fields. As those represent only snapshots of the situation in two years, with likely crop rotation in between, the geometrical union of both records was assumed to represent the most likely scenario for arable farming under the new agricultural policy. The scenario for the year 1990 was created first by taking mappings from the agricultural use from the year 1986 published in the dissertation by Lentz *(1990)*. This basis then was refined and adapted to the year 1990, as based on visual inspection of arable land on areal images from the years 1985 and 1991. The spatial data then were cross-checked with statistical data, and accordingly were adapted. However, the total area of the scenario was allowed to be larger than the one reported in the statistical data in order to account for crop rotational area. The scenario for viticulture in Pfyn-Finges (3) was created by extrapolating the trend of the past decade. The model used data from 2006 until 2014, and extrapolated until the year 2040 based on a linear and a quadratic prediction model. The detailed calculations are described in the results Section 2.2.2 ('Comparison Based on Different Land Use Scenarios'). As a result, the land use scenarios for Pfyn-Finges were not spatially explicit. Only the combination with the PM or the MCE models yielded spatially explicit forecasts for viticulture in Pfyn-Finges.

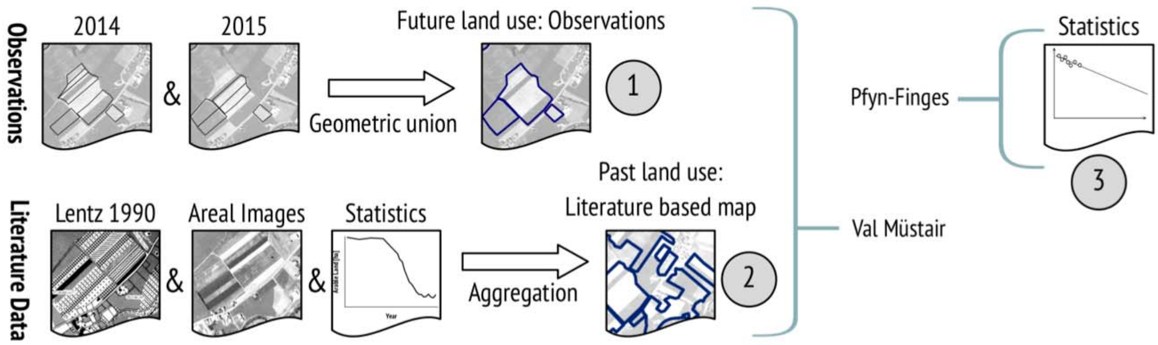
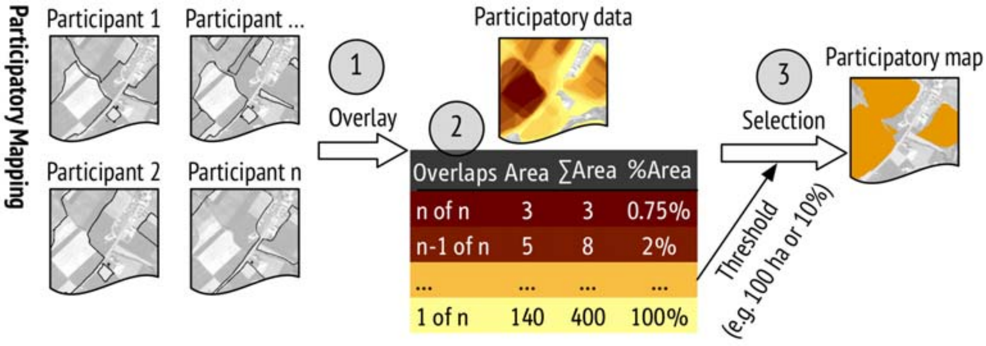


Figure 4-3: Creation of land use scenarios
The circled numbers correspond to the numbers in the text

4.2.3 Processing of Participatory Mapping Data

In an effort to assess so-called 'hotspots' in participatory mapping, we counted the number of participants marking an area *(Black & Liljeblad 2006)*, summed their total area, and accordingly calculated the percentage of the 'hotspot' with respect to the total area. Figure 4-4 provides an overview of the data processing: first (1), we aggregated the raw data of the participatory mapping by overlaying and intersecting all areas mapped by participants in this sample; second (2), we calculated the number of participants marking the same area (= overlaps) and ordered the polygons after this number, where the more participants that marked an area, the higher this area was ranked, with the area for each number of overlaps subsequently calculated, where the cumulative sum of the areas with a higher number of overlaps and the respective percentage of the acreage of these areas with regards the total area then mapped for this task; and third (3), a certain cut-off with respect to the percentage or absolute area was chosen to isolate a ‘hot-spot’ for further analysis, with this analysis then showing some differences between the two areas of study.



Overlaps	Area	∑Area	%Area
n of n	3	3	0.75%
n-1 of n	5	8	2%
...	...	...	...
1 of n	140	400	100%

Figure 4-4: Overview of the data processing in PM
The circled numbers correspond to the numbers in the text. Note that the threshold applied in the example (100 ha or 10 %) is not displayed in the attribute table of the participatory data, but will lie somewhere between n-1 and 1 overlaps

Comparison to Past and Future Land Use

For the comparison of PM with past and future land use in the Val Müstair, we selected the top ***n*** entries of the participatory mapping, defined by their summed area, as calculated in (2) of Figure 4-4. We then utilised the corresponding spatial data of the PM (denoted as participatory map) for comparison to the land use scenarios, as detailed in Figure 4-5. The creation of the land use scenarios was described in Section 4.2.2 (‘Creating Land Use Scenarios’). The spatial data can be considered the hotspot corresponding to this group of participants concerning the past or future land use. As the threshold for the hotspot of the participatory map, a summed area was used for the selection (Stage 3) shown in Figure 4-4. In the case of the comparison with observations or the literature based map, the threshold was referred to as an evaluation area, which we subsequently refer to as E. As a consequence, for a given E, we selected the most commonly marked plots, the summed area of which is no greater than E. Therefore, for each participatory mapping data set, E corresponds to a certain minimal number of overlays (= participants marking the area). However, the minimal number of overlays might vary for each data set: for example, imagine an E of 8 ha and a PM dataset with 11 participants; 3 ha are marked by all 11 participants and a further 5 ha are marked by 10 out of the 11 participants. Thus, a total of 8 ha are marked by at least 10 participants. Hence, as we were interested in the top 8 ha of this data set (E= 8 ha), we would select all areas marked by 10 or more participants. If we would be interested in the top 4 ha of this data set (E= 4 ha), we then would select the 3 ha marked by all 11 participants. However, if we would have had fewer participants (< 11), we then would need to include the areas marked by a smaller number of participants in order to establish a data set of comparable acreage (E). In our study, we selected the hotspots based on a given E, and subsequently performed the comparison: for example, if we were interested in E = 100 ha, we compared the most often marked 100 ha from different participatory data set with the literature based or observed data respectively. This becomes relevant in the subsequently applied Jackknifing procedure, as explained in Section 4.4.2 'Jackknifing'.

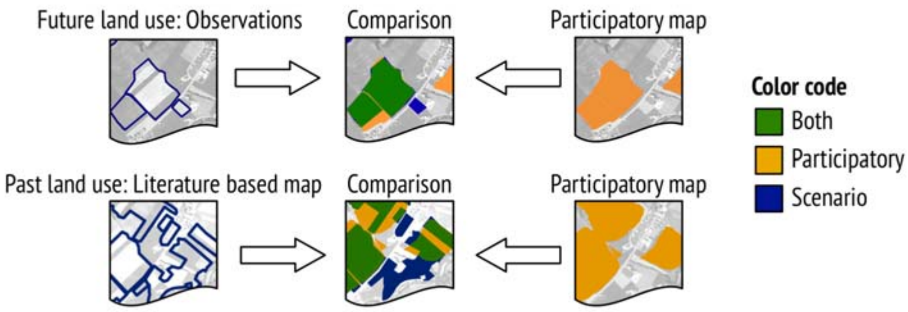


Figure 4-5: Comparing the participatory map with the past and future land use
Illustration on how the two datasets shown in Figure 4-3 are compared to the participatory map, which in turn is created by applying the procedure outlined in Figure 4-4

For the future land use of arable farming, we were further able to calculate the correctness and completeness of each participant's individual prediction, referred to as individual predictive quality, as detailed in Figure 4-6. We first calculated the observed arable farming that could be attributed to this participant (3) by intersecting the observed arable fields (1) with the fields this participant indicated to cultivate (2). Subsequently, we overlaid the arable fields that the participant indicated to be covered by arable farming under the new federal agricultural policy (4) with the corresponding areas intersected from the observed ones (3). Eventually, we calculated the individual predictive quality from this participant (5): A) by calculating the share of the total area observed (3) lying within the predicted arable farming (4); B) by calculating the share of the predicted arable farming (4) to be covered by observed arable farming (3); and C), by comparing the area of the observed arable farming (4) with the area this farmer announced in the questionnaire.

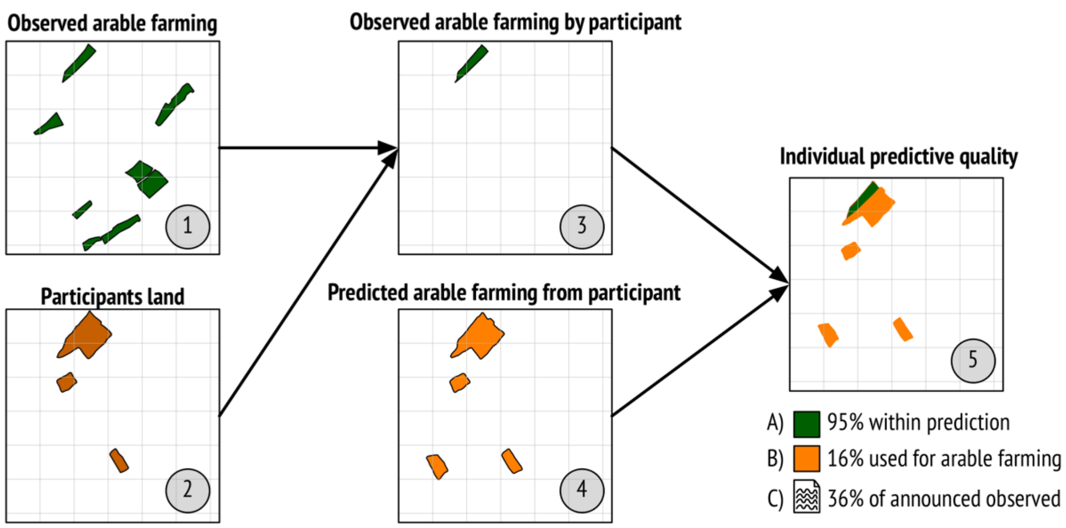


Figure 4-6: Calculation of the individual predictive quality
The circled numbers correspond to the numbers in the text. The observations by the researcher (1) are compared to the PM of the participants (2,4) and their statement in the questionnaire (not shown)

Comparison to MCE

For Pfyn-Finges, two prognoses were collected: areas where vineyards are expected to be abandoned and areas where viticulture is expected to persist. The timeframe of the study on viticulture in Pfyn-Finges was deliberatively set to 25 years as this represents the average life-span of a vine in viticulture.

Figure 4-7 provides an overview of the spatial data-processing, with the details of the MCE calculations described in Section 4.5 ('Multi Criteria Evaluation'). First, the overlays of the participatory mapping of each area, with (1) and without (2) a change in viticulture, were performed. The two resulting data sets ('change' and 'persistence') were subtracted from each other ('persistence' minus 'change'), yielding a data set with a difference of overlaps (3). The data then were clipped to the extent of the vineyards (4).

Negative numbers in the difference of overlaps correspond to a majority of participants, forecasting a change in viticulture, whilst positive numbers correspond to a majority forecasting persistence. Areas marked as both, changing and persisting viticulture, denote conflicting opinions. In the case of conflicting opinions, the absolute value of the difference of overlaps is not equal to the maximum number of overlaps for persistence or change, but actually is smaller; therefore, the maximum numbers of overlaps (n-x) must not equal the maximum number of overlaps for persistence (n) but can be smaller by a number (x) of concurring 'change' opinions ($x \in \{0...m\}$, whereas m is the maximum number of overlaps for 'change'). Moreover, the analogue is true for the minimum number of overlaps (-m+y). The number of conflicting opinions relative to the sum of all opinions ('change' and 'persistence') is understood as the degree of uncertainty associated with the prognosis (not shown in Figure 4-7).

Other than for the Val Müstair, in Pfyn-Finges, there is no observed data available for validation; hence, the aim, in this case study, was centred on drawing a comparison between the PM outcome to that of the MCE (5). In terms of the comparison of the data sets, a value-based selection *(Cox et al. 2014; Karimi et al. 2015; Whitehead et al. 2014)*—in consideration to the percentage of the total area—was undertaken; the rationale being that, as an example, a decision-maker wants to focus on the 8 % of vineyards, which are most likely not a vineyard in 25 years anymore and, in order to do so, the decision-maker would select the 8 % of the areas with the lowest values of the outcome. Such a reasoning follows the underlying general assumption that the total area devoted to vineyards declines by b percent, and thus potential conservation measures should focus on these areas (from the perspective of abandonment). For the comparison of the methods, the b percent of the total resulting area with lowest values were drawn from each method (6 and 7). Alternatively, one also could follow the assumption that the top a percent are going to be sustained in any case, and thus do not need to be considered for possible measures (sustaining perspective), which would yield two different layers (namely 8 and 9). For each perspective (sustaining and abandonment), the corresponding layers were compared to each other (10 and 11) and measures of concurrence calculated, as described in Section 4.3.2 'Evaluation of the Prognoses in Pfyn-Finges'.

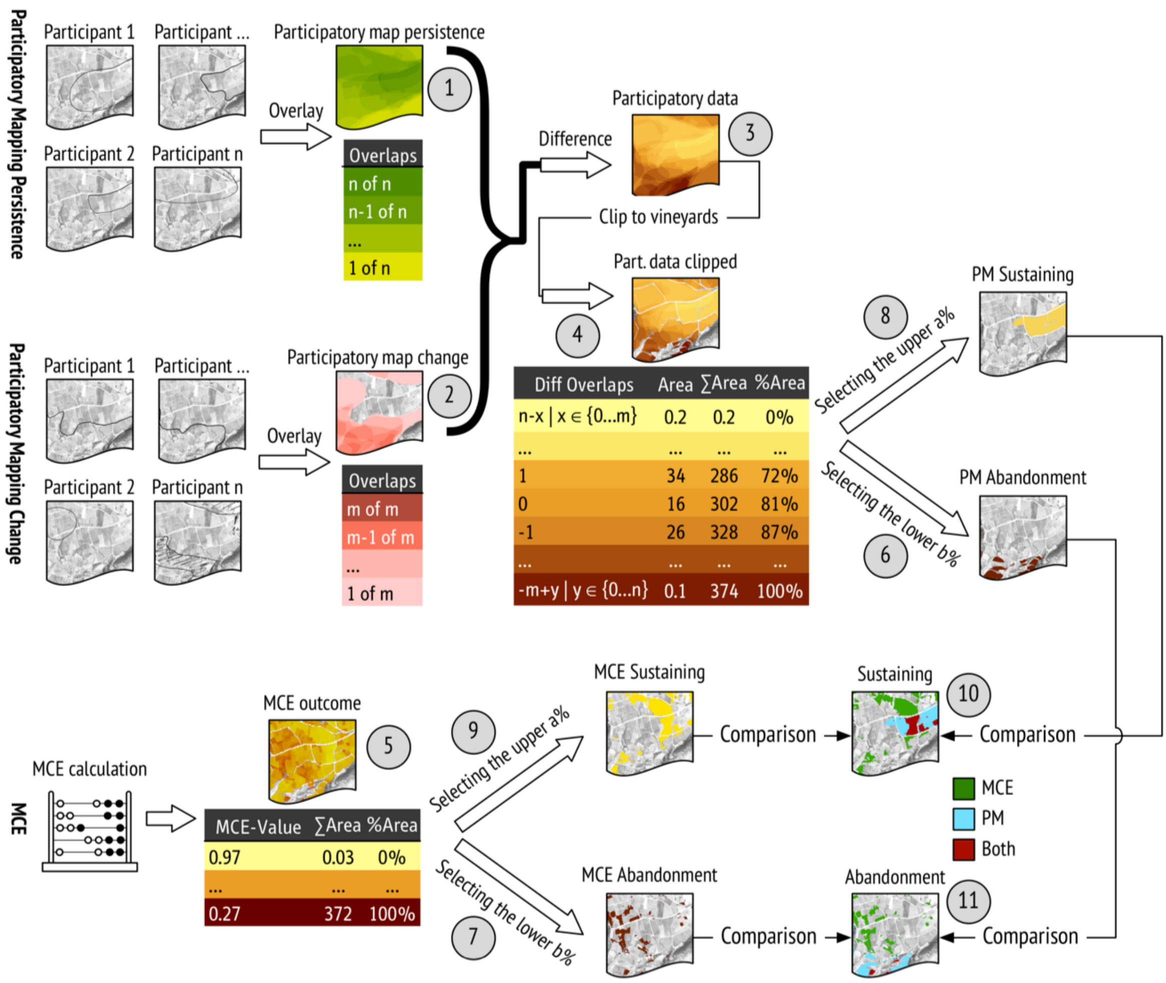


Figure 4-7: Overview of the data processing in Pfyn-Finges
The circled numbers correspond to the numbers in the text. The threshold (6-9) applied to the PM and the MCE outcome follows the procedure outlined in Figure 4-1. The comparison is analogue to the one shown in Figure 4-5

In our case, the possible percentages for *a* and *b* were derived from the participatory mapping. When choosing a PM threshold, one would need to decide to consider the areas with a certain number of opinions. As there are no half-opinions, in the PM data, *a* and *b* can only take values corresponding to integers from (-m+y) to (n-x) of overlaps.

Figure 4-7 shows the percentages of 72 %, 81 % and 87 % corresponding to 1, 0 and -1 opinions, respectively. In such a case, there is no 'hotspot' corresponding to any percentage between these three values; therefore, comparisons between the two methods are based on a particular set of percentages of the area, the values of which are determined by the participatory data.

In order to establish get a benchmark for the prognosis, a random map was introduced, as was performed in a similar study *(Brown 2012a)*. The random map was created by randomly generating 10 000 points over the study area and accordingly assigning them values with a similar distribution of values as in the result from the MCE and the PM. The points then served as input to interpolate the area using a bivariate quintic polynomial over a triangulated irregular network. The result then was classified into 11 classes of equal interval. In so doing, we received a map with similar visual appearance, spatial autocorrelation, histogram and cumulative sum of values, but a random spatial distribution. The processing of spatial data of the random model is not displayed in Figure 4-7, but was analogue to that from the MCE besides the way of data-generation.

Further, in order to isolate 'hotspots' of continuing and non-continuing viticulture, we applied "Getis-Ord Gi*" statistics *(Getis & Ord 1992)* after aggregating the value of each method to the cultivation unit (patches of vines that are cultivated together, i.e. are planted the same way). This aggregation was necessary as the procedure is sensitive to the subdivision of space. Previous to this step, the PM results were subdivided by the polygons drawn by the participants; the outcome of the MCE was tessellated by raster cells of 5 m resolution, and the random distribution by the triangular irregular network. We judged the cultivation unit to be the most suitable aggregation unit for all the three methods, as it has a natural correspondence and each cultivation covers more than a single pixel of the MCE. Getis-Ord Gi* was promoted in similar studies *(Karimi et al. 2015; Zhu et al. 2010)*. Using Getis-Ord Gi* Z-scores as a sorting variable, an equal procedure was performed, as shown in Figure 4-7. However, as the Z-scores are a continuous variable across all layers, there was no given set of percentages of the area. We took hotspots by discerning the summed percentage of the total area in 2 % steps, corresponding to 1, 3, 5, … 97, 99 % of the total area for each, a and b.

4.3 Evaluation of the Results

There are two distinct procedures of evaluation in this thesis for the Val Müstair and the Pfyn-Finges case study, respectively. In the Val Müstair case study, observed data is available, to which the PM results can be compared and where the quality of the PM can be assessed in terms of data imperfection, as discussed in Related Work: Section 2.4.2 'Validation, Verification and Data Quality'. In the case of Pfyn-Finges, the evaluation needs to draw on other sources of information, namely different methods, expert judgements and context information. Therefore, in the case of Pfyn-Finges, the evaluation does not yield measures of data quality, such as for the Val Müstair, but rather focuses on the plausibility and validity of the results.

4.3.1 Evaluation of PM in the Val Müstair[4]

Recall, from Section 2.1, that the PM participants in the Val Müstair case study were asked to map two types of land: those they thought were used for arable farming in 1990 (here denoted as 'former arable farmland') and those they expected to be converted to arable farmland under the new agrarian policy (denoted as 'future arable farmland'). The results of PM then are evaluated concerning the most complete and correct mapping of the former and future arable farming. 'Complete', in this regard, means that all areas known to be the former or future arable farmland indeed are covered by the PM.

[4] This section is partly based on *(Rohrbach et al. 2015)*

‘Correct’ means the mapping does not include additional areas not covered in the former or future arable farmland. In order to do so, two sets of polygons are compared, namely the ‘ground truth’ (notably the situation of arable farming in 1990 and the observations in the first two years after the enactment of the new agricultural policy as shown in Figure 4-3) and a ‘retrieved set’ (the participatory mapping outcome). Consequently, our data were analysed from a set theoretical perspective.

Searching for the most adequate measures for quantifying the notion of data quality relevant for our study, we draw on the GIScience literature, remote sensing research related to land use classification, and on measures from information retrieval. However, we face various differences compared to the quality assessments of land use classification of remote sensed data *(e.g. Comber 2013)*. We do not have a continuous land use map as we do not have information pertaining to the extent and attributes of the area participants did not mark. Moreover, if we would assume the non-marked area is non-arable land, the data quality would change with the amount of land considered around the mapped polygons; therefore, the decision was made to exclusively focus on the areas marked by the participants. Nevertheless, the mathematically equivalent terms from remote sensing were mentioned for illustration purposes.

The classical GIS literature adheres to a typology of data quality that includes positional accuracy, attribute accuracy, logical consistency, completeness, lineage, and semantic accuracy *(Oort 2006; Veregin 1999)*. However, positional accuracy mostly is only operationalised for point data *(Veregin 1999)*. We followed a more general typology of imperfection, distinguishing between imprecision and inaccuracy *(Worboys & Duckham 2004)*. Whilst inaccuracy refers to the lack of correlation between observations and reality, imprecision centres on the lack of specificity or the lack of detail in an observation.

In order to operationalise accuracy—understood as the correlation between observations and reality—we decided to focus on notions of completeness and correctness for a set of polygons *(Heipke et al. 1997)*. Whilst in the case of this problem it is relatively straightforward to relate to the concept of completeness *(Oort 2006)*, it is much more difficult to identify an adequate concept that measures the notion of correctness of polygonal data within the GIScience literature. The measure that comes closest to what we need are those developed in information retrieval—more specifically, ‘recall’ (subsequently called completeness), ‘precision’ (called correctness) and the harmonic mean thereof, the F1-value *(Olson & Delen 2008)*.

Unfortunately, the term ‘precision’ has a completely different meaning in the context of GIScience: in GIScience, it is used to describe the degree of detail with which a measurement or number is represented. In information retrieval, ‘precision’ describes the overall quality of a unified set of values. The notion in information-retrieval therefore is rather related to the term ‘accuracy’ in GIScience. In order to avoid confusion, the term ‘correctness’ is used *(Heipke et al. 1997)*.

Figure 4-8 shows how those values are typically computed in information retrieval by intersecting retrieved data (A) with the ground truth (B). Retrieved data contains true and false positives. *Correctness* (*precision*) is the share of true positives in the retrieved data and mathematically equals *consumers' accuracy* in remote sensing terminology *(Congalton 1991)*. Notably, 100 % minus correctness equals the *error of commission* or the *false positive rate*. *Completeness* (*recall*) is the share of true positives on the total ground truth and mathematically equals the *producers' accuracy* in remote sensing. 100 % minus completeness corresponds to the *error of omission* or the *false negative rate*; thus, mapping only a small but correct area results in a high correctness but low completeness, whereas mapping a large but mostly incorrect area results in a high completeness, but low correctness. Therefore, we focused on the F1-value, which is the harmonic mean of correctness and completeness. A perfect match would result in the correctness, completeness and F1-value all being equal to one.

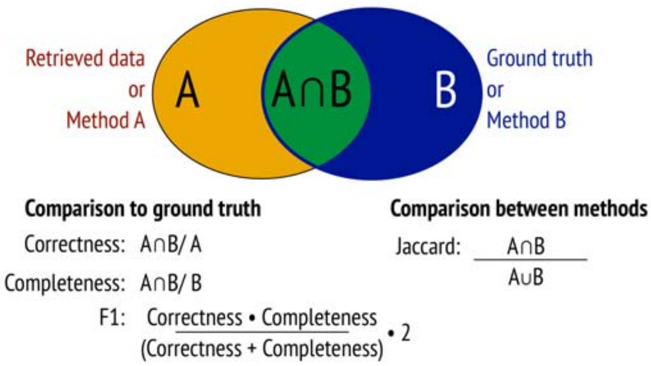


Figure 4-8: Calculation of the correctness, completeness, and F1-value as well as the Jaccard-Coefficient. Note that in information retrieval, correctness is termed 'precision', while completeness is termed 'recall'. The figure displays both, a comparison between methods and between a method and a 'ground truth'

4.3.2 Evaluation of the Prognoses in Pfyn-Finges

The evaluation of the three prognoses for viticulture development in Pfyn-Finges was done by three different methods:

- The overlay of spatial data and the calculation of concurrence between methods
- Participatory validation in a workshop and through a mail survey
- Evaluation through the qualitative data gained in the fieldwork.

Concurrence between Methods

Selections taken from the spatial datasets generated by the three different methods (PM, MCE and random process) were overlaid and the intersecting area calculated. Selections were taken by using equal percentages of areas, with highest or lowest likelihood of continued cultivation in 25 years, as described in Section 4.2.2 ('Creating Land Use Scenarios') and particularly in Figure 4-7. The Jaccard-Coefficient then was calculated by dividing the intersecting areas by the total area, as shown in Figure 4-8 *(Jaccard 1908)*. The coefficient ranges 0–1, where the larger it is, the more methods concur. The

Jaccard-Coefficient was applied in similar studies *(Karimi et al. 2015)*. This method allowed assessing of the level of concurrency across the three methods. In an effort to assess the correlation between them, we used spatial statistics, which can account for spatial autocorrelation, as autocorrelated measurements cannot be considered independent *(Dormann et al. 2007)*. Hence, we calculated the Tjøstheim coefficient *(Hubert & Golledge 1982)* as a measure of statistical correlation and used the modified T-Test *(Clifford et al. 1989)* to evaluate the significance of Pearson's correlation coefficient between the two methods and their uncertainties.

Participatory Validation

In order to validate the results, non-local experts and local participants discussed the mapped results in a workshop held in August 2015. The two key questions for this validation discussion were, for each of the three methods, whether the result of the prognosis was plausible and whether it was detailed enough; however, the local grape-growers/wine-makers, the researchers and the natural park administration at the outset of the workshop jointly defined the precise criteria for this evaluation. In the workshop, the results of the three methods were presented as anonymised maps (i.e. without indication of the method), as shown in Appendix D: 'Workshop materials'. The maps were created for easy and intuitive readability *(Dent et al. 2009; Slocum 2014)*. Following the collection of the evaluation sheets, each method was explained, with the preliminary results from the participants' responses discussed. As results of the workshop, the strengths and weaknesses of each method were established.

Additionally, the non-local experts as participants of the Multi Criteria Evaluation were later approached by post mail, provided with the anonymised maps and asked to evaluate the results concerning the evaluation criteria used in the workshop. The questionnaire is shown in Appendix E: 'Evaluation Questionnaire'. Non-respondents were sent a follow-up letter after three weeks. After receiving a response or two weeks after the follow-up letter, the non-local experts received a document explaining each method.

Evaluation through Qualitative Information

The prognoses were further evaluated using comments given in the participatory mapping exercise with the local experts. Those comments were recorded, transcribed and later added as a separate annotation layer. The comments then were analysed and grouped based on content and spatial location in an effort to reach high spatial and topical density. For the analysis of the content, a coding similar to the grounded theory was applied *(Muckel 2011; Strauss 2004)*. This allowed the contextualisation of the results, with the differences between methods explained and information about social values, in particular locations, added.

4.4 Resampling

4.4.1 Bootstrapping

For the estimation of the uncertainty of the MCE-prognosis, we applied the bootstrapping method, which is well known in terms of its abilities to estimate standard deviations *(Chernick 2007; Good 2005)*. The bootstrapping draws random samples of equal size from the total data with replacement—in our case, this means the random selection of several groups of 13 participants out of the total 13 participants wherein some participants may occur several times.

4.4.2 Jackknifing

To assess changes in data quality depending on the sample size—that is, to assess the saturation of the sample—we used a resampling procedure similar to 'Jackknifing'. Our reasoning is based on the following question: 'What would have happened to the aggregated participatory mapping results if we had missed one participant, for example, because the participant had fallen sick?' We follow an approach similar to 'Jackknifing' or 'cross-validation' *(Rohrbach et al. 2015)*, which is done by leaving out a single observation and accordingly computing all possible combinations of the remaining data *(Good 2005; Rodgers 1999)*. Leaving out one of the n observations results in n combinations, each consisting of n-1 observations. Leaving out two observations produces $n!/([n-2]! \bullet 2!)$ combinations, each comprising n-2 observations. We continue to leave out observations until there are only two observations left. In our case, this approach produced one combination of 16 participants, 16 combinations of 15 participants, 120 combinations of 14 participants, and so forth. We resampled combinations using the programming language python, creating a shape file for every possible combination of participants. We performed a spatial aggregation for each shape file, as explained in Section 4.2.3 ('Processing of Participatory Mapping Data'), and computed the data quality measures introduced above. This allowed us to calculate the data quality corresponding to variable numbers of participants. In order to compare the combinations of participants with different numbers of participants, hotspots with a similar acreage were used through applying the same evaluation area E (c.f. Section 4.2.3 'Processing of Participatory Mapping Data').

4.5 Multi Criteria Evaluation

4.5.1 Criteria Selection

Criteria were selected based on a literature review and interviews with key experts. We ended up with 9 criteria, arranged in a hierarchical tree with the top goal being 'Most likely a vineyard in 25 years'. The tree was slightly modified in the first two expert interviews, but then stayed the same for the remaining 11 interviews (n= 13). The criteria tree is displayed in the results in Figure 5-16.

4.5.2 Criteria Weights

We weighted the criteria according to the analytical hierarchy process *(Saaty 1995)*. The analytical hierarchy process (AHP) is a well-established method, used widely in the arena of Multi Criteria Evaluation *(Malczewski & Rinner 2015; Malczewski 1999)*. The participants performed pairwise comparison on a diverging 9-point scale, ranging from one criterion dominating over another criterion to the other criterion being dominant, with both criteria equally important in the middle. These judgments then were transformed to ratios of importance. Instead of using a ratio scale, as originally proposed *(Saaty 1995)*, the balanced scale was used as it proved to be better reflect people's judgments and is more robust in the presence of inconsistencies *(Franek & Kresta 2014; Salo & Hämäläinen 1997)*. In order to aggregate the individual weights matrix to a group weights matrix, we used the geometric mean as proposed in the literature *(Ishizaka & Labib 2011)*. We then calculated the criteria weights from the matrix using the 'AHP'-function in the R-package 'pmr' *(Lee & Yu 2013)*. This yielded us the weight of each criterion.

4.5.3 Value Functions

In order to compare and sum the criteria, they had to be translated to the same unit. This was done by using so-called value functions *(Hepner 1984; Malczewski 1999)*, which reclassifies the criteria-layers values to values on a normalised scale, ranging 0–1. Figure 4-9 sketches the normalisation of a 4-pixel raster. The resulting value corresponds to the probability that this pixel will be a vineyard in 25 years based on this criterion. Therefore, the value function may vary according to the decision-maker *(Beinat 1997; Keeney 1992)*, as well as in space *(Hepner 1984; Malczewski 1999)*. In our case, there were no indications of varying value functions over space. As we were interested in the result of the group of experts, we aggregated the decision-makers' perspectives.

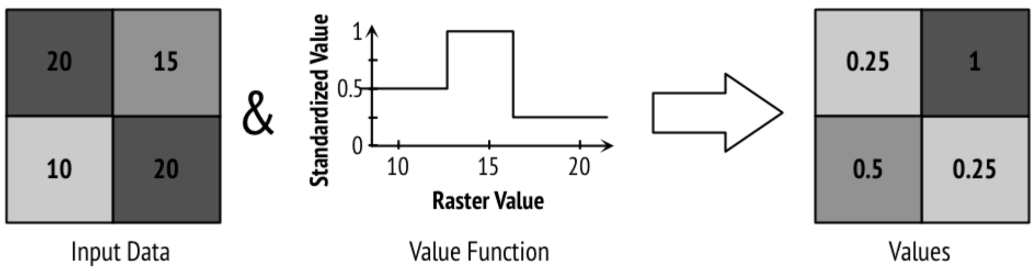


Figure 4-9: Standardisation of the input data of one criterion
The figure bases on an invented 4-pixel raster and an invented simple value function, which is used to normalise the raster cell values. Darker raster cells correspond to higher values

There are several methods centred on estimating the curves of value functions, where such curves can have many different shapes *(Beinat 1997)*. One of the better-known techniques for estimating the curves is called the bi-section technique *(Winterfeldt & Edwards 1986)*. Through this method, one first asks for the values, where the criterion value reaches the highest and lowest standardised value, respectively. One then finds the criterion value that yields 0.5 on the standardised scale and accordingly estimates the 0.25 and 0.75 values *(Kalelkar & Brooks 1978; Keeney & Raiffa 1993)*. This technique requires the curves to be monotonic (i.e. continuously de- or increasing value with increasing input number). One could transform any relationship to a monotonic curve by, for example, calculating the deviation of the highest valued input number. However, this might create problems when aggregating several opinions.

Through interactions with the experts, we have come to realise that they rather talked in ranges of optimal values and thresholds for too high and too low values, similar to the value functions show in Morgan *(1998: 243)*. In order to adjust the method to the experts' way of reasoning, we introduced these categories in our survey. Such a reasoning is similar to the rough set theory *(Pawlak 1982)*, introduced earlier in Related Work (Section 2.4.2: 'Validation, Verification and Data Quality').

Based on the ranges given by the experts, we calculated classes of input (criterion) values that yield equal standardised values. The standardised value for a criterion value was calculated according to the number of experts stating that this criterion value lies within the optimal and/or the acceptable range. Figure 4-10 shows the value function for a single expert for an arbitrary criterion. One could think of, for example, altitude, and then understand the criterion values as meters. However, we intentionally left the unit dimensionless, as this illustration should only serve as an example. Assume an expert stated that input values between 1000 and 1500 are optimal, and values below 500, or above 2000 are too low or too high, respectively. Hence, the range spanning 1000–1500 is considered optimal, whilst the range 500–2000 is acceptable. If the criterion value lies within the optimal range, it is given a standardised value of 1. If the value of the criterion falls within the acceptable but outside the optimal range (i.e. between 500 and 1000, or 1500 and 2000), it is given a standardised value of 0.5. If the criterion value falls outside the range, it is given a value of 0.

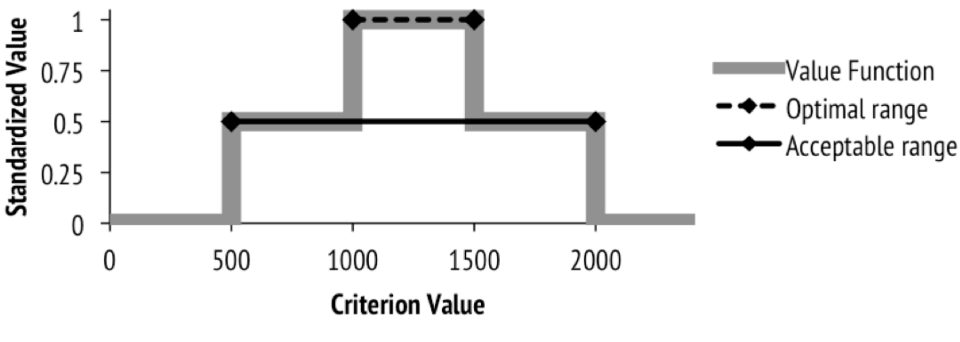


Figure 4-10: Value function for one criterion and a single expert
The four values provided by the expert are indicated with a black diamond

When taking several experts together, the value functions become more complex, as shown on an example in Figure 4-11 for three experts. In the example, all three experts denoted criterion values between 1500 and 2000 as optimal range. Two of the three experts considered values up to 3500 to be optimal and only one expert classified even values from 1000 to 1500 as optimal. The corresponding standardised value can be understood as the share of overlapping acceptable and optimal ranges on the maximum number of overlapping ranges given by the experts. For instance, in the illustration, there are three experts with a maximum of 6 ranges overlapping (3 optimal + 3 acceptable ranges between the criteria value 1500 to 2000). If all optimal ranges overlap, the standardised value will be 1 (6 of 6), as the optimal range always lies within the acceptable range. If two of three optimal ranges overlap, the standardised value is 0.8$\underline{3}$ (5 of 6). If there are only acceptable ranges overlapping, the standardised value equals 0.5 (3 of 6) and if there is only one expert stating the criterion value to be acceptable its standardised value is 0.1$\underline{6}$ (1 of 6). The resulting value function resembles very much a fuzzy-membership function in fuzzy set theory, as in a study by Feizizadeh *et al. (2014).*

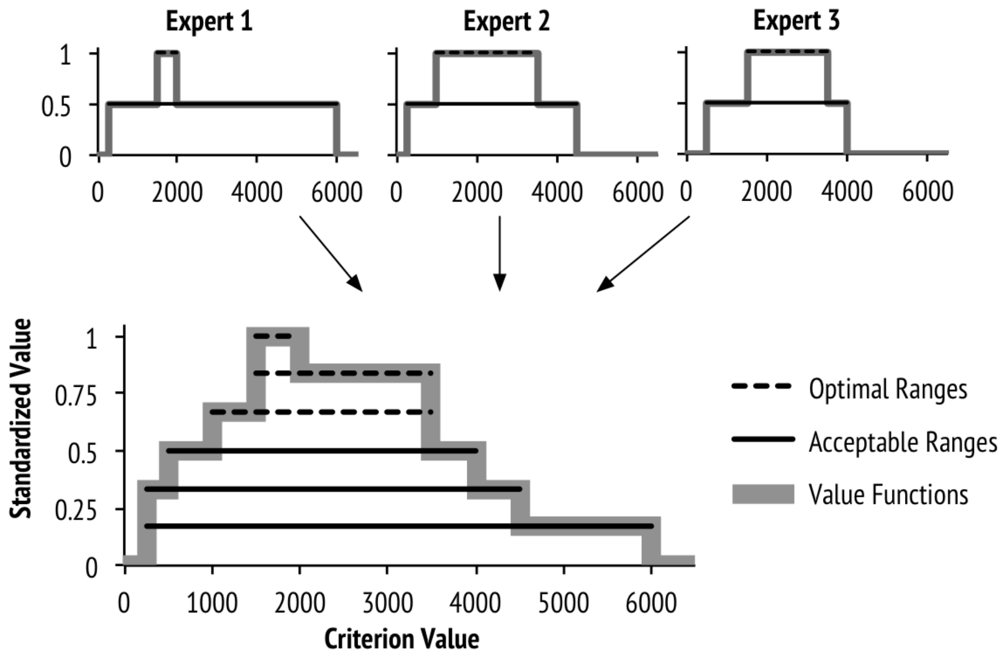


Figure 4-11: Value function for one criterion, as a result of the opinions of three experts
The three experts each provide a range for optimal and acceptable values, then are combined by 'stacking' them on top of each other

4.5.4 MCE Sensitivity Analysis

Uncertainties may emerge at several steps of the MCE procedure: 1) within the input data, 2) in the criteria weights, 3) when standardising the input data, and 4) through the interactions of uncertainties at each step. We addressed the uncertainty associated with the criteria weights (2), the standardisation (3) and uncertainty as a result of the interaction of the two steps. Firstly, the corresponding criteria weights and value functions are calculated, with the two for each bootstrapped sample multiplied. By so doing, we were able to account for interaction effects between the two steps, such as the interaction between the ideal slope angle and its overall importance. As a result, this allowed the calculation of the uncertainty, expressed as standard deviation (SD), per criteria per input value range. A possible outcome would be that slopes between 8 and 10 % have a SD of 0.3 associated. This yields a function similar to the one in Figure 4-11, with the *y*-axis labelled SD. After analysing several runs and bootstrap sizes, we concluded that the SD stabilised well before 500 bootstraps. We then followed two procedures to calculate the total uncertainty:

- **Complete Monte Carlo Simulation:** In this procedure, we bootstrapped 500 representations of the sample and accordingly calculated the outcome of the MCE for each bootstrapped resample. We then calculated the SD per pixel out of the 500 runs. This approach includes all the interaction effects, but requires 500 operations to be performed per pixel.
- **Analytical combination of the SD per criterion:** We took the 500 bootstraps and used the SD per input value for each criterion, as shown in the results (Figure 5-18). Through this approach, each SD per input value was used to reclass the spatial data, thus resulting in a spatial layer of SD per criterion. We then aggregated the standard deviations analytically to calculate the total uncertainty per pixel as shown in the following paragraph. This second approach has the advantage of being computationally less demanding, as there are only as many operations to be performed per pixel as there are criteria plus a summation.

The analytical combination of the SD per criterion accounts for interaction between the criterion weights and the criterion value function, taken for each criterion separately. However, the interaction between different criteria is not incorporated: for instance, if an expert states that altitude is very important, this implies that other criteria are less important, as all the weights must sum up to one. This interaction is not included in our study but could be accounted for by calculating the covariance between the weighted criteria functions. As there are 9 criteria, there are 45 covariances between them, each of them corresponding to a covariance function (e.g., in slopes between 8 and 10 % and 50-75mm of rainfall, there is a covariance of -0.05). If one wanted to account for them, it would require calculating 45 covariance functions and the corresponding layers. We intentionally neglected these covariance effects to investigate their influence and simply combined the individual variances of each criteria to calculate the total variance by using the following error propagation formula: $Var_{tot} = \sum Var_{criteria}$, as suggested in Malczewski *(1999: 270)*.

4.6 Qualitative Interviews and Questionnaire

As described earlier in Section 4.1.2 ('Tasks'), at the beginning of the encounter, there was a short interview and there was a questionnaire prior to and following the completion of the mapping exercise. The qualitative expert interviews were performed as qualitative expert interviews *(Gläser & Laudel 2006; Meuser & Nagel 1991)*. These lasted an average time of 15–60 minutes, with eventual continuation throughout the rest of the encounter, which in total lasted between one and two hours. The interviews started with a biographical question, peoples' perception of present and future land use change and eventually questions about the importance and the feasibility of local varieties. The interviews were tape-recorded, transcribed, and coded in an abductive manner with a set of codes coming from theory (deduction) and codes emerging from the transcribed texts (induction) *(Lamnek 2005; Mayring 2003, 2009)*. For coding and analysis, we used the open source software TAMS analyzer[5].

The questionnaires (Appendix A and B) were digitised and analysed using frequency distributions and correlation analysis using the 'Wilcoxon signed rank test' for paired samples with continuity correction ('wilcox.test') from the R-package 'stats' *(R Core Team 2015)*. The questionnaires were grouped after area of research and timepoint (before and after the PM).

[5] http://tamsys.sourceforge.net

5 Results

5.1 Participatory Mapping Land Use Scenarios

5.1.1 Mapping of Past Arable Farming in the Val Müstair[6]

Figure 5-1 shows the results of the participatory mapping past land use or the scale 1:25 000. The 15 participants drew a total of 277 polygons (average of 19 polygons per person), with a median size of 2.6 ha. On average, each participant covered approximately 110 ha, with a median of 96 ha (min 25 ha, max 305 ha). The totally mapped area covers nearly 400 ha.

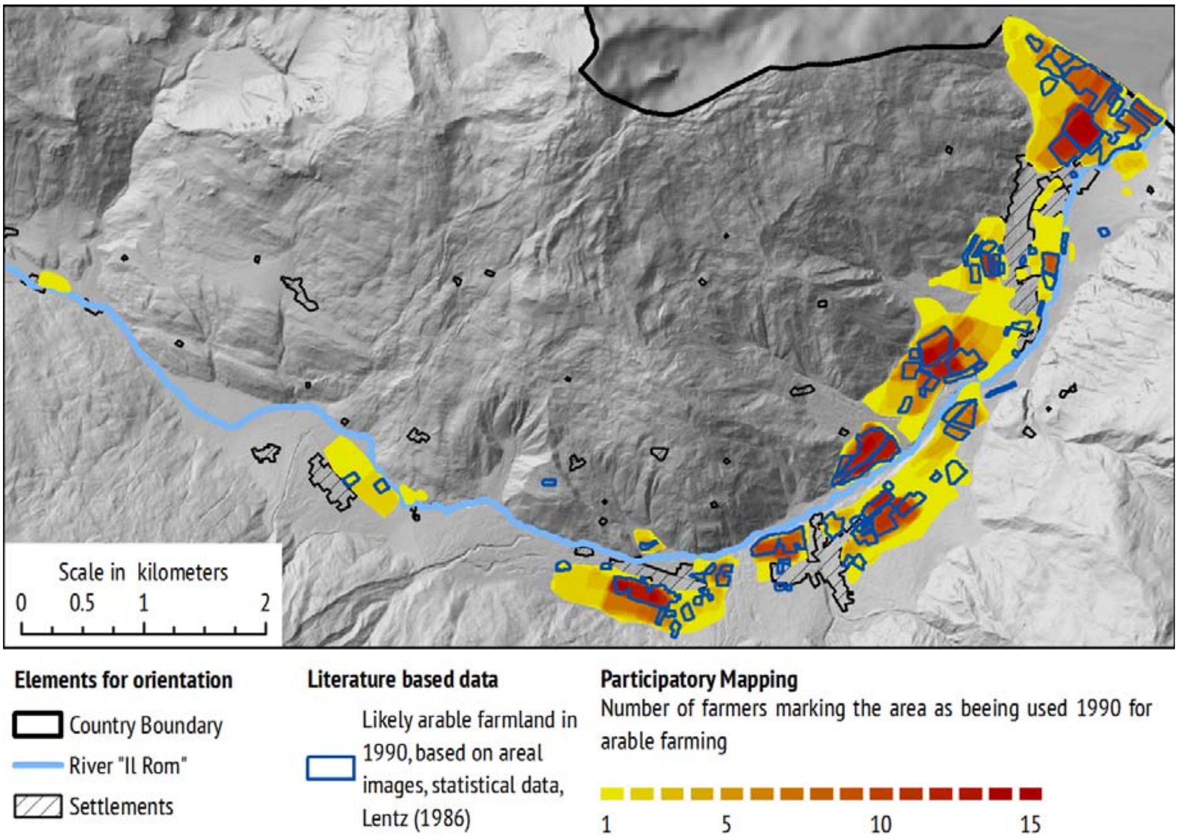


Figure 5-1: Results of the participatory mapping and the literature-based data
Darker shaded areas correspond to more participants stating the land to be used for arable farming in 1990. The blue outline corresponds to the 'ground truth' the PM data is compared to

When comparing the PM to the literature based data ('ground truth'), areas upon which many participants agreed were often represented, thus showing higher correctness than areas marked by fewer participants. Areas marked by 14 or 15 participants were entirely present in the ground truth

[6] This section is partly based on *(Rohrbach et al. 2015)*

(correctness = 100 %), whilst those areas marked by only one participant had a correctness of 28 %. As explained below, in the following analysis, drawing on completeness (recall) and correctness (precision), we used summed areas as opposed to different numbers of overlaps.

Evaluation Area E and Saturation for Past Arable Farming

Figure 5-2, shows the data quality (correctness, completeness and F1-value) by the cumulative sum of areas (E) for combinations of 3, 5, 10 and 15 out of a total of 15 participants. For this analysis, we used only the data collected on the 1:25 000 scale, and limited the *x*-axis to 250 ha. Each line represents one combination of participants, generated by Jackknifing, as described in Section 4.4.2 ('Jackknifing'). Each line is shaded transparent according to the number of combinations possible for this number of participants: for example, in the case of three out of 15 participants, there are 455 combinations. The line connects as many data points as there are selections of overlapping areas possible. In the case of three participants, there are three selections possible, resulting in three data points per measure: areas marked by one or more, two or more, or all three participants. Each of these selections corresponds to a value of completeness, correctness and F1-value. The line connects these data points.

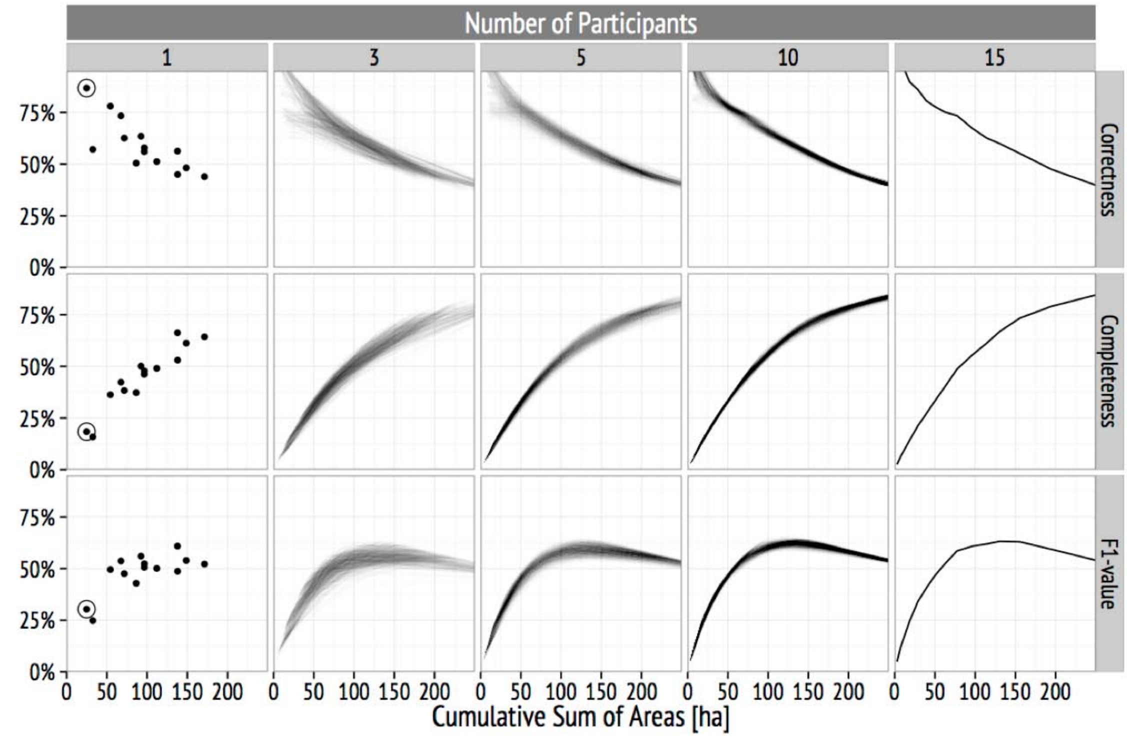


Figure 5-2: Plots of correctness, completeness and F1-values for individual participants and combinations of 3, 5, 10 and 15 out of 15 participants by cumulative summed area
The leftmost plots shows dots for the values of the individual participants. Each line corresponds to a combination of 3, 5, 10 or 15 participants respectively. The lines are displayed transparent, according to the number of combinations present. For 15 participants, there is only one combination possible, hence only one line drawn

The leftmost part of the graph shows the values of individual participants, represented as dots: for example, the circled point refers to a participant marking 25 ha with a correctness of 87 %, a completeness of 18 % and a resulting F1-value of 30 %. The rightmost column displays data when taking all 15 participants together. There is a single line as there is only one combination of 15 data points per measure (where not all are displayed due to the limits in the x-axis). The maximum of the F1-value is reached at slightly more than 100 ha. At 100 ha, correctness reaches around 67 %, completeness around 55 % and thus the F1-value around 60 %.

According to Figure 5-2, correctness tends to be higher when selecting smaller areas. Completeness, on the other hand, increases when evaluating bigger areas. Figure 5-2 further indicates that correctness increases with the number of participants marking an area. The figure also shows that the correctness of a hotspot not only depends on the number of participants but also on the size of the area. In our case, F1-values (combining correctness and completeness) are highest around the area of the ground truth (117 ha). Increasing the number of participants reduces the general variability and thus increases the reliability of the results.

Figure 5-3 shows the box whisker plots for F1-values for four different evaluation areas and on three different scales for different numbers of participants. The graph corresponds to a typical saturation curve, with larger evaluation areas yielding flatter curves. The four sizes of evaluation areas are selected for illustration. The 117 ha corresponds to the ground truth, and 100 ha correspond to the average of what the participants drew across all scales; 50 and 200 ha are added for comparison. A line connecting the means of different numbers of participants is shown together with the boxplots. The graph is limited to F1-values between 20 and 75 as there the variation is most prominent. Overall, the difference in quality of the aggregated data amongst the three scales is small, with a maximal F1-value of 67 % for the 1:25 000 scale and 70 % on the 1:5 000 scale. Additional participants increase the F1-values by less than only 1 %, Having selected 5 participants on the 1:5 000 scale, 6 on the 1:12 500 scale and 7 on the 1:25 000 scale. Considering the F1-value of the whole group, using only 6 participants yields 90 % of the F1-value of the complete data set.

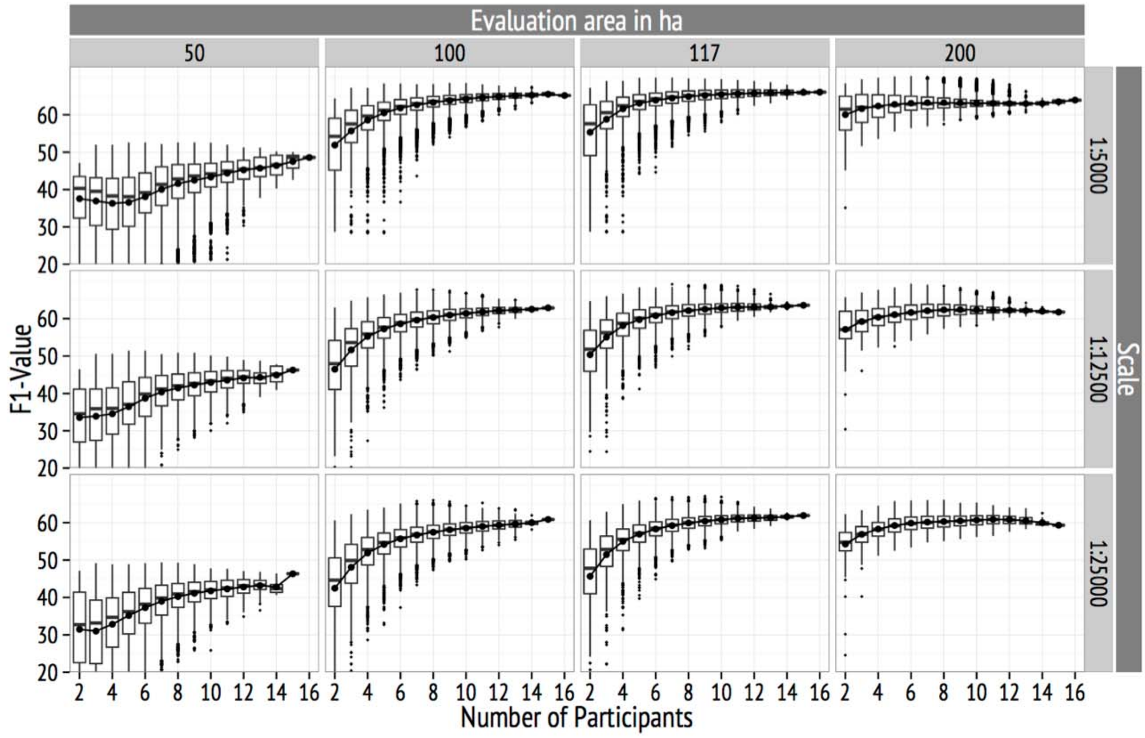


Figure 5-3: F1-values according to different sample sizes, areas evaluated and scales
Each graph shows the saturation curve by plotting the F1-value depending on an increasing number of participants. Rows of graphs correspond to different scales, columns to different evaluation areas

5.1.2 Mapping of Future Arable Farming in the Val Müstair

Figure 5-4 shows the results of participatory mapping the most likely areas where arable farming would be revived on the 1:12 500 scale. Additionally, the outlines of the observed arable farming area in the years 2014 and 2015 are shown. On average, the 15 participants marked 51 ha on the map (min 14 ha, max 122 ha), and likely included the area necessary for crop rotations. The farmers marked a total of 124 polygons with a median size of 2.4 ha and an average of 9 polygons per participants. The total area covered is about 210 ha. When asked for their thoughts while marking particular areas, they mentioned favourable natural features (slope, soil depth, stones) or personal attitude of the farmer cultivating the area. Touristic reasons, landscape beauty or similar reasons were never mentioned.

The observations of the years 2014 and 2015 were quite similar and, in order to account for crop ration, the two datasets were merged. Three areas used for crops in the year 2014 are highlighted: one area on the westerly end, and two areas in the middle of the map. None of the participants predicted those areas to be used for arable farming. We don't have further information about the two areas in the middle. The most westerly area is cultivated by a farmer, which only recently took over the farm from his parents.

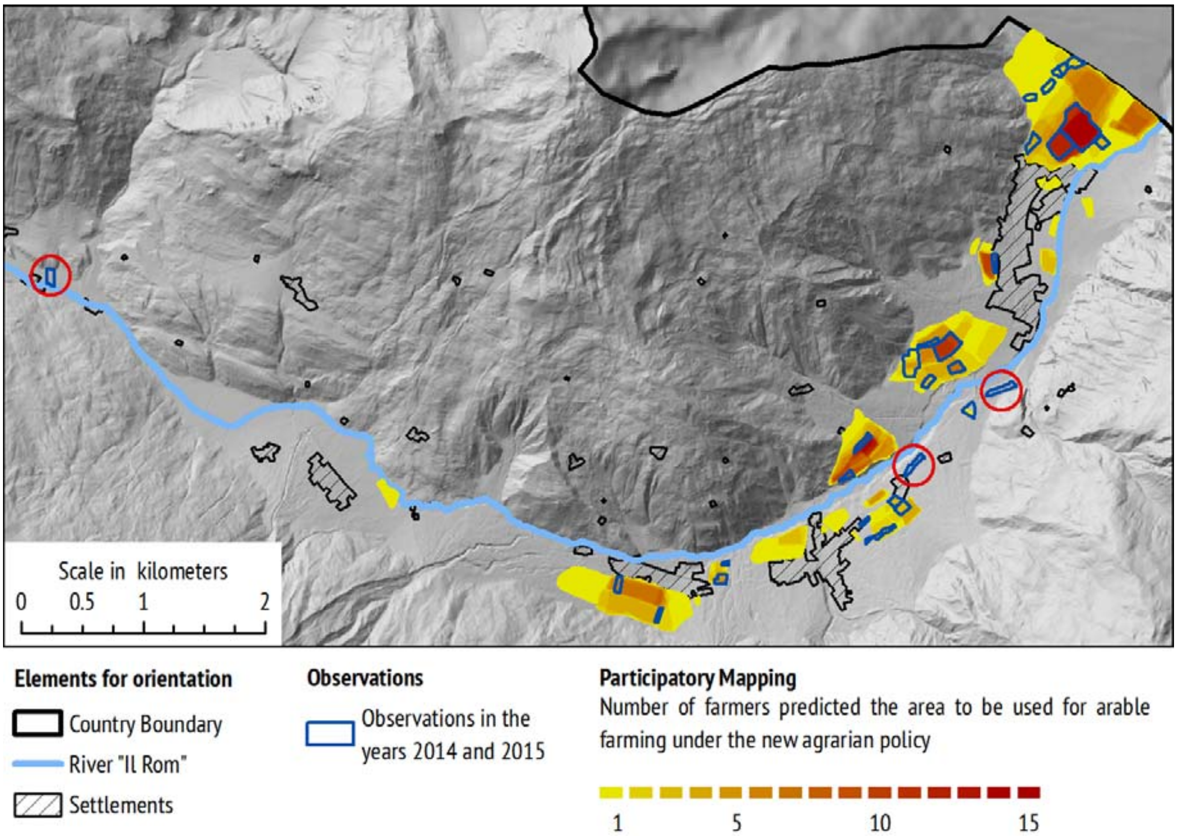


Figure 5-4: Observed and predicted arable farming under the new agrarian policy
Darker shaded areas correspond to more participants stating the land to be used for arable farming under the new agricultural policy. The blue outline corresponds to the 'ground truth' the PM data is compared to. The red circled areas are referred to in the text

Participatory Mapping of Own Arable Farming under the New Agrarian Policy

The methodology centred on how the individual predictive quality is calculated is shown in Methods, Figure 4-6. The displayed polygons in the methods-figure correspond to the data of the circled point in Figure 5-5. For those measures, we used the data at the scale of 1:5 000. It can be noted that the method is based on the self-reported land. Therefore, a participant can classify a patch as a place where this participant would do arable farming, without tagging this patch as own land (as seen in the lower left corner of Figure 4-6). According to the methodology applied, such a patch would never become correctly predicted as used for arable farming.

Figure 5-5 a) displays the boxplot of the shares of the area of observed arable farming lying within the area predicted by the participatory mapping survey on three different scales. This value corresponds to the completeness of the prediction. The red dot represents the mean of all the values, the circled dot a selected participant. On the scale of 1:5 000, 95 % of the land attributed to this participant and used for arable farming, was lying within the patches this participant predicted. The remaining 5 % can be considered to be a result of the unclear drawing. On the scale of 1:12 500; however, the participant predicted only 67 % of the arable farmland attributed to this participant on this scale. This signifies that

33 % of the participant's land used for arable farming was not predicted by this participant in the survey on this scale.

Figure 5-5 b) shows the ratio of the area predicted in the questionnaire with the area observed on the ground using the parcels classified as own land on the largest scale possible (usually 1:5 000). The participant circled stated in the questionnaire to be cultivating about 1.75 ha, whilst actually only 0.6 ha of arable farming were observed. Accordingly, for this participant, we observed about 36 % of what was indicated in the questionnaire. For some participants, the ratio is lower or higher, especially amongst participants who, in the questionnaire, indicated small amounts of arable farming under the new agrarian policy and didn't do any arable farming in the two first years after the policy's enactment.

Figure 5-5 c) then displays the ratios between observed and forecasted arable farming in the PM and the questionnaire. As a consequence of crop rotation, participants mark more land in the PM than they intend to use in a particular year. Therefore, one can assume the total forecasted arable land in the PM survey to be both: bigger than that observed in a given year and bigger than the total area forecasted in the questionnaire. However, the ratio between the land forecasted in the questionnaire and the land drawn in the PM-survey is expected to correlate with a ratio similar to the one between the observed arable farming and the one stated in the PM-survey. The circled participant indicated 1.75 ha in the questionnaire and 3.8 ha in the PM-Survey, corresponding to a ratio of 46 %. Therefore, one would expect around 46 % of the area indicated in the PM-Survey to be used for arable farming. However, only 16 % (0.6 ha) of the land predicted in the PM-Survey is actually covered with arable farming. The correlation between the two variables is rather low (r^2= 30 %), indicating the presence of a third factor.

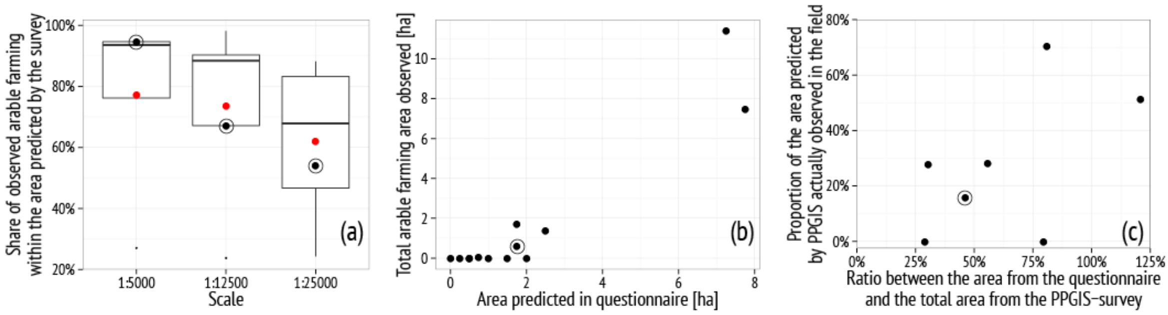


Figure 5-5: Individual assessment of mapped and stated vs. observed arable farming
The leftmost figure shows the predictive quality depending on the scale, the middle figure the ratio between observed and stated arable farming and the figure to the right compares the ratios between observed and drawn and between stated and drawn.

Table 5-1 shows counts for the observed, the mapped and the questionnaire-based responses. Generally, one would expect to observe arable farming from participants that have stated arable farming in the questionnaire; however, arable farming was only observed amongst half (6) of the participants that have stated arable farming in the questionnaire (12). Nonetheless, there was no arable farming observed on the land of the two participants that didn't state any arable farming in the questionnaire.

Table 5-1: Counts of observed and stated arable farming

	Participatory Mapping		*Questionnaire*		
	Drew arable farming	*Didn't draw arable farming*	*Stated arable farming*	*Stated no arable farming*	*No statement given*
Arable farming observed (N=7)	5	2	6	0	1
No arable farming observed (N=10)	4	6	6	2	2

Evaluation Area E and Saturation of Future Arable Farming

Figure 5-6 shows correctness, completeness and the resulting F1-value for the group's prediction of arable farming in the first two years after the enactment of the new agricultural policy. This graph is analogue to Figure 5-2, with the difference that it shows the results for the land use prediction instead of the past land use and uses the data on the 1:12 500 mapping scale, as there the F1-value is higher than on the 1:25 000 scale, as explained below. The highest F1-values are reached when selecting an evaluation area between 15 and 25 ha, with the area taken as ground truth corresponding to 30.7 ha. Considering the F1-value of the whole group, the F1-value for the three scales is maximal 43 % for the 1:25 000 scale and 52 % for the 1:5 000 and the 1:12 500 scale. At the maximum F1-value, the completeness equals 42 % and the correctness 69 %.

Saturation curves then are shown in Figure 5-7. The graph is limited to a range of F1-values between 15 and 63, focusing on the most prominent region of change. On the 1:5 000 and the 1:12 500 scale, the inclusion of more than 9 participants on average increase the F1-values, at this point at about 50 % for an evaluation area of 25 ha, by less than only 1 %. For the 1:25 000 scale, the increase of less than 1 % is only reached at more than 11 participants than with an F1-value of about 42 %.

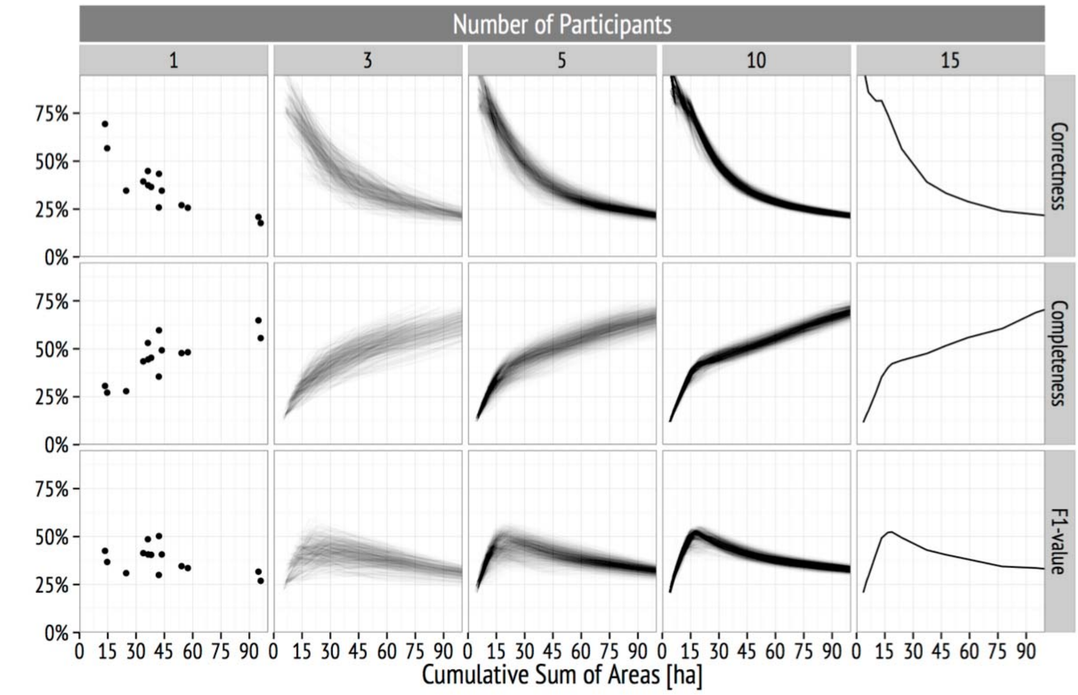


Figure 5-6: Correctness, completeness and F1-value for different sample sizes in predictive mapping of arable farming in the Val Müstair under the new agricultural policy
The leftmost plots shows dots for the values of the individual participants. Each line corresponds to a combination of 3, 5, 10 or 15 participants respectively. The lines are displayed transparent, according to the number of combinations present. For 15 participants, there is only one combination possible, hence only one line drawn

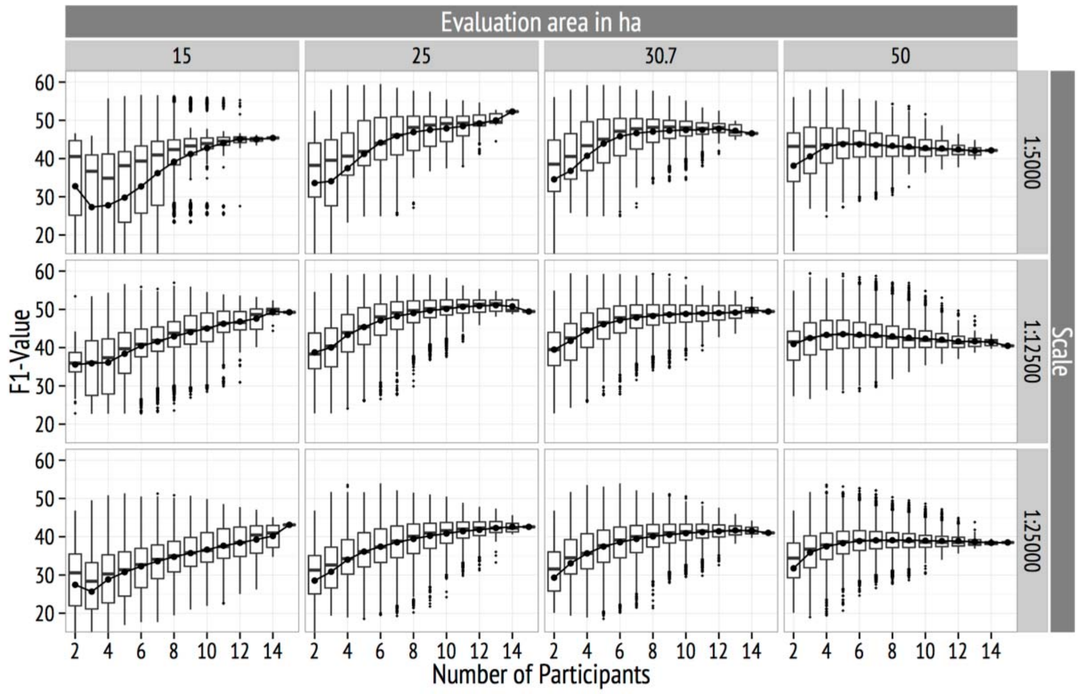


Figure 5-7: Saturation for the prediction of arable farming in the Val Müstair
Each graph shows the saturation curve by plotting the F1-value depending on an increasing number of participants. Rows of graphs correspond to different scales, columns to different evaluation areas

5.1.3 Comparing the Mapping of the Past and the Future Arable Farming in the Val Müstair

The Effect of Mapping Scale on Mapping Past and Future Arable Farming

Figure 5-8 shows that individual participants reached higher F1-values for mapping arable farming on larger scales, which was the last scale used for mapping. With increasing scale, the average F1-value for PM past arable farming climbed from 48 to 54 %, with maxima increasing from 60 to 65 % and minima from 25 to 34 %. At the same time, the group F1-values for mapping past arable farming (Figure 5-3) increased by a smaller percentage (67–70 %). The average F1-value for PM future arable farming increased from 32 % on the 1:25 000 scale to 37 % on the 1:12 500 scale, with the reaching 36 % on the 1:5 000 scale. The smallest maximum is 43 % (on the scale 1:25 000) and the largest 52 % (on the scale 1:5 000). The smallest minimum is 11 % (on the scale 1:25 000) whilst the largest is 21 % (on the scale 1:12 500). For mapping future arable farming (Figure 5-7), the F1-value increased with a large percentage (43–52 %) than the average individual values.

Generally, individual F1-values increase throughout the mapping procedures, as well as when using larger scales in both tasks. However, the group F1-values for mapping past arable farming did not change much, whereas the group F1-value for mapping future arable farming did change more strongly with increasing scale.

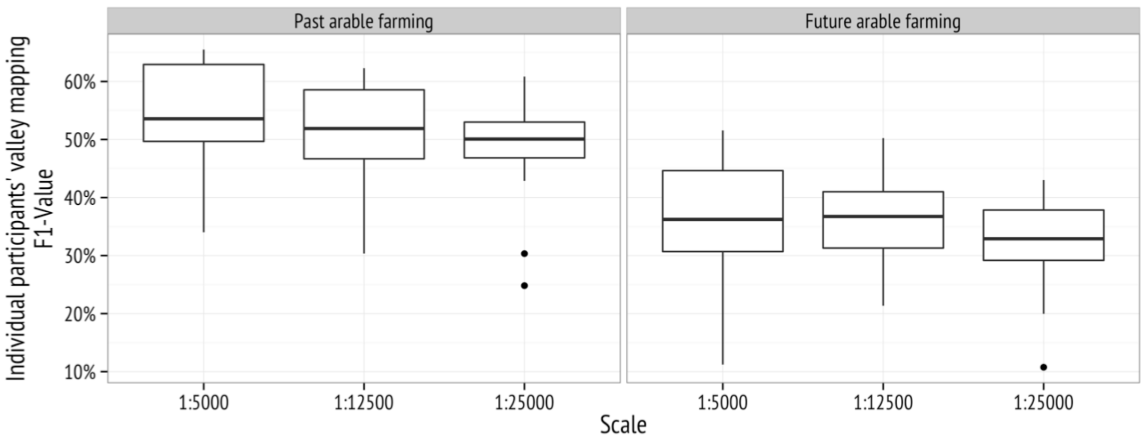


Figure 5-8: F1-values of individual participants on different scales
The boxplot bases on the F1-values of individual participants. The left three boxplot showing the values for past arable farming and the right the values for future arable farming, with the scale declining from left to right

The Effect of Individual Performance on the Group Outcome

Figure 5-9 and Figure 5-10 allow the comparison of the F1-value of groups containing seven individuals with highest and lowest F1-values with the mixed groups. Using seven out of the 15 participants, we obtained many mixed combinations and two non-overlapping combinations of seven individuals with the highest and lowest individual F1-values. The individuals with lowest/highest F1-value correspond to the lowermost/uppermost seven points in the bottom-left square of Figure 5-2 and Figure 5-6 respectively. Both Figure 5-9 and Figure 5-10 show the F1-values of groups containing seven participants at different evaluation areas for the historic and the future arable farming respectively.

Participants with low and high F1-values complement one another in the PM of arable farming in 1990 on the scale of 1:25 000. Evaluating at a cumulative sum of areas of 100 ha—notably the region of highest overall F1-values—illustrates this: the group with participants with the highest individual F1-values (dashed line) yielded high, but not the highest group F1-value at 100 ha. The combination of participants with the lowest individual F1-values (dotted line) did create a lower, but not the lowest, group F1-value at 100 ha. Different groups comprising participants with mixed F1-values (grey lines) yielded both, the highest and lowest F1-values at 100 ha. This indicates that the participants with low F1-values complement one another. If participants have much knowledge about a certain region within the area of study, but less about another one, they individually have a low F1-value due to the low coverage. However, if such participants are in a group of participants, with complementing knowledge about different regions within the area of study, they together reach a high F1-value, which seems to be the case for PM of past arable farming on this scale. On other scales, the effect was not as prominently observed.

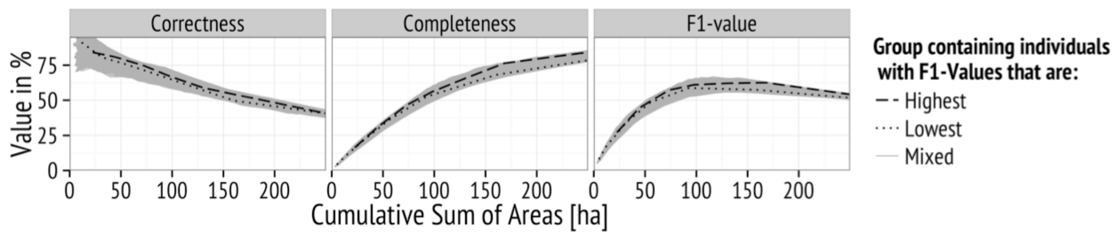


Figure 5-9: Past arable farming: Comparison of combinations containing 7 participants with highest, lowest or mixed individual F1-values for mapping
The graph shows correctness, completeness and F1-value for the PM data from a) two groups out of participants with highest and lowest individual F1-values respectively (dashed and dotted), and b) all the other groups consisting out of participants with various individual F1-values (grey). Data on the scale of 1:25 000 was used

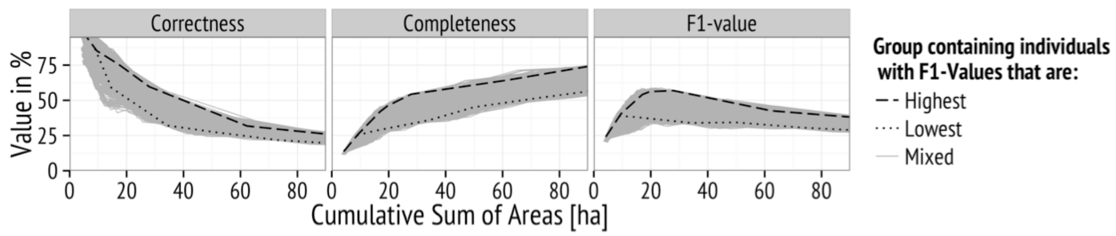


Figure 5-10: Future arable farming: Comparison of combinations containing 7 participants with highest, lowest or mixed individual F1-values for mapping
The graph is analogue to Figure 5-9. Data on the scale of 1:12 500 was used

However, when taking the PM data for the future arable farming, as shown in Figure 5-10, the participants do not seem to complement each other. Comparing the F1-value at 20 ha—notably the area with highest group F1-values—the group of participants with high or low individual F1-values yield, respectively, high or low F1-values as a group. Therefore, the PM of the participants do not seem to complement each other, but rather that the participants with low individual F1-value made similar errors and the participants with high F1-value marked similarly correct areas. The variation of F1-values between different groups of participants is larger as saturation did not seem to have been reached with 7 participants (shown in Figure 5-7) other than in the PM of the past arable farmland.

Forecasting Arable Farming with the Historic PM Dataset

Does the PM of the state in 1990 forecast the situation under the new agricultural policy? Moreover, if comparing PM to the land use scenario under the new agricultural policy: what data quality does the PM dataset of arable farmland in 1990 yield when compared to the dataset about future arable farmland? This depends on the area of evaluation. If selecting areas of evaluation between 30 ha and 75 ha, the PM dataset for the arable land in 1990 (the 'wrong' PM dataset) yields a higher F1-value than those actually aiming at predicting the future arable farmland, as shown in Figure 5-11. For evaluation areas up to 30 ha on the 1:5 000 scale and about 15 ha for the 1:25 000 scale, correctness and completeness are lower in the 'wrong' PM dataset than in the 'correct' PM datasets. Using the PM dataset on the scale of 1:5 000, for the 'wrong' dataset a maximum F1-value of 48 % is reached at an evaluation area of 33 ha, compared to a maximum F1-value of 52 % of the 'right' dataset at an evaluation area of 18 ha.

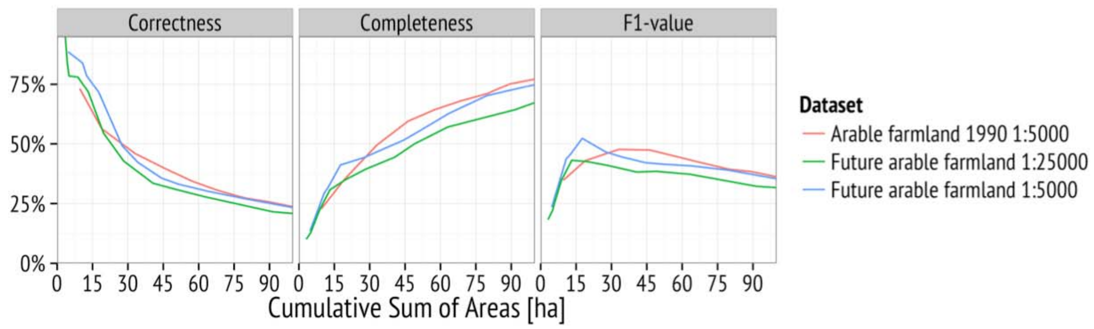


Figure 5-11: Data quality parameters of three PM datasets for the arable land under the new agricultural policy
Three PM datasets were compared: One PM dataset contains the PM data from the 1990 task and two PM datasets both contain the data from the prediction of arable farmland under the new agricultural policy but on different scales

5.1.4 Mapping Future Land Use in Pfyn-Finges

Figure 5-12 shows the results of participatory mapping the future of the vineyards in the region of Pfyn-Finges. Out of the 33 participants in the study, 28 made a spatially explicit statement about the location of vineyards which might not exist anymore in the future ('change') and 24 made a statement about the vineyards which will likely still exist by the year 2040 ('persistence'). The difference between the opinions ('persistence' minus 'change') is shown below the two other maps. The participants drew an average of 10.6 polygons with a median size of 0.76 ha concerning areas they suspect no longer are vineyards and an average of 9 polygons with a median size of 3.5 ha for those areas that likely will exist by the year 2040. Therefore, the participants mapped more (296 vs. 214), but in the tendency smaller polygons for the areas that will not likely remain vineyards in 25 years.

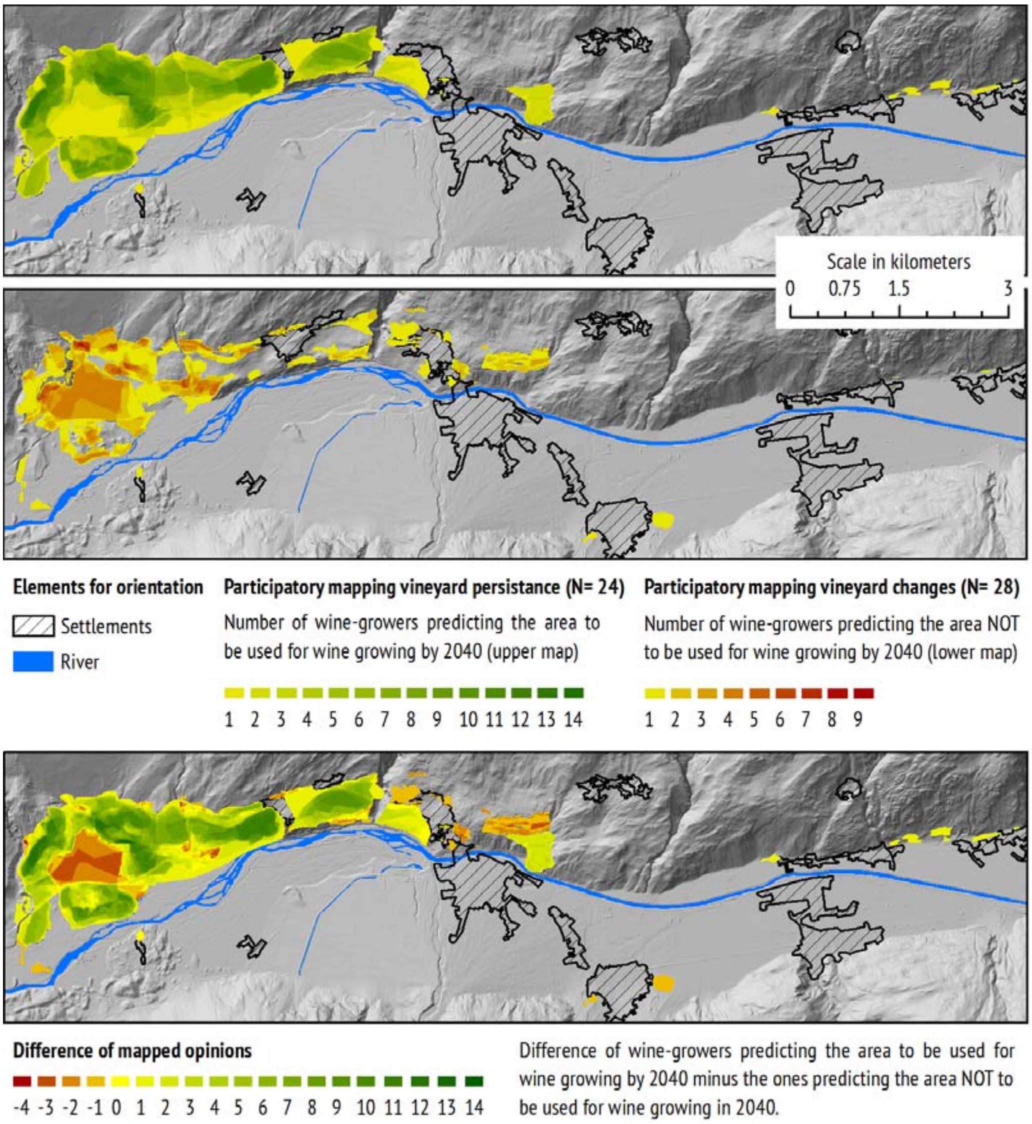


Figure 5-12: Results of the participatory mapping of future land use of vineyards in the region of Pfyn-Finges
As most the spatial data is concentrated on the area between Salgesch and Leuk, in the left half of the maps, subsequent spatial representation will focus on this part of the map. For the statistical analysis, all data will be included

5.1.5 Comparing the PM Data Characteristics of the Two Areas of Study

Mapping of Own Land

Figure 5-13 highlights the difference between the area marked in the PM on the scale of 1:5 000 and the area stated in the questionnaire to be cultivated by this participant. Positive deviations indicate that this participant stated more area in the questionnaire than was marked, whereas negative values indicate the opposite. If the orthophoto used for the PM did not cover all the area cultivated, this was noted on the questionnaire, and the value correspondingly corrected. One can see that, for the Val Müstair, the farmers tended to write a larger area on the questionnaire than marked in the participatory mapping, whilst for Pfyn-Finges, deviation was spread more equally between the positive and negative.

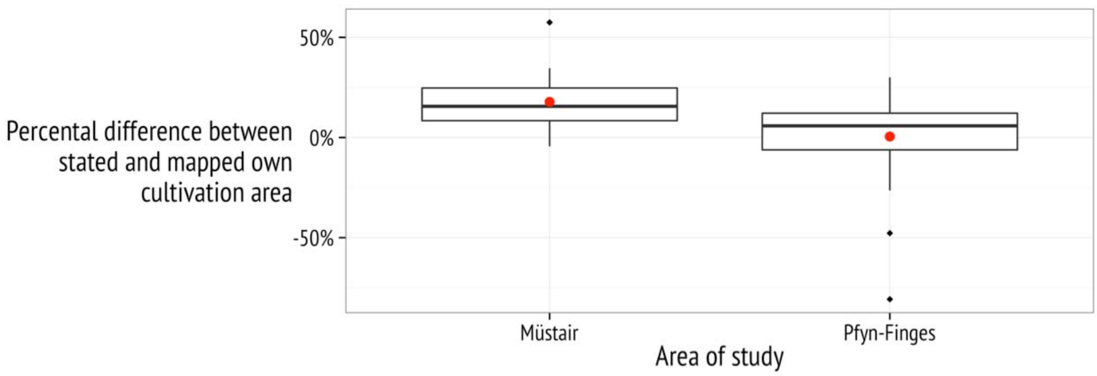


Figure 5-13: Difference between stated and mapped own cultivation area
Reading example: In the Val Müstair, the farmers generally stated more area in the questionnaire, than they marked in the PM

Agreement amongst the Participants

In order to assess the level of consensus among the participants, we developed the consensus graph. This graph (Figure 5-15) allows judging the consensus among the participants using only data-inherent characteristics, as shown in Figure 5-14. The more the curve extends towards the left side, the higher the proportion of the study area that has only been marked by a small part of the participants. In this case additional participants add new areas, instead of confirming already mapped areas. A curve that extends more towards the right side of the graph indicates that the participants mostly marked the same areas. Hence, the agreement among the participants is higher.

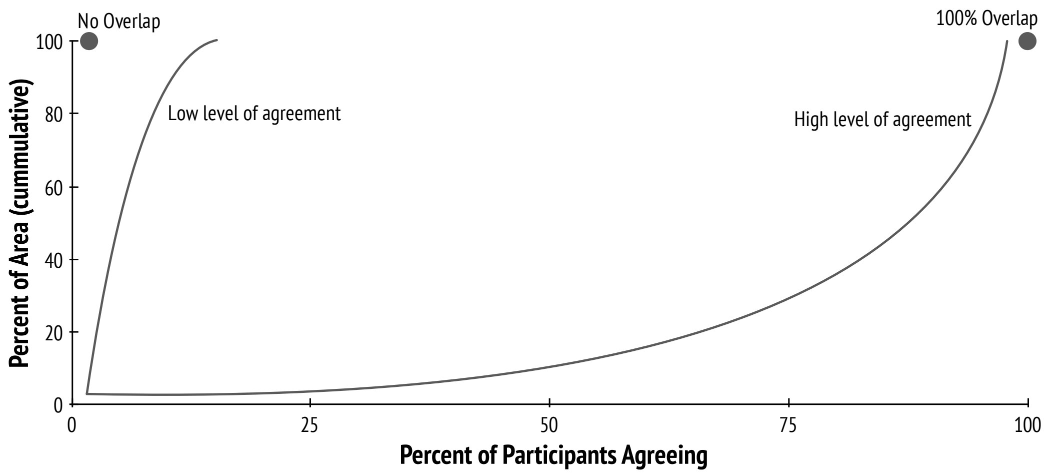


Figure 5-14: Graph used to foster the interpretation of the consensus graph
This graph the cumulative percent of the area versus the percent of the participants agreeing for a hypothetical PM with a low and a high level of agreement respectively

Figure 5-15 displays the percent of participants marking a piece of land and the cumulative area of the land marked. For the task of mapping arable farmland in 1990 in the Val Müstair, the uppermost right point displays that there is some land marked by all the participants as being used for arable farming in 1990. For the same set of measurements, the lowermost left point indicates that 52 % of the marked land was marked by not more than 6.25 % of the participants (i.e. one out of the total 16 participants). Figure 5-15 further shows that there was no place on which more than half of the participants stated that there will no longer be a vineyard in 25 years.

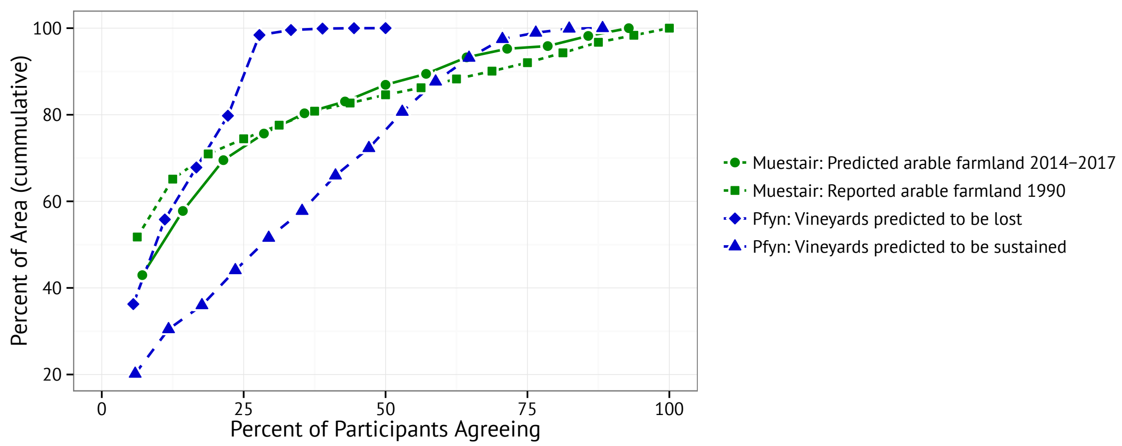


Figure 5-15: Comparing consensus amongst the areas of research and the different tasks
Please note, that for Pfyn-Finges, this analysis only contains the data for the commune of Salgesch. The datasets are all on the scale of 1:5 000

For this analysis, the data from Pfyn-Finges was clipped to the commune of Salgesch in order to reduce the possible bias of areas, with only few participants. Both areas are constrained where, in one case, the locations with possible arable farming and, in the other, the extent of vineyards is limited. However, even though nuances are slightly different, the data for other communes—or even the whole area of study—did not contradict the conclusions drawn from this dataset.

This graph allows reading the level of agreement amongst participants, e.g., if one selects to analyse 'hotspots', for example, the 20 % of the area marked by the most participants. Depending on the task and the area, this would correspond to a different share of the total sample. This share is shown as the closest point to the 80 % of the cumulative area. In Figure 5-15, this corresponds to the point on the *x*-axis, when the line crosses the 80 % on the *y*-axis. This means, when looking for historic arable farmland in the Val Müstair, one would select the area marked by more than 38 % of the participants and, in the case of the predicted arable farmland, the area marked by more than 36 %. For the vineyards, which are predicted to be sustained, one would select areas marked by more than 53 % of the participants and for vineyards predicted to be lost by more than 22 %. It should be noted that this does not correspond to the total area within that 'hotspot'. Therefore, the total area of this 'hotspot' might be larger or smaller, depending on the area marked for the given task.

5.2 Comparing PM to MCE

5.2.1 Outcomes of the MCE

Criteria Selection

The 9 criteria, determining whether or not a parcel will be used in the future, are summarised in Table 5-2. The criteria were selected in conjunction with the non-local experts. However, two points of discussion remained: firstly, some experts mentioned that it would be important to include the actual condition of the vineyard, the so-called plant capital, but, as we asked for criteria determining whether the vineyard will still be cultivated in 20 years, we argued that, until then, the majority of the vineyards would need to be replanted, rendering the present plant capital to be unimportant, which convinced most of the experts; and secondly, several experts mentioned the spatial distribution of the vineyards and their distribution to the vinery as of crucial importance as this determines the costs and time needed for a wine-grower to cultivate the parcels; however, we argued that the parcels might change the owner within the next 20 years, which would render such information wrong.

Table 5-2: Criteria used within the MCE

Criterion	*Description*	*Data Source*
Distance to road	This measures the distance between the edge of the production unit and the next road. Some parcels are only accessible by foot. The distance to the next road is crucial for transporting the harvest as well as fertilizing and pest management.	Streets: Swisstopo TLM 2014 (taken all streets wider than 2m, manually checked). Production units: Cantonal survey of parcels, manually checked and aggregated to production units. Distance calculated using FME 2015.

Criterion	*Description*	*Data Source*
Size of production unit	This layer was created based on cadastral data, which then was checked manually. Some parcels are very small, e.g., due to partible inheritance and not suited for industrial production.	Parcels: See above Sloped size calculated using FME 2015
Building zone	The vineyards, which are inside of the building zone, can be used for housing. This increases the land value and thus opens lucrative alternatives to wine farming.	Building zone layer: From the cantonal office
Slope	Some slope is often regarded as positive, as the terrain has better drainage and the cold air doesn't accumulate.	Swisstopo, 5m raster
Soil water retention	Low soil water retention capacities require a sophisticated and costly irrigation system. On the other hand, it was shown, that some water stress is beneficial for the system. Therefore, the soil water retention can be too high.	Soil: Soil survey from 2007
Aspect	Traditionally, southern exposed slopes are only used, however, in the area of study, most vineyards are anyway southern exposed.	Swisstopo, 5m raster
Altitude	Altitude together with the insolation determines the temperature.	Swisstopo, 5m raster
Insolation	Insolation is important for the ripening of the grapes, especially between the April and October.	Own calculation using ArcGIS solar analyst, based on the altitude model.
Precipitation	High precipitation can stimulate moulds, low values can be compensated by irrigation, but increase costs. As winter and spring precipitation is not crucial, we summed the precipitation from July to October	25m raster, based on *(Zimmermann & Kienast 1999)*, resampled to 5m

Criteria Weights

Figure 5-16 shows the criteria tree with intermediate weights written on the branches and the final criteria weights written below of each criterion. The criteria are ordered from left to right with decreasing weight. 'Distance to road' has the biggest weight whereas 'Precipitation' the smallest. The 13 non-local experts then were resampled via the bootstrapping method, as described in Methods: Section 4.4.1 ('Bootstrapping), in order to estimate the variation of each criteria weight. Figure 5-17 shows the comparison of the aggregated values from all 13 participants with the value range from 500 bootstraps. It becomes clear that the influence of the parcel size and the building zone exhibit the biggest variability.

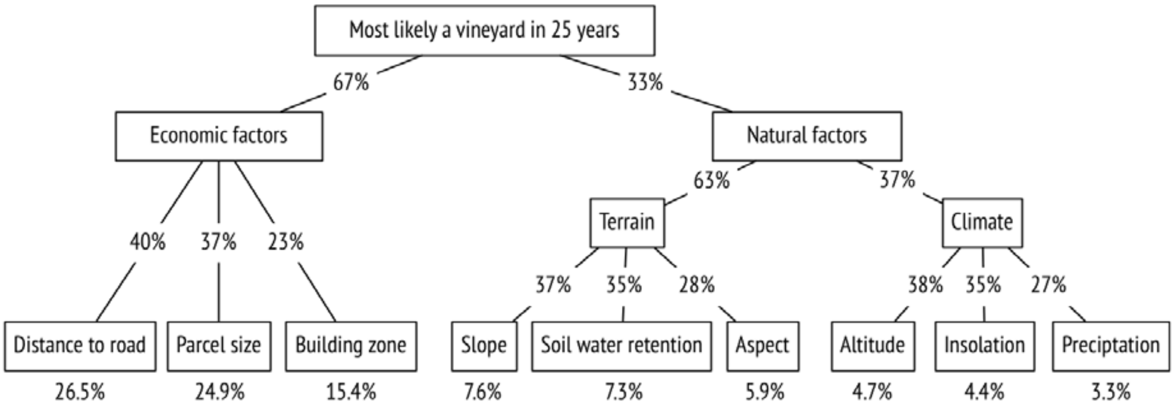


Figure 5-16: Criteria tree with intermediate and final weights
The lowest level of boxes shows to the criteria, with the final weights written below. The numbers on the branches of the tree denote intermediate weights

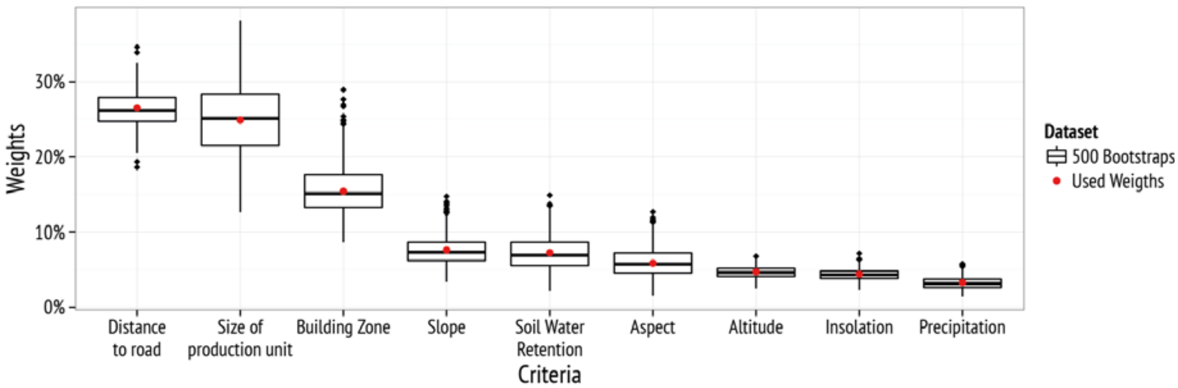


Figure 5-17: Criteria weights range from 500 bootstraps compared to the used weights
The red point represents the aggregation of all non-local experts and the boxplots the variation of 500 bootstraps

Criteria Value Functions

Figure 5-18 shows the resulting value functions after aggregating them. The value functions then are used to standardise the input criteria layers. Figure 5-19 displays the standardised criteria layers. Figure 5-18 further shows the standard deviation per input value range. Figure 5-18 further displays the standard deviations associated with each criteria value (i.e. vineyards on an altitude of 600 m (a.s.l.) yield a value of 0.7 with an associated standard deviation of nearly 0.25 in respect to altitude). Vineyards, which yield values close to one on all the criteria, are very likely to still be cultivated by 2040.

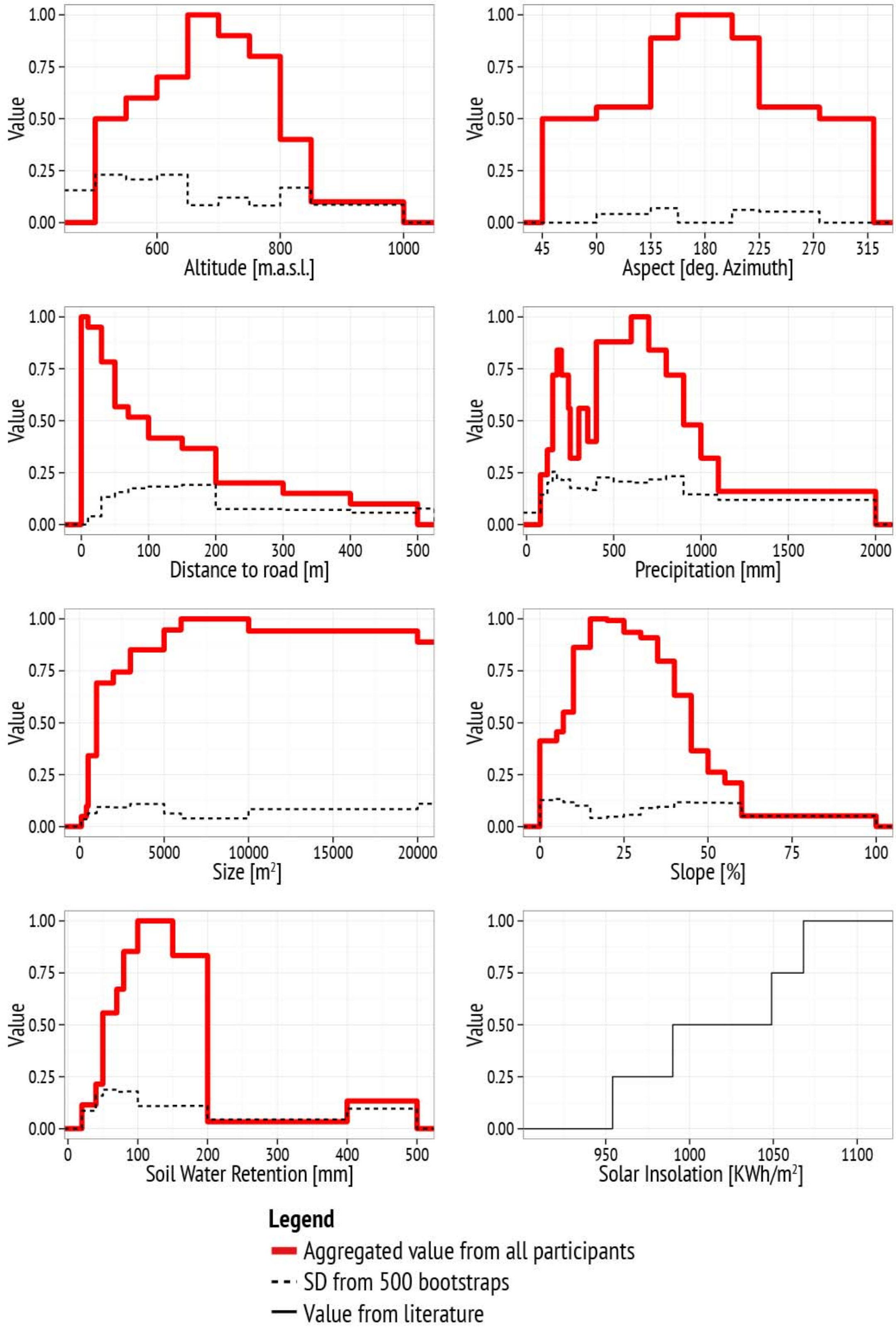


Figure 5-18: Value functions for all the 9 criteria with associated standard deviation resulting from 500 bootstraps

Both, the value and the standard deviation are a function of the criteria input value. For the solar insolation criteria, literature based values were chosen. Higher values correspond to a bigger probability of continued cultivation of a vineyard

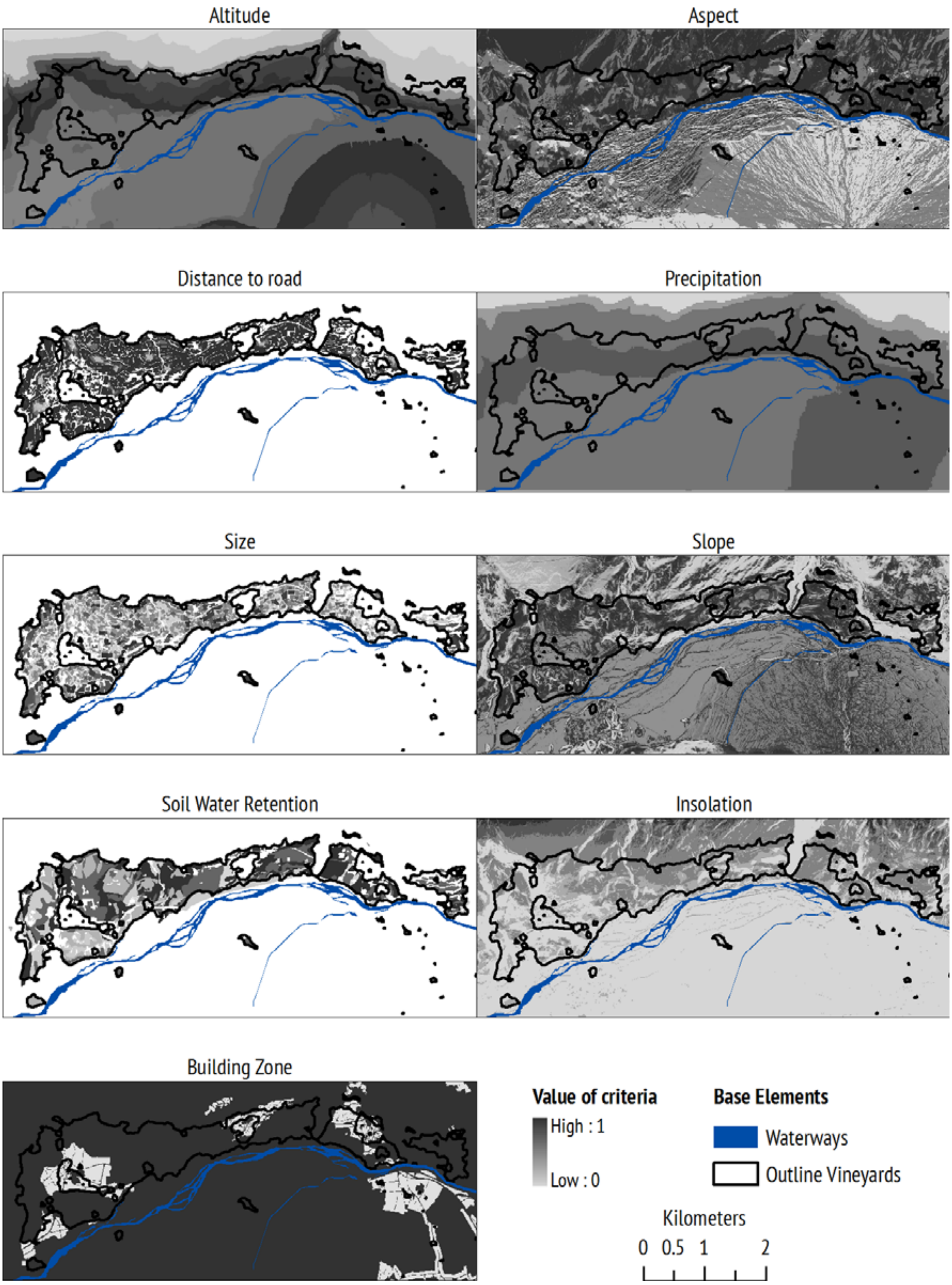


Figure 5-19: Criteria layer with standardised values
Spatial explicit representation of the value functions shown in Figure 5-18. Higher values correspond to a larger probability of continued cultivation by the year 2040

Uncertainty of the MCE Outcome

The total uncertainty is a result of the SD for the weights of each criterion (shown in Figure 5-17) and the SD for each value function (shown in Figure 5-18). However, there are two ways of aggregating those uncertainties, as explained in Methods: Section 4.5.4 'MCE Sensitivity Analysis'. Figure 5-20 shows the value of the standard deviation (SD) and of the relative SD in relation to the MCE-outcome for both methods. Each point in the graph corresponds to a pixel of the MCE. The relative SD equals the SD divided by its MCE-value. The mean of the relative SD of the complete Monte-Carlo simulation (4.14 %, SD= 1.17 %) is slightly lower than the one for the analytical combination of the SD per criteria (6.58 %, SD= 0.77 %). The relative SD from the complete Monte-Carlo simulation ranges from 1.9–20.6 %, with the one based on the analytical combination of the SD ranging from 5.2–20.1 %.

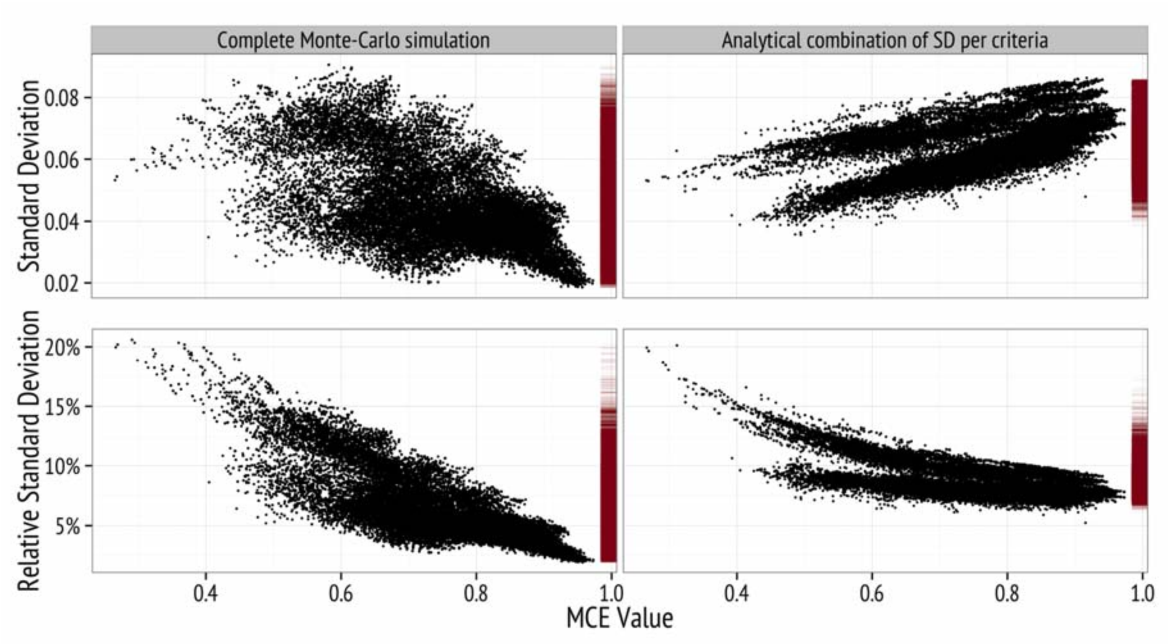


Figure 5-20: Comparing the standard deviation gained by the complete Monte-Carlo simulation and the one calculated by analytical combination to the value of the MCE
Higher values of the relative SD indicate higher uncertainty associated with the outcome. The graph indicates, there is less uncertainty for higher values of the MCE than there is for lower values

5.2.2 Comparison of MCE an PM

Descriptive Comparison of the Results of the MCE and the PM

Figure 5-21 shows the results from the MCE, the PM and a randomly generated layer next to each other. Figure 5-21 allows for the visual comparison of the spatial distribution of the outcome of the methods. For better black-and-white printability and easy comparison between the different methods, we applied a unipolar colour scale.

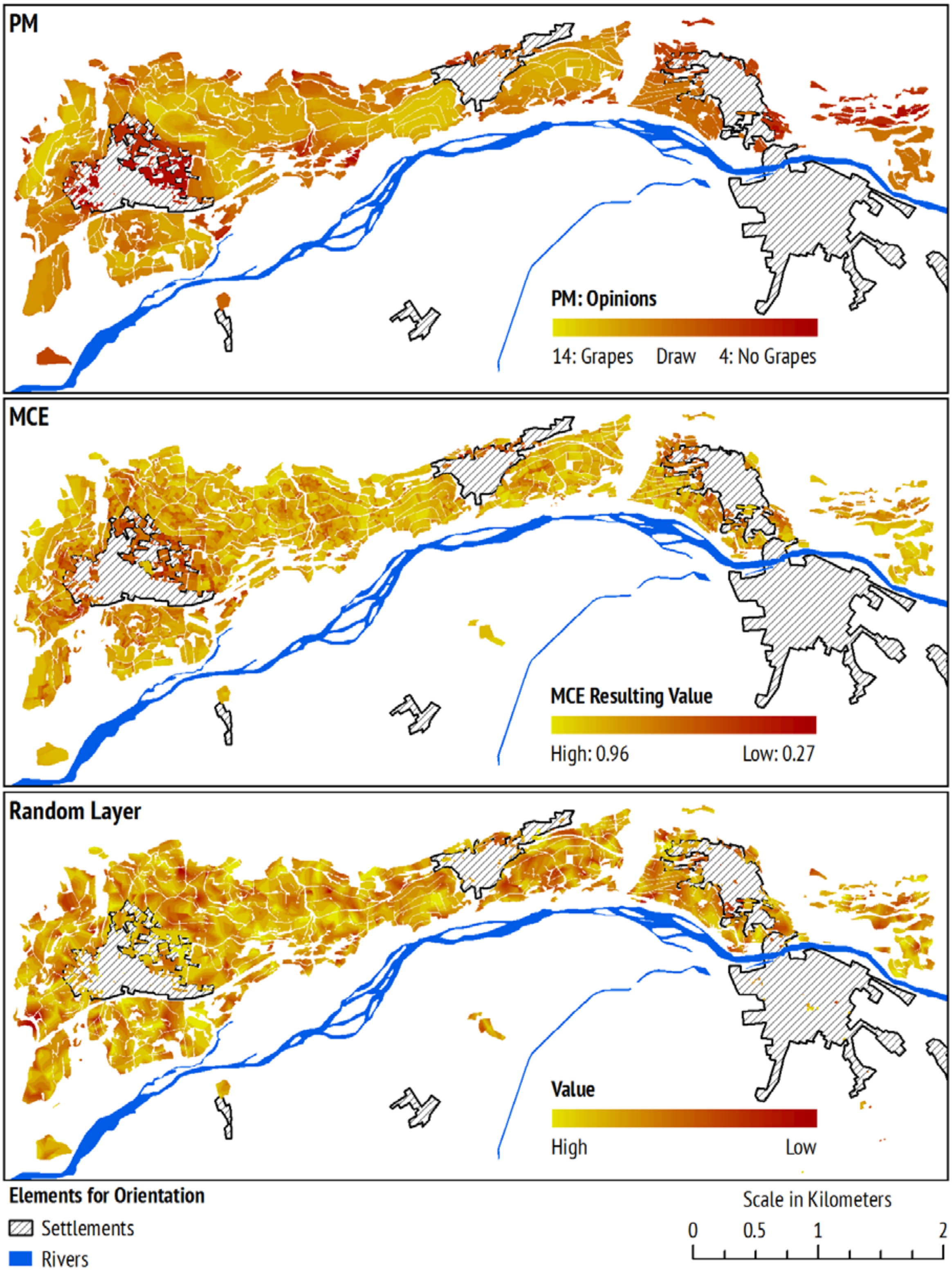


Figure 5-21: Maps of the result from participatory mapping, the Multi Criteria Evaluation and the random distribution
Darker colours correspond to a lower probability of the area to be cultivated as a vineyard in the year 2040

Figure 5-22 shows the cumulative sum of the area for the different methods and allows for the visual comparison the non-spatial distribution of the values. Figure 5-22 additionally presents the distribution of a normalised version of the PM-layer. The normalised PM-Layer standardises the value to a range of 0–1, with distributing the negative PM values over the same range as the positive ones; in other words, we assigned the negative values (–4 to –1) to the range of 0 to 0.5 and the non-negative values (0 to 14) to the range from 0.5 to 1, with 0 equalling 0.5. This corresponds to applying a bi-polar scale stretching, as we did for the evaluation workshop (Appendix D). The scale then has its midpoint at the draw of opinions and stretches to the opinions stating there will be no vineyards in 2025 on the one side and to the opinions stating there will be vineyards on the other side. As can be seen in Figure 5-22, this scaling yields a curve for the cumulative sum of the area, which is very similar to the one from the MCE. Figure 5-22 additionally shows selected breakpoints derived from the PM cumulative sum curve, corresponding to the value classes in the PM. Of the 19 values of the PM-survey (-4 to 14), we selected 16 values for further analysis, corresponding to 0, 3, 8, 15, 19, 28, 36, 43, 48, 56, 65, 74, 82, 89, 94 and 100 % of the total area.

It is notable that the random layer covers a) a larger area than the other two layers and b) due to the reclassification details a step-wise behaviour. Regarding a): the PM and the MCE layer do cover neither the whole vineyards-area, nor exactly the same area. The area is about 20 ha, which is not shared, and 25 ha, which neither of them covers. However, the comparison follows the rationale that a certain percentage of the result will be used for further analysis, regardless of the size of the share in absolute terms. Regarding b): We didn't consider that to be introducing an error, as the spatial distribution of the random layer is random, therefore the selection of values is random too.

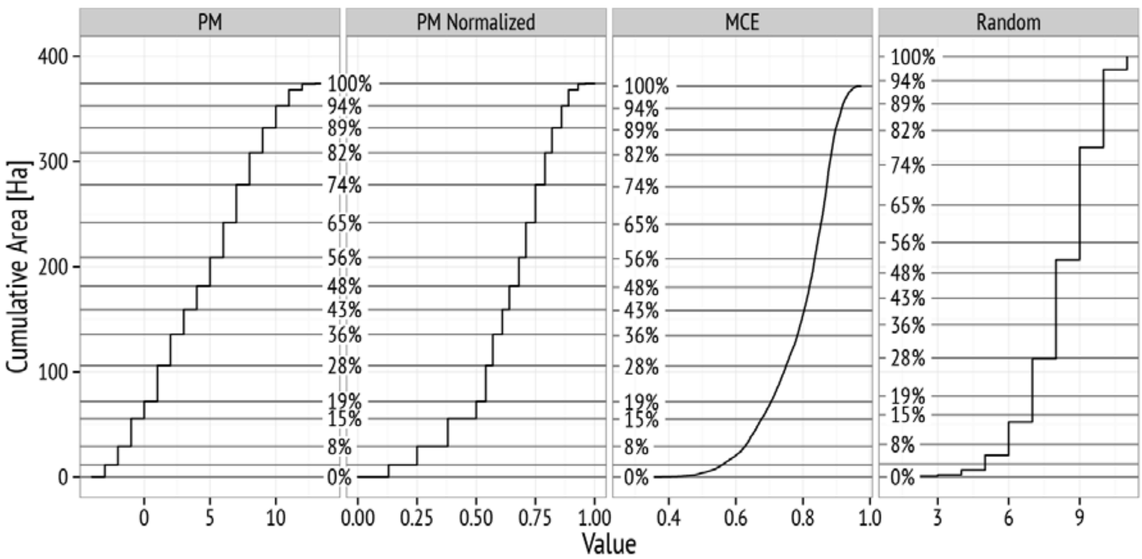


Figure 5-22: Cumulative sum of the area according to the outcome of the different methods
The outcome of a method corresponds to the number of opinions, normalised number of opinions, MCE outcome and random value respectively

Comparison of MCE and PM Results based on Modelled Extents of Vineyards

Figure 5-23 shows an interpolation and extrapolation of the data displayed in Case Studies Description Figure 7, from 2006 until 2040, based on a linear and a quadratic prediction model. In the linear model, the years 2003–2005 were interpreted as a plateau in the extent of the viticulture, as visible around the year 2000 for the Canton of Valais in Case Studies Description Figure 6. Therefore, only the years 2006–2014 were used for model-fitting. According to the linear model, the predicted area for 2040 lies between 334 and 351 ha (mean = 343 ha), corresponding to a mean decline by 17 % since 2006. The linear model shows an extremely high fit (R^2 = 0.98). For comparison, we also calculated a quadratic model, which shows an even higher fit (R^2 = 0.99), using data from 2003 to 2013. According to the quadratic model, the predicted area for 2040 lies between 160 and 246 ha, with a mean of 203 ha, which would correspond to a decline of 51 % since 2006.

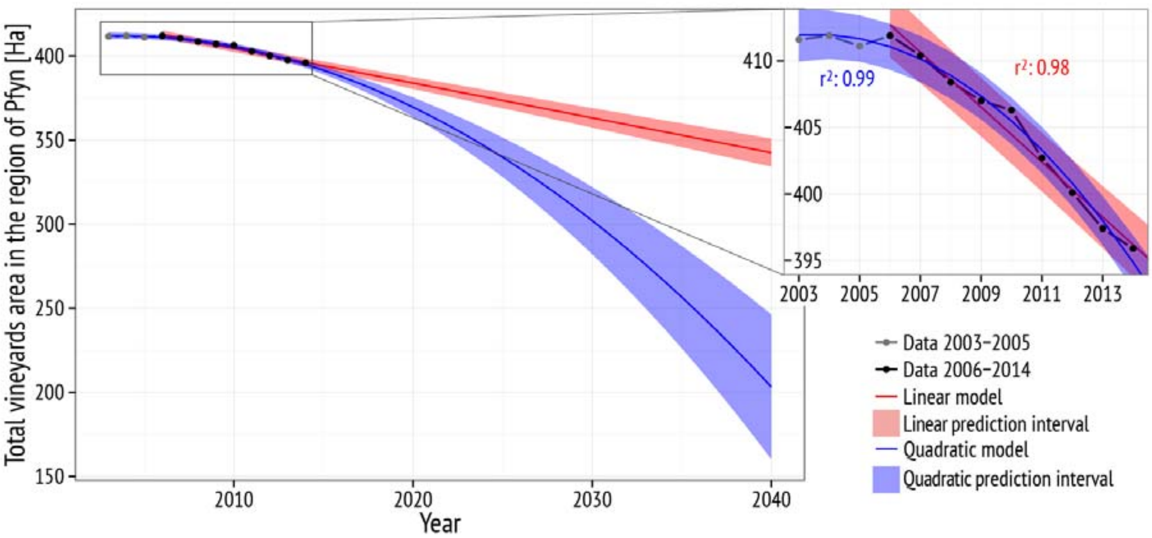


Figure 5-23: Extrapolation of the trend in the development of the area for vineyards of the past years to 2040 for Pfyn-Finges
Own model. Data source: *Weinerntebericht (2004-2014)*

Both the linear as well as the quadratic model are simplistic and flawed, as by some year they will forecast a negative acreage of vineyards. However, within the limited timeframe considered, they are a good approximation of the expected changes. The quadratic model assumes an accelerated decline, which hence results in a more rapid decline than in the linear model, which assumes a continued decline of the past year's average. The linear model might better represent people's perceptions. Research in psychology suggests that people tend to extrapolate linearly *(Hey et al. 2009; Sterman 1994; Wagenaar & Sagaria 1975)*, using the last available data point(s) as reference *(Harvey 2007)*. This is congruent with the results of a recent qualitative study, positing a decline of about 20 % *(Dalliard 2011)*, which is within the range of the linear prediction. Furthermore, as the trend of the Canton of Valais shows a similar decline in acreage since 2000, we assumed the predictions for the region of Pfyn-Finges to be a valid starting point for interpreting the spatial results from the MCE and the PM. In the present study, we use the linear and the quadratic predictions as input parameters for the analysis of the MCE and PM results. A decline of 17 or 51 % (linear and quadratic model) corresponds to a sustaining of 83 and 49 % respectively.

Figure 5-24 shows the Jaccard-Coefficient between the three methods based on different thresholds of changes chosen and depending on the perspective. In the abandonment perspective, choosing a larger share of the area yields a scenario with more area changing. In the sustaining perspective, choosing a larger share of the area corresponds to a scenario with more area remaining vineyards. Figure 5-24 indicates three points on each, the abandonment and the sustaining curve, by vertical and horizontal lines. The points are at about 15 %, 50 % and 85 % of the area. The 15 % and 50 % abandonment as well as the 50 % and the 85 % sustaining thresholds correspond roughly to the extrapolations shown in Figure 5-23. The layers underlying the indicated points are spatially explicitly represented as maps in Figure 5-25.

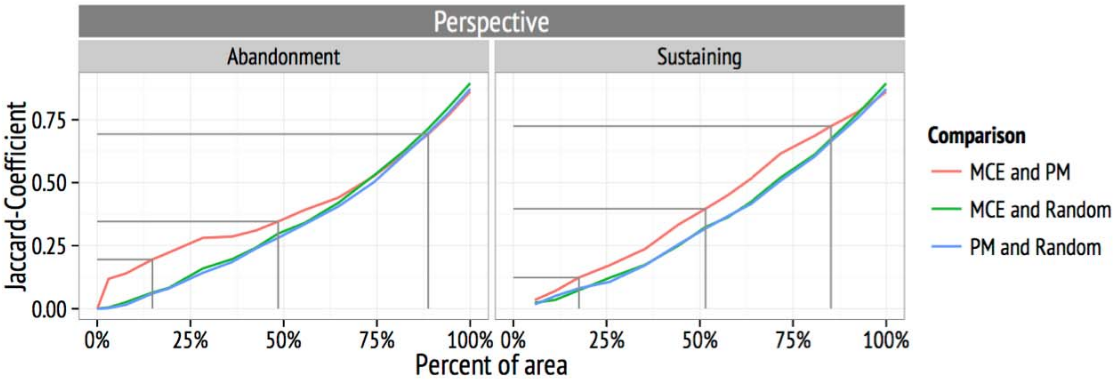


Figure 5-24: Comparing the Jaccard-Coefficient between the methods for different levels of abandonment or sustain
The larger the difference between the red line ('MCE and PM') and the other lines, the stronger the methods PM and MCE concur spatially between each other while concurring less with the random method

Figure 5-25 displays six maps with the intersecting areas of the different results. The total area in each map is not printed in hectares as this depends on the respective method, but corresponds to the percentage printed in the upper left corner of the maps. The total area for intersections with the random layer is somewhat larger for the intersection of MCE a PM, as the random layer is approximately 6 % larger than the other layers (400 vs. 375 ha). The combined red and yellow area corresponds to the share of congruency between MCE and PM. A larger proportion of that area in regards the total area displayed corresponds to a higher Jaccard-Coefficient. The overlap of all three methods (orange) can be neglected when comparing the three methods but indicates the amount of 'random congruency' amongst the three methods. Therefore, if the area of MCE and PM (red) is bigger than the area for MCE and random (green) or the one for PM and random (blue), the Jaccard-Coefficient for MCE and PM is greater than that for MCE or PM and random, respectively. This can be seen best in the top maps of Figure 5-25. If the opposite is true, and the intersection of MCE and PM is smaller than the intersections of PM with the random layer, as in the bottom left map of Figure 5-25, the Jaccard-Coefficient is equal or slightly smaller.

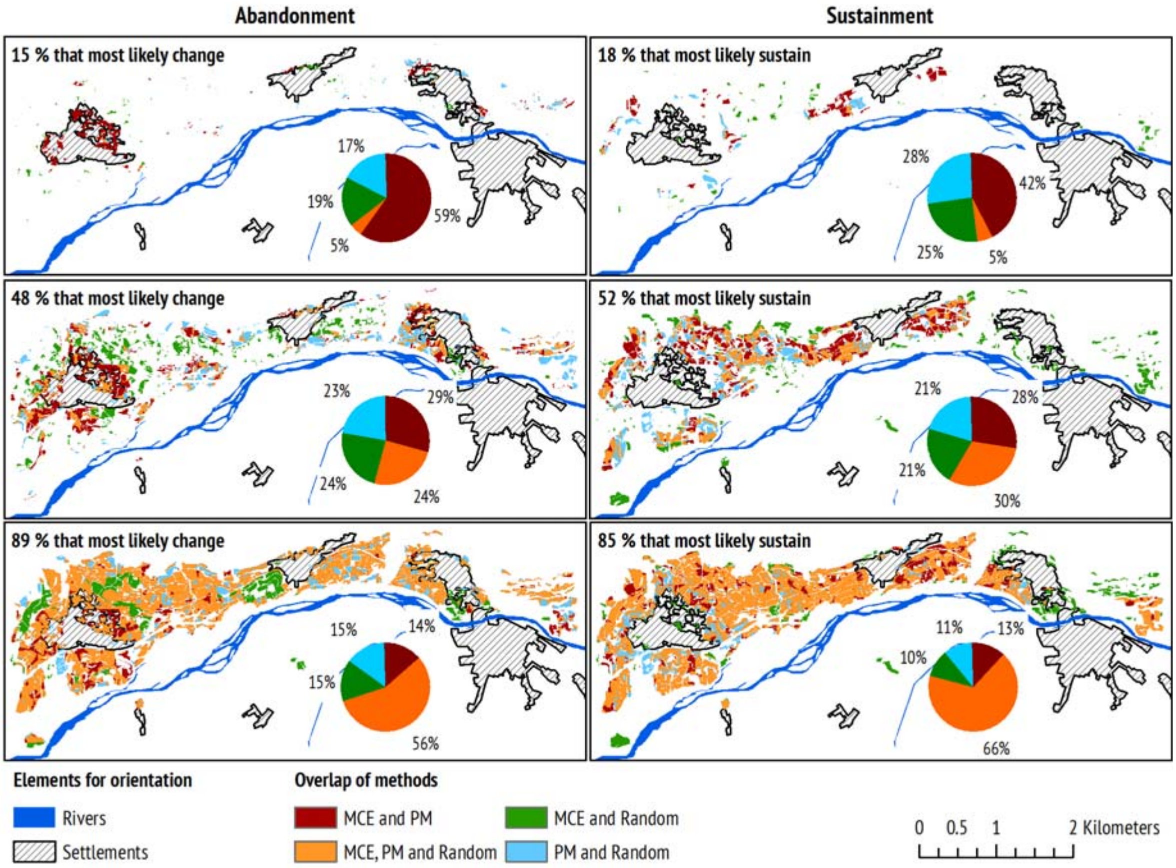


Figure 5-25: Spatial representation of the overlaps for six thresholds highlighted in Figure 5-24
The maps display the spatial distribution of concurrence between the three methods. The pie diagram shows the percentage of the overlaps on the total area considered.

Comparison of Getis-ord Gi* Hotspots

Figure 5-26 shows those hotspots and further indicates non-significant regions in grey colour. Using Getis-ord Gi* statistics yields the regions with lowest, respectively, highest Z-score. Low and high Z-score 'hotspots' represent areas that are surrounded by regions with a comparatively lower or respectively higher score than the mean. Therefore, the calculation smoothens out singular low values. Regions with low Z-score therefore are more likely to be not used as vineyard by the year 2040, whilst regions with high Z-score are more likely to be used as vineyard by the year 2040. Regions with a Z-score of between -1.96 and 1.96, on a 95 % level, are not statistically significantly more likely to be in either group. For the calculation of Getis-ord Gi* statistics, the values of each method were aggregated to the cultivation units. The calculations then used fixed bandwidth of 150 m, which yielded reasonable 'hotspots' of continuing and non-continuing vineyards.

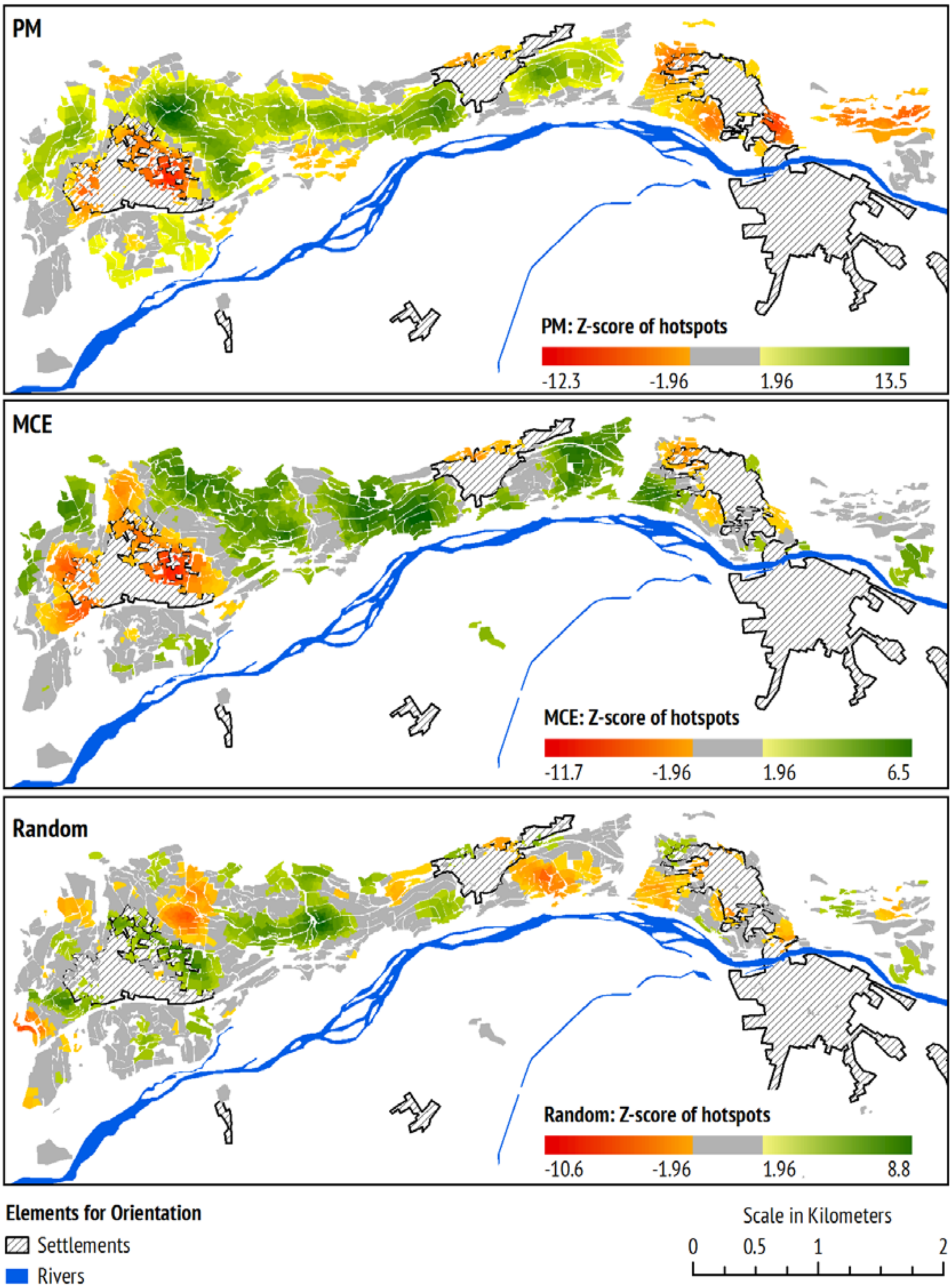


Figure 5-26: Getis-Ord Gi* - Hotspots of the PM and MCE data, aggregated to the cultivation unit
The green areas represent hotspots, which are likely to be sustained as vineyards and the red areas hotspots, which are likely to not be sustained. Grey areas represent cultivation units, which are nether more likely to be cultivated nor not undergo changes

Following the rationale of the analysis in Figure 5-24, the hotspots of each method in Figure 5-26 then are compared to each other, which yields Figure 5-27. The larger the percentage of the total area compared, the more areas with lower Z-scores, and hence a lower level of significance, are included in the comparison. If including more than a certain threshold of the total area, one then includes non-significant hotspots besides the significant ones. The dashed line in Figure 5-27 indicates the point at which hotspots of lower significance than 95% are included. Figure 5-27 shows that approximately 17 % of the MCE and PM area can be compared in an 'abandonment perspective' and approximately 43 % in a 'sustaining perspective' without the inclusion of non-significant hotspots.

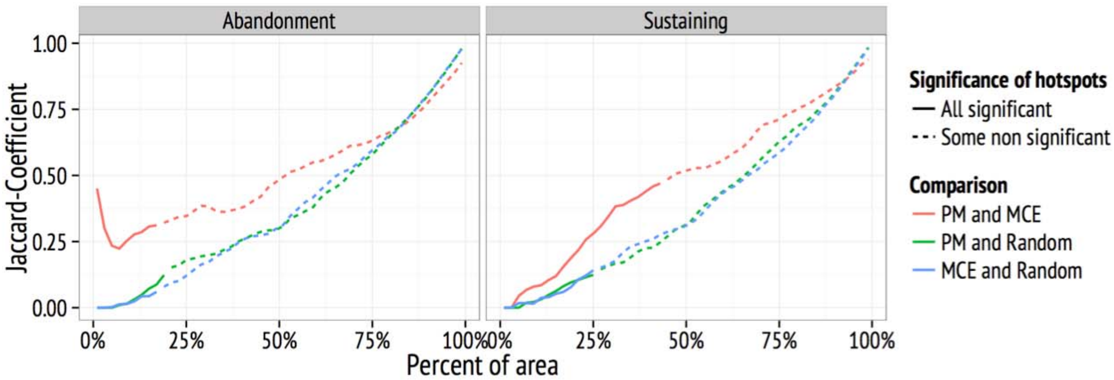


Figure 5-27: Comparison of hotspots from different methods calculated by Getis-Ord Gi*
The larger the higher the red line ('MCE and PM') compared to the other lines, the stronger the methods PM and MCE concur spatially between each other while concurring less with the random method. When comparing larger percentages of areas, the comparison includes hotspots with a z-value of > -1.96 or < 1.96 respectively

Applying a Getis-ord GI* hotspot analysis increases the concurrence between the PM and the MCE. Comparing up to 15 % of the area with highest significance of being a hotspot for abandonment (abandonment perspective), the Jaccard-Coefficient of PM and MCE hotspots are more than four times larger than those for PM or MCE with the random distribution. Without applying Getis-ord GI*, PM and MCE are only three times larger than the one of either method with the random method. When taking up to 43 % of areas with highest significance of being a hotspot for continuing cultivation (sustaining perspective), the Jaccard-Coefficient is at least 1.7 times larger than with the random data. Without applying Getis-ord GI*, the Jaccard-Coefficient of MCE and PM is only 1.3 times larger than that of the PM or MCE with the random data.

The overlapping significant hotspots are shown in Figure 5-28. The area of those hotspots corresponds to the numerator of the Jaccard-Coefficient at the last point of the non-dashed line in Figure 5-27, equalling 114 and 42 ha for the sustaining and the abandonment perspective, respectively. This approach to analysis is similar to that presented in Figure 5-25. Figure 5-28 can be read as an integration of a 17 % abandonment and a 43 % sustaining threshold, with a focus on hotspots, rather than individual cells of likely continuation or change of viticulture, as used for Figure 5-25. Taking only the hotspots, where both methods overlap, yields 11 % and 29 % of the total area, which can be said to be likely abandoned or likely sustained, respectively.

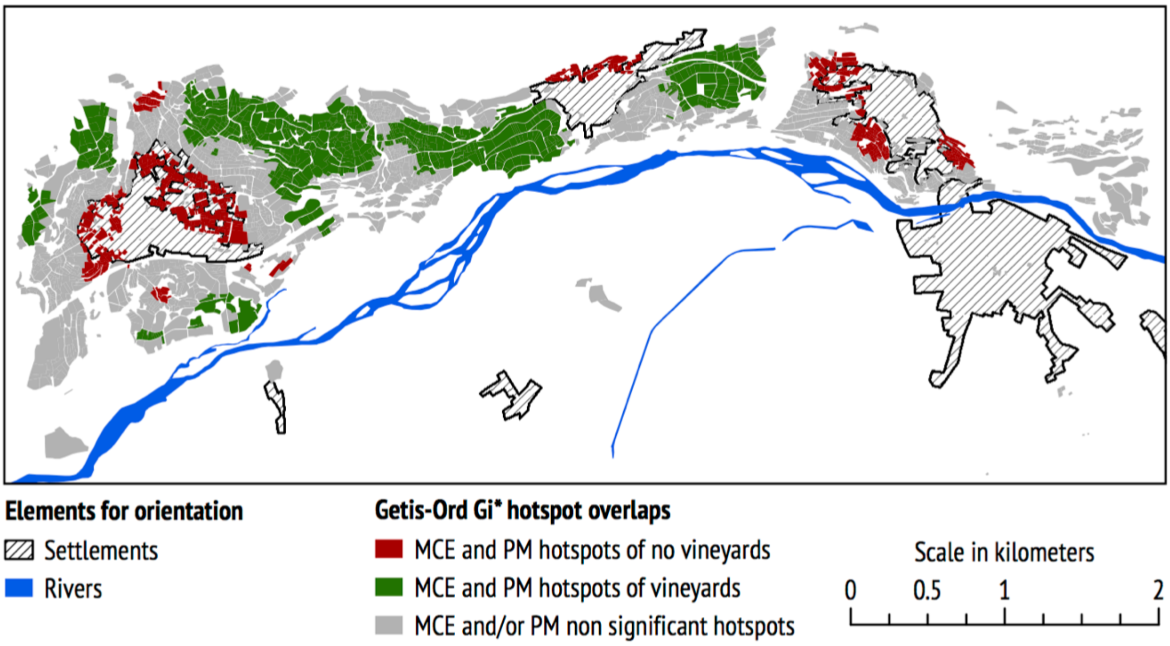


Figure 5-28: Overlap of MCE and PM significant hotspots of continuing of non-continuing vineyard cultivation

The map shows areas, where Getis-ord Gi* indicates hotspots of sustaining (green) and changing (red) vineyards, according to both methods, MCE and PM. Grey areas are no significant (p=0.05) hotspots according to at least one of the two methods

Comparing the uncertainties of the PM and the MCE outcome

Figure 5-29 shows the spatial distribution of the uncertainty associated with the MCE and the participatory mapping. In the case of PM, the uncertainty is calculated as the minority divided by the majority of opinions, titled as the share of conflicting opinions. For example, if a parcel was mapped both for cultivation as a vineyard and not as a vineyard by the year 2040, the number of opinions is two, with both (100 %) of them conflicting. In the case of three opinions, the share of conflicting opinions is 50 %, as it would be one opinion divided by the two other opinions. In the case of four opinions, the share of conflicting opinions would be either 0 %, 33 % or 100 %, depending on whether the ratio is four versus zero, three versus one or two versus two, respectively. For the MCE, the uncertainty is calculated by bootstrapping. This corresponds to the results of the complete Monte-Carlo simulation shown in Figure 5-20. This comparison is based on the relative standard deviation, i.e. the absolute standard deviation divided by the MCE outcome.

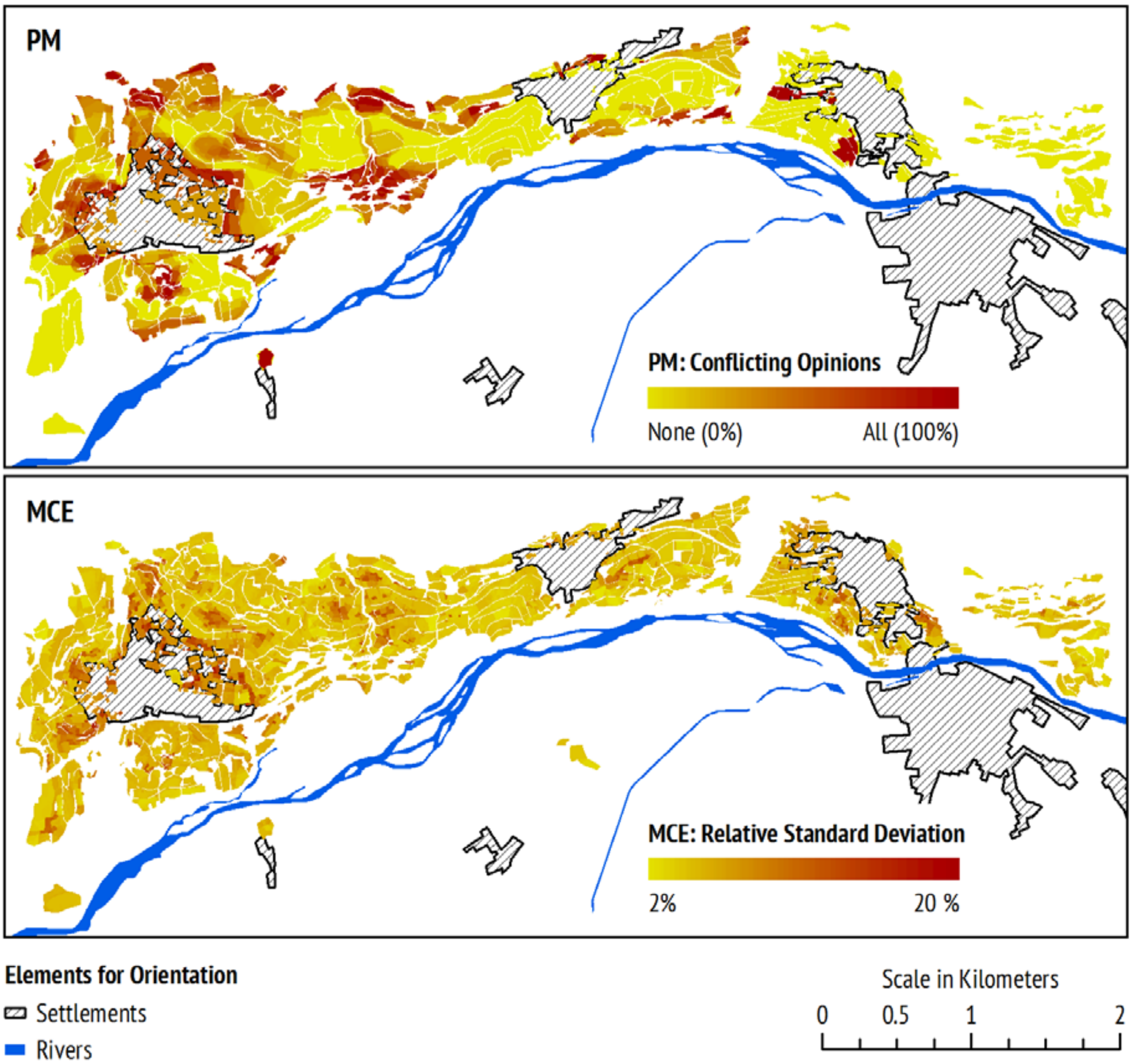


Figure 5-29: Spatial distribution of uncertainty in the PM and the MCE survey
Darker areas correspond to areas with higher levels of uncertainty

Figure 5-30 shows the results and the uncertainty of the PM in comparison to those of the MCE. Figure 5-31 shows the spatial autocorrelation in a correlogram (expressed as Morans' I over a certain lag-distance). Table 5-3 and Table 5-4 list Tjøstheim's coefficient for spatial association *(Hubert & Golledge 1982)* along with a (non-spatial) spearman correlation coefficients in the upper half and a modified t-tests for spatially autocorrelated data in the lower half of the table *(Clifford et al. 1989)* for the results and the MCE, respectively. The calculations were performed using the library SpatialPack in r *(Osorio & Vallejos 2014)*. The p-value for the modified t-test stabilised using 200 distance bins to reduce the degrees of freedom.

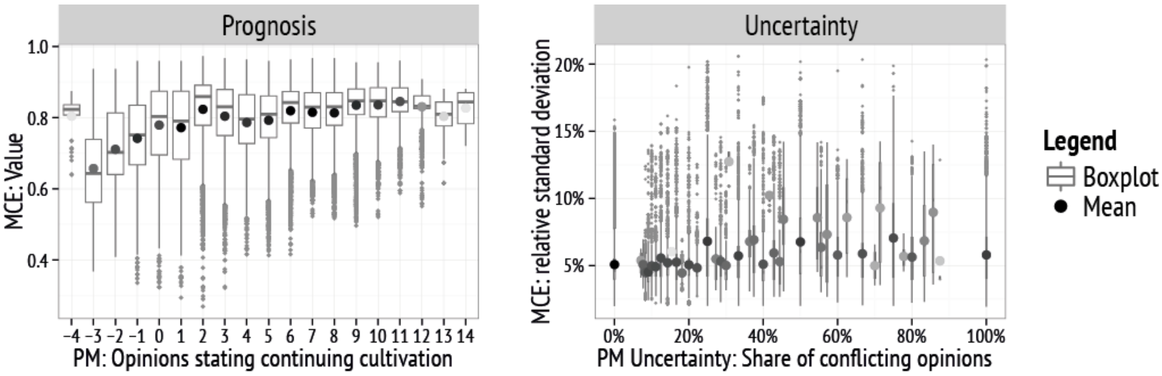


Figure 5-30: Plots of the values from the results and the uncertainty
The means are shaded according to the number of pixels present in the corresponding class. The boxplot shows takes all the values for this particular class.

Table 5-3: Correlation of the results

	PM	*MCE*	*Random*
PM		Tjøstheim's: 0.35 Spearman: 0.27	Tjøstheim's: -0.07 Spearman: -0.05
MCE	Modified T-Test: t(197 DF)= 30.2, $p < 0.001$		Tjøstheim's: 0.02 Spearman: -0.03
Random	Modified T-Test: t(471 DF)= 1.1, $p > 0.1$	Modified T-Test: t(638 DF)= 1.3, $p > 0.1$	

Table 5-4: Correlation of the uncertainties

	PM: Conflicting Opinions	*MCE: Relative SD*
PM: Conflicting Opinions		Tjøstheim's: 0.15 Spearman: 0.15
MCE: Relative SD	Modified T-Test: t(276 DF)= 9.9, $p < 0.005$	

Figure 5-31 shows the spatial correlogram of the results and the uncertainties. Spatial autocorrelation measured by Moran's I seems to reach almost zero at a lagged distance of approximately 500 m for all the prognoses. The spatial autocorrelation was calculated using the raster package in R.

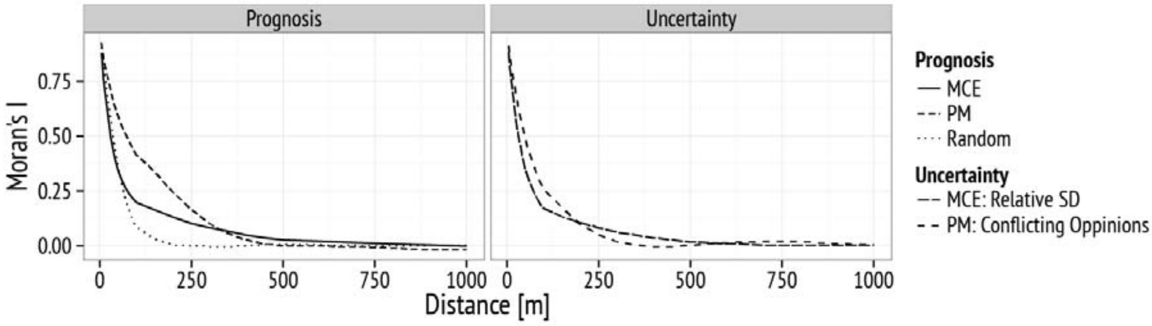


Figure 5-31: Spatial correlograms of the results (left) and the uncertainty (right)

5.2.3 Evaluating the Results

The evaluation workshop was held on August 31, 2015 in the old castle of Leuk. The workshop was jointly organised by the administration of the natural park, and was attended by 13 participants. As an outcome of the workshop, five criteria emerged, namely:

1. **Plausibility**: How much the results are perceived to be correct and correspond to participants' expectations.
2. **Spatial Resolution**: Whether or not the results are shown with adequate spatial resolution and level of detail.
3. **Temporal Correctness**: Whether or not the prognosis represents the situation in approximately 25 years and not earlier or later.
4. **Spatial Correctness**: Whether the results are correct but contain a spatial shift or another spatial disagreement with reality.
5. **Consideration of ameliorations**: Whether the prognosis correctly reflects the possibility or absence of a possibility to carry out land improvements, as for example removing dry stone walls or building new access roads.

Out of these five criteria, criteria 4 and 5 were too ambiguous to be answered by all the participants; there was not enough time in the workshop to clarify them in detail, and therefore the decision was made to exclude them from further analysis. Each of the criteria was evaluated on an ordinal scale, ranging perfect to failing.

Of the 13 attendants of the workshop, only 7 rated the different methods. A second round of ratings was collected through a postal survey, sent to the 13 experts who participated in the MCE. After two weeks, a reminder was sent, leading to a total of 6 additional ratings. The overall ratings therefore were based on 13 opinions.

Figure 5-32 shows the results of the evaluation as boxplots. The results for the postal mailing (letter) and the workshop are shown separately, as well as jointly. Few differences between the letter and the workshop ratings are observable, with the exception of the generally lower scoring of the random method in the postal survey and, more specifically, the lower score on plausibility. As the evaluation sometimes is strongly clustered, with more than 75 % of the values being in a single class, the boxplot shrinks to a line (i.e. for 'spatial resolution' of the PM). One can see that both the MCE and the PM, on average, score higher than the random scenario on all criteria; however, the average score for PM on 'spatial resolution' is only slightly higher than that for the Random distribution, with the median equal. The MCE scores higher than the PM on 'spatial resolution', with the PM scoring higher on 'plausibility'. Both PM and MCE have the same median score in regards temporal correctness, with the mean in the case of PM being higher.

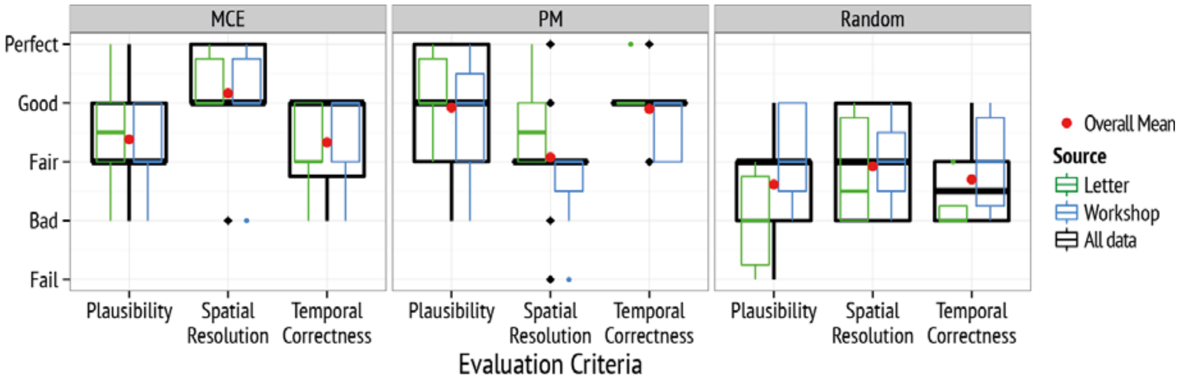


Figure 5-32: Results from the evaluation
The figure shows the evaluation of the MCE, the PM and the random method for a selection of three evaluation criteria (Plausibility, Spatial Resolution and temporal correctness). The evaluation was done with local experts in a workshop (blue) and through letters with non-local experts (green)

5.2.4 Adding Another Layer of Information: Annotations from Participants in Pfyn-Finges

For easier comparison, the results from the MCE and the PM are interpreted on the same scale. High values in the outcome of the MCE, notably the various opinions stating that the area will be used in the future, are interpreted as a high probability that the area in question will be used as a vineyard in the future, as opposed to a high uncertainty in the continuation of the cultivation. A large share of conflicting opinions in PM or a high relative SD in the MCE are interpreted as uncertainty in the prognosis.

As shown in Figure 5-33, the annotations might contradict or corroborate the results of the MCE, and accordingly deliver underlying explanations for the differences between the two methods. In the first example, the participant mentions the lack of access and the presence of dry-stone walls. Although such dry-stone walls were not incorporated in the MCE, the lack of access would strongly influence the outcome. This can be seen on the area of the second annotation. The areas not close to the street receive lower values in the MCE. The PM, in contrast, reflects the annotations and yields for the area of annotation 1 as a rather low value. However, the lack of access mentioned in the second annotation does not manifest for the areas distant to the roads in the outcome of the PM. Here, the annotations help in developing understanding of the differences between the two methods. In total, we collected 14 annotations that help in achieving better understanding of the results of the PM or the MCE. However, we are not going to display them all here as this would infringe upon participants' privacy.

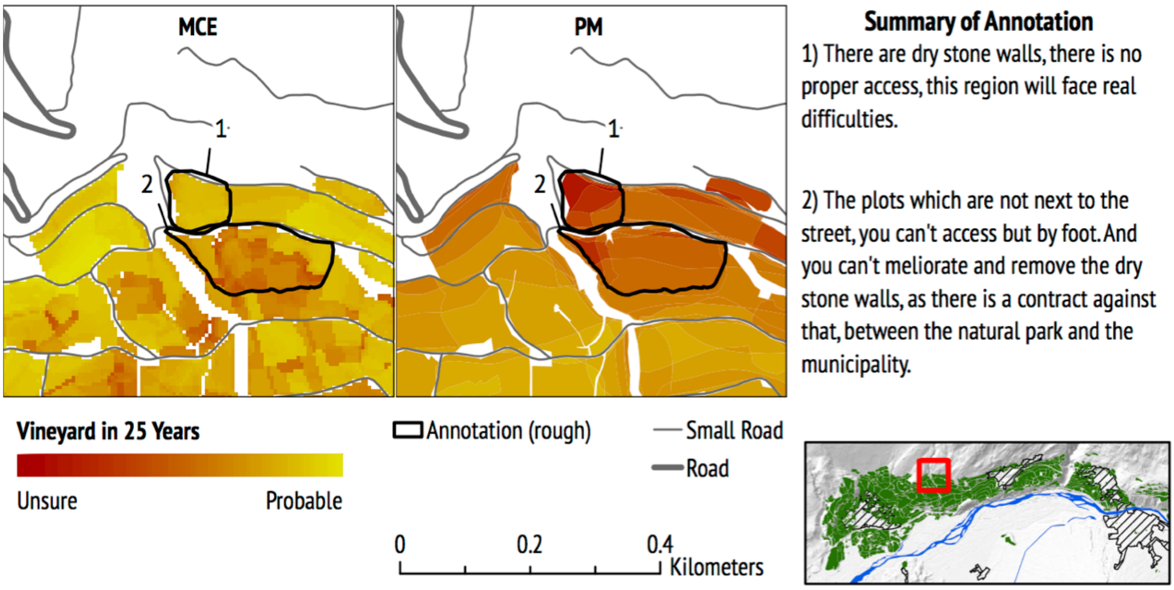


Figure 5-33: Example of annotations, which either contradict (1) or confirm (2) the outcome of the MCE and thus explain possible differences in the two methods

Annotations might as well add a completely new layer of social values and predictions, as shown. In total, we collected 13 annotations, which add some kind of social background information to the study. In Figure 5-34, three annotations from different participants highlighted various social value associated with the vineyards in this particular area. The first one highlights the historical value, the second one expresses that it would be nice to see some financial support, and the third one recognises that other people are very fond of this. At the same time, all three mention that it is a threatened area and therefore it is likely to no longer be cultivated in 25 years' time. According to the results of both methods, as shown in Figure 5-25 and the hotspot-analysis detailed in Figure 5-28, this region is amongst those least likely to be vineyards in 25 years' time. Therefore, these annotations highlight a possible conflict between expected development and social values.

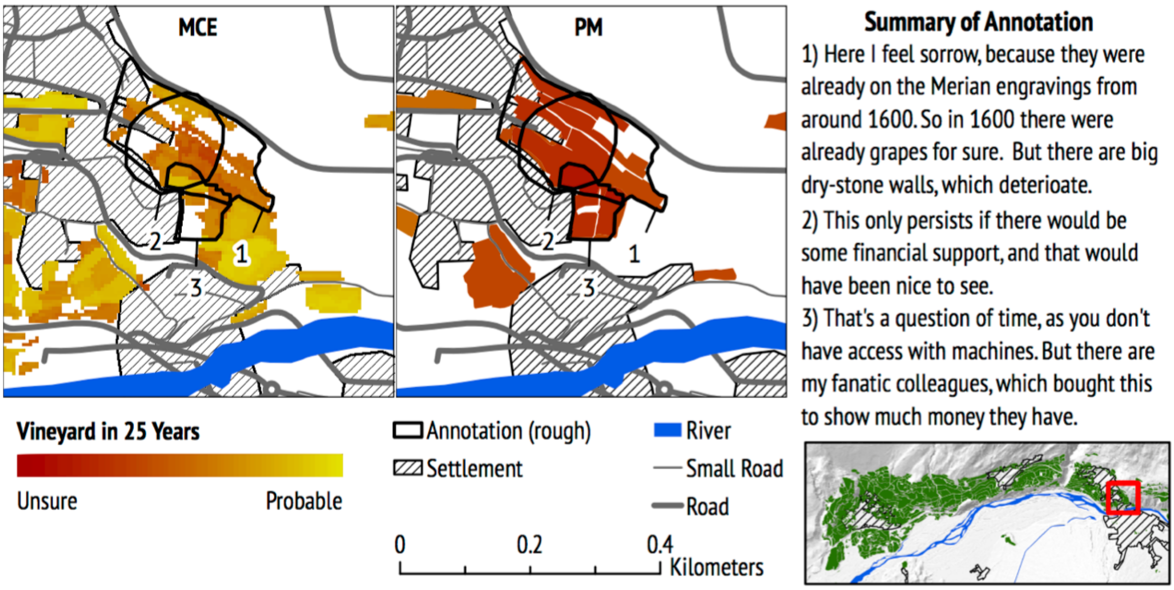


Figure 5-34: An example of annotations highlighting a social value in an environment, which likely will not be cultivated anymore in 25 years

Figure 5-35 and Figure 5-36 show annotations from three participants that express uncertainty, which depends on larger scale political processes influencing the development. The area shows a medium probability in both methods, MCE and PM, to be sustained as vineyards, so merely looking at the results does not exhibit the uncertainty expressed in the annotations. The uncertainties in the methods (relative SD and share of conflicting opinions) are shown in Figure 5-36. The uncertainty from the political situation is not incorporated within any of the criteria influencing the MCE, meaning the results of the MCE do not show a high relative SD. The PM, however, shows a high degree of conflicting opinions, possibly because various people judge the influence of the state to be different. We classed a total of eight annotations as helping to understand uncertainty within the forecast.

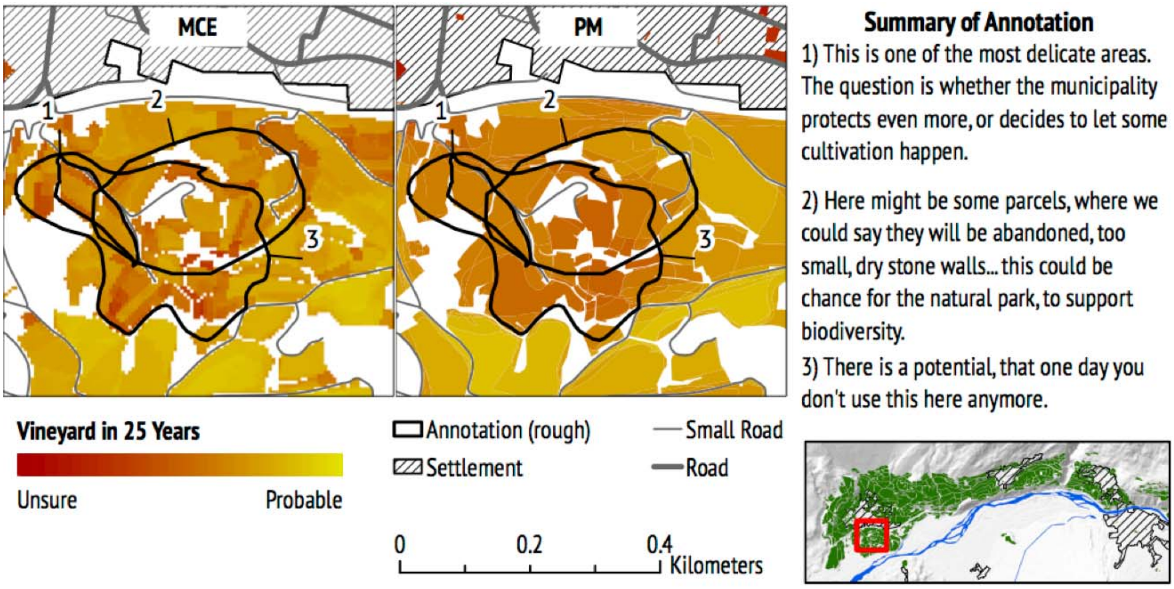


Figure 5-35: Example of three annotations, which express some uncertainty and some will for change to be taking place

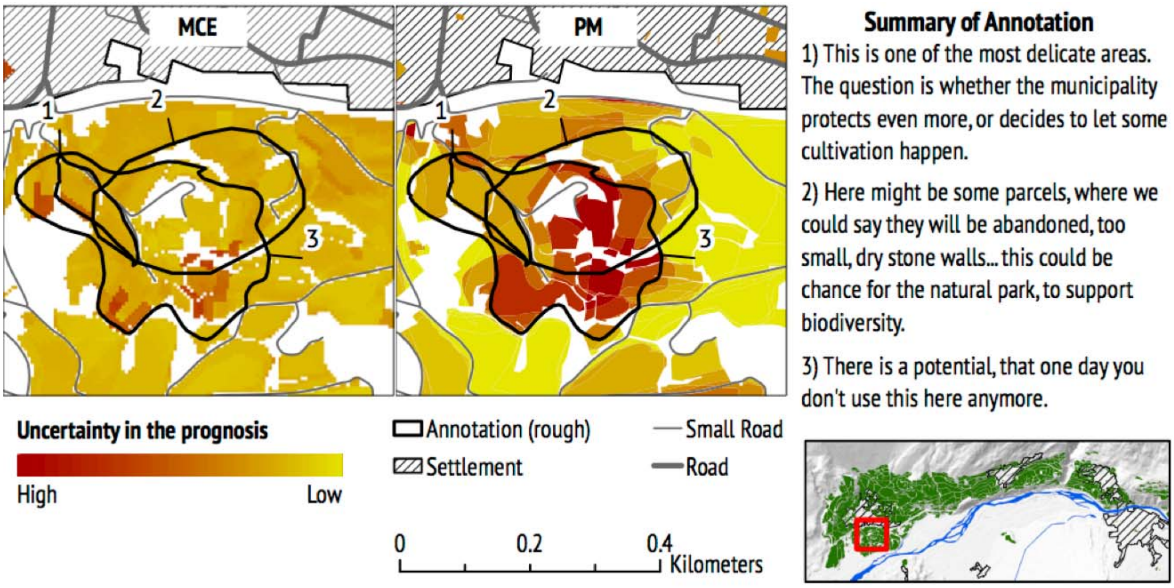


Figure 5-36: The annotations from Figure 5-35, this time with the associated uncertainty displayed

5.3 The Social Dimension

5.3.1 Characterising the Social Values associated with Arable Farming in the Val Müstair

In the questionnaire, the farmers stated arable farming as part of their culture, as shown in Figure 5-38. Several interviews highlighted consistent statements with that judgement as the farmers mentioned the high yields and the good-quality grains produced in the valley. The following quote illustrates this: *«We used to produce the best grains of Switzerland [...] they travelled to Zurich with their bags, where it was tested and everything. And they always won»*. Although most farmers stated arable farming as belonging to the culture in the tick-box-questionnaire, the expert interviews then showed a more diverse personal identification. Only some farmers identified strongly with arable farming (e.g.: *«I was truly a passionate arable farmer»*), which were predominantly, but not exclusively the ones performing arable farming. Others stated that they personally dislike arable farming (e.g.: *«No, it was a bad, a very bad experience»)*.

Interestingly, only few farmers mentioned maize as belonging to the culture compared to grains or potatoes, which were always considered part of the valley's culture. The considerable plantations of maize during 1970–1990 do not seem to have changed the cultural identity of the valley. However, potatoes were only planted on sizable area prior to 1970, and sometimes farmers even agreed that potatoes do not alter the landscape in its appearance. Nonetheless, in the past, they have been considered important for sustenance. Still, some farmers plant small quantities of potatoes for private use due to tradition and taste.

Regarding the reasons behind land use change, we identified external and internal drivers: as external drivers, we identified the change in policy, globalising markets and technology; in terms of internal drivers, we recognised the change in family size, small farm size and the shift to organic agriculture. The change in agricultural policy, as described in Section 3.1 'Val Müstair', and the conversion to organic agriculture were mentioned as the main drivers of the decline in arable farming. Some things were described as getting worse, such as the increasing pressure, the need to grow in size and the increasing power of government policy. However, most of them perceived the general development as something good, having relieved them from the pressure of subsistence agriculture.

The production of agricultural goods and generally the usefulness of arable farming in the mountains were very often articulated. As a farmer said: *«You don't keep a cow anymore because of its beauty, it should deliver something...»*. Common, however, across all farmers were statements of sorrow regarding the past beauty of the valley with ripe cereals, when looking down from a hilltop: *«In autumn, if you went a bit higher to the mountains. Then you saw these nice colours down here.»* Even if they couldn't imagine doing arable farming themselves, they liked to look at the fields and think of the challenge of growing good crops.

In the qualitative interviews, no connection was identified between the particular varieties planted and the attachment of the farmers to arable farming. Farmers were mostly interested in the performance of the variety in their environment. When talking about old varieties, more than half of the statements were not only about the old variety, but concerning the production of an agricultural good. Figure 5-37 shows salient cross-codings within the interviews. Cross-coding occurs, when one statement belongs to two categories, such as, for example, the following statement expressing the importance of agricultural productivity in old varieties: *«of course, today you expect certain yields from a given variety»*. Hence, cross-coding gives evidence for constructs that often are expressed in conjunction. This analysis has shown the mediating effect of the production of agricultural goods to connect the attachment with arable farming to old varieties. There are further interactions concerning structural and organisational problems, which influence the production of arable goods, the social organisation and the perceived viability of arable farming in the mountains.

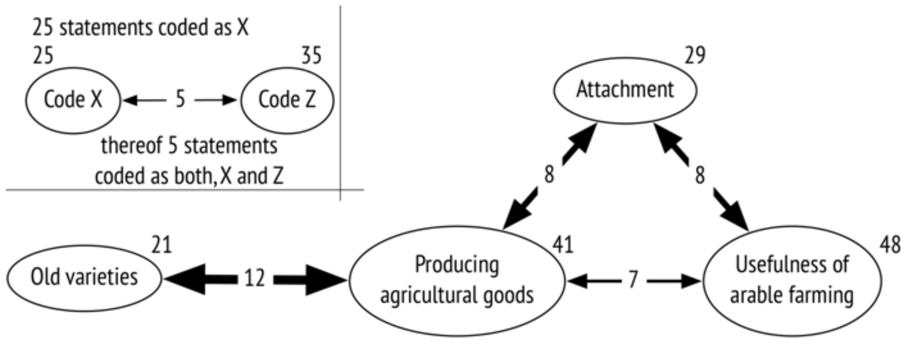


Figure 5-37: Salient cross-codings from the interviews

Table 5-5: Definitions of the codes displayed in Figure 5-37

Code	***Definition***	***Anchoring example***
Attachment	Expressions of attachment to arable farming	«If you looked at it earlier, all these fields, that's just... beautiful»
Usefulness of arable farming	Judgements about the viability of arable farming in the mountains	«It's just not suitable for the mountains.»
Producing agricultural goods	Expressions highlighting the value of an agricultural produce	«I think we should produce something, not only experiment and collect subsidies.»
Old varieties	Attitudes and experiences concerning rare, old or traditional varieties	«Lost were of course the old varieties, which almost originated in the valley.»

The social importance of arable farming is not only connected to the production of goods but also to its viability, as shown in Figure 5-34. As another farmer put it, *«I like the fields in the Val Müstair. You can* *produce… but is difficult to market the produce from such a remote region.»* Even though they are very proud of the good yields they once had, they considered the environment for production to be problematic nowadays. Main drivers for this development are connected to the operational setting of the farm and the changes in policy and technology. The productivity of larger agriculture in the lowlands outperforms that of the mountainous environment; the machinery and supply chain being oriented towards larger and flatter terrains also yields the following conclusion: *«Arable farming in the mountains with, let's say, half to one hectare, compared to the lowlands, with fields of 4-5 hectares, makes you say: No, that's not worth it.»*

5.3.2 Characterising Social Values Associated with Viticulture in Pfyn-Finges

Generally, the cultural importance of the viticulture in the Pfyn-Finges area is stated to be very high (c.f. Figure 5-38). However, different grape farmers seem to hold different cultural values and express different forms of attachment to tradition, the land and their trade. To characterise these, the sample was grouped based on two disjunctive criteria: firstly, we separated by the employment level (part-time vs. full-time), a grouping applied in similar studies *(Domeniconi et al. 2010; Emery 2001)*, where part-time grape-growers/wine-makers sell wine or cultivate grapes as a hobby with or without economic interest and full-time grape-growers/wine-makers generally have larger economic interest and dependence on grape-growing/wine-production as they don't have a second source of income; and secondly, we used differences in attachment to wine making, a factor often correlated with the motivation of farmers to enter the wine business, as mentioned in other studies *(Domeniconi et al. 2010; Schlegel 1973; Vallat 2010)*. Some grape-growers/wine-makers with a strong attachment to wine-making bought land as a teenager or had other occupations, and thus decided on their own accord to start making wine. Grape-growers/wine-makers with a weaker attachment to wine-making typically inherited some land, took over land when the parents were looking for a successor, or otherwise were actively pushed into viticulture as a result of their surroundings. Grape-growers/wine-makers who show a weaker attachment to this kind of work exhibit a strong attachment to the land itself, as it is inherited *(Domeniconi et al. 2010)*. As they do not identify much with the grape-growing/wine-production arena, they usually do not have a big social network in the wine industry.

Both grouping factors, namely employment level and motivation, are shown to exist in similar studies *(Domeniconi et al. 2010; Emery 2001)* and have shown a significant explanatory power within our data. Applying these factors on our data yields Table 5-6, which summarises the key characteristics of the combined factors. However, one should note that these characteristics are archetypal since individual grape-growers/wine-makers can switch groups over time as, for example, the motivation or the occupational level changes. Ownership, as compared to the common long-term tenancy of land did not appear to be of great importance, as it did not seem to be a decisive factor neither for the perspective on abandoning land, nor for the place attachment.

Table 5-6: Characterising groups of grape farmers

	Part time wine-grower	*Full time wine-grower*
Strong attachment to grape-growing/wine-production	Fascinated with the work. (N=4)	Emotional regarding the profession and the work. Show pride in the history. (N= 10)
Weak attachment to grape-growing/wine-production	Large emotional bond to the area, the land and the wine-culture of the area. (N=7)	Traditionalists, which feel the need to conserve the cultural heritage. (N=11)

Most of the participants were convinced that some vineyards would be abandoned in the near future, but they evaluated this prognosis as differently disruptive. Based on the outcome of the interviews, Table 5-7 summarises different perceptions and reactions depending on the individual farmers employment level (part vs. full time) and the basic motivation to enter the vine business (highly intrinsic vs. partly extrinsic). Generally, full-time grape-growers/wine-makers did not perceive abandoning vineyards to be as disruptive as part-timers.

Full-time grape-growers/wine-makers seemed to be more affected by changes in the price of grapes. However, in the mindset of most participants, the two elements—abandoning vineyards and grape price—are coupled; hence, the abandonment of vineyards is a sign of the low grape prices. In the future, however, prices for grapes and the land use might become decoupled through subsidies targeted for the preservation of the cultural landscape.

Table 5-7: Different reactions on changed land uses in the study area Pfyn-Finges

Occupational level	*Part time wine-grower*		*Full time wine-grower*	
Attachment to grape-growing	*Strong*	*Weak*	*Strong*	*Weak*
Perspective on abandoning vineyards	Abandoning vineyards is seen as problem and there is openness for other land uses	Abandoning vineyards is a big problem and other land uses are not really an option	Abandoning vineyards is natural and other land uses may be more viable	Abandoning vineyards is cautiously observed and a new equilibrium of the system expected
Typical Reactions	Action, Cooperation, Confrontation	Stay and Rest	Redefine Place	Stay and Rest
Speed of reaction	Slow	Slow	Fast	Fast

Occupational level Attachment to grape-growing	*Part time wine-grower* *Strong*	 *Weak*	*Full time wine-grower* *Strong*	 *Weak*
Main driving forces for reactions	High intrinsic motivation, positive attachment to existing place definition	Strong social norms and traditions	Entrepreneurship	Strong social norms, tradition and dependence
To take care of	Frustration	Tipping points of choosing another reaction	A fast redefinition may overrule others	Tipping points of choosing another reaction

The attachment, the perspective on abandoning vineyards and the resources, in turn, shape different reactions *(Mihaylov & Perkins 2014)*. Grape-growers/wine-makers, which show a weak attachment to the work, typically wait for the changes to happen. They perceive selling land as something odd and would not likely sell their own land. For them, the quality of cultural ecosystem services diminishes as vineyards are abandoned, used for construction or otherwise transformed for a much more rationalised wine-production. Within that group, the part-timers judge abandoning land as more problematic, whilst the full-timers follow a more pragmatic perspective.

For the farmers strongly attached to grape-growing/wine-production, it seems more important to have viable alternatives to grape-growing/wine-production for less suitable land and to grow wine on the land considered to be in perfect conditions. Thereof, part-timers are emotionally involved in the development of the region and seem to aim for rational solutions. For them, the quality of cultural ecosystem services may increase or decrease depending on how much they are involved in land use change. The full-timers show the most pragmatic view as they not only accept but even push other land uses.

The different levels of attachment and economic dependency relate to different levels of commitment to the place *(Hummon 1992: 264–274)*. Our data shows that the strongly attached farmers express more interest in taking part in community activities and organisation than weaker attached farmers, who may be well aware of the activities but more reluctant to take part in self-organised activities. In any case, social networks may need to be adapted as grape-growers/wine-makers are more mobile and spread throughout the landscape.

Part-time grape-growers/wine-makers are reacting slower and are more reluctant concerning changes than full-time grape-growers/wine-makers. With a strong attachment to grape-growing/wine-production, the latter are especially eager to rationalise the work and their corporate structures, as observed by Emery *(2001)*. Whilst weaker attached grape-growers/wine-makers stress the cultural and traditional value of the landscape, for the grape-growers/wine-makers strongly attached to their profession, use value is more dominant. This may cause conflicts due to different speeds of reactions and redefinitions of the place by subgroups, as summarised in Table 5-8: for example, if some grape-growers/wine-makers follow more economically viable practices, such as the construction of housing, this conflicts with the desire for tradition in the use value of the land to grow wine.

Specifically, part-time grape-growers/wine-makers are facing problems finding successors. They argue that grape-production is not profitable, and that the younger generation has little connection to and knowledge of grape-growing/wine-production, and further that they do not have an interest in the tradition. To give the land to big companies and to professionalise the business is a solution for the more economically viable areas but ultimately causes the extinction of presently existing networks of part-time grape-growers/wine-makers. This can be understood as a transformation of the social organisation.

Table 5-8: Expected change in SOP due to land use change

	Part time wine-grower	*Full time wine-grower*
Strong attachment to grape-growing/wine-production	Change in sense of place (land use change influences primarily the value perception and then the landscape)	Change in sense of place (land use change influences primarily the landscape and then the value perception)
Weak attachment to grape-growing/wine-production	Weakening sense of place due to changes conflicting with values	Weakening sense of place due to changes conflicting with values

5.3.3 Changes in Attitudes, Social Norms and PBC through the PM in the Two Areas of Study

Generally, there are rather strong attitudes and PBCs concerning the land use studied, with the SN being somewhat mixed, as visible in Figure 5-38. The Wilcoxon signed rank test with continuity correction for paired data shows that the PM exercise generally had only a very minor influence on those values. The perceived importance for culture shows a significant increase ($N = 49$, $p = 0.04$) and, at a lower level, the perception that others performing the same land use ($N = 47$, $p = 0.09$). On the other hand, there is strong evidence to support that PM had no effect on the perception of knowledge and possibilities regarding the land use. None of the 49 participants showed any change on this item, indicating that perceived knowledge and possibilities are fairly stable. In the Pfyn-Finges-Study area, further, there are no changes in the evaluation in terms of whether or not performing viticulture is generally a ‘good thing to do’. Conversely, there is no significant measure to suggest that PM reduces the intensity of any of those attributes.

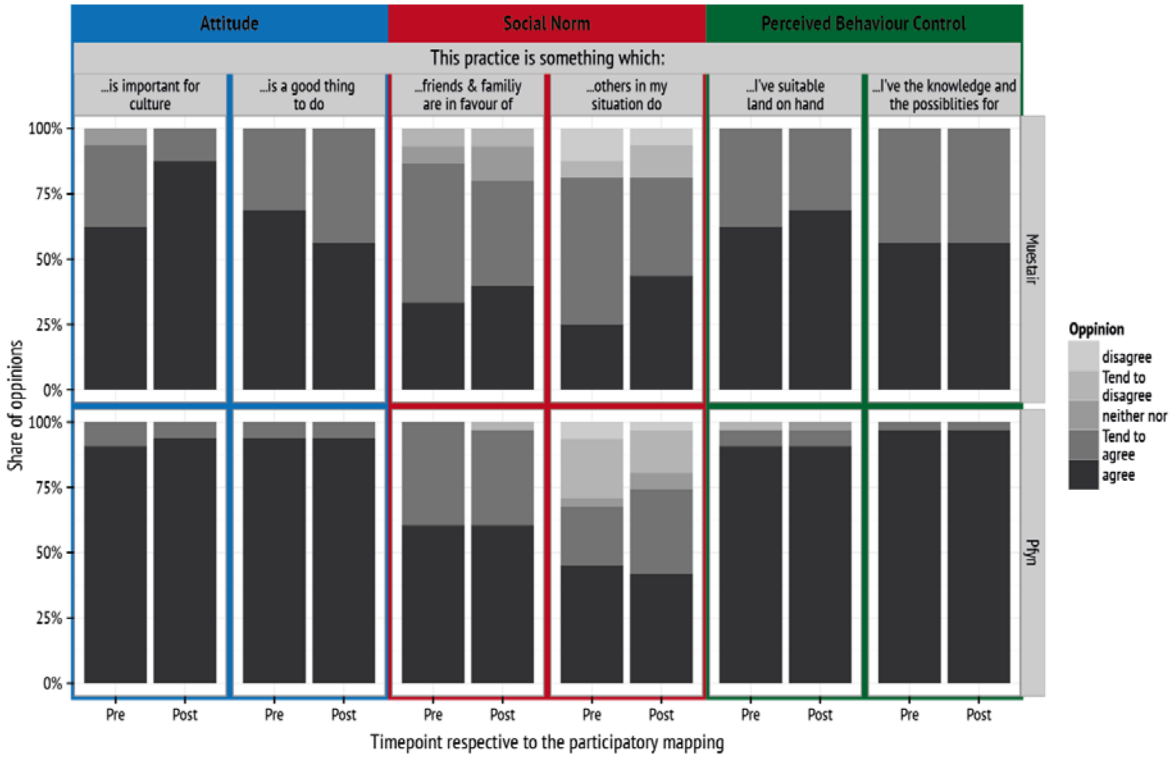


Figure 5-38: The values of some items concerning attitude, social norm and perceived behaviour control regarding the land use studied in the two case studies
Each item is split into the two areas of research (titled 'Muestair' on the top and 'Pfyn' at the bottom) as well as depending on the timepoint either before ('Pre' on the left) or after ('Post' on the right) the PM tasks. The items are then grouped according to attitudes (blue), social norm (red) and perceived behaviour control (green)

PM generally was evaluated as a pleasant experience, with most of the participants agreeing with the statement that PM was a pleasant experience and participants of the study in the Val Müstair agreeing with this statement to an even greater degree, even though the study lasted for a longer period than in Pfyn-Finges.

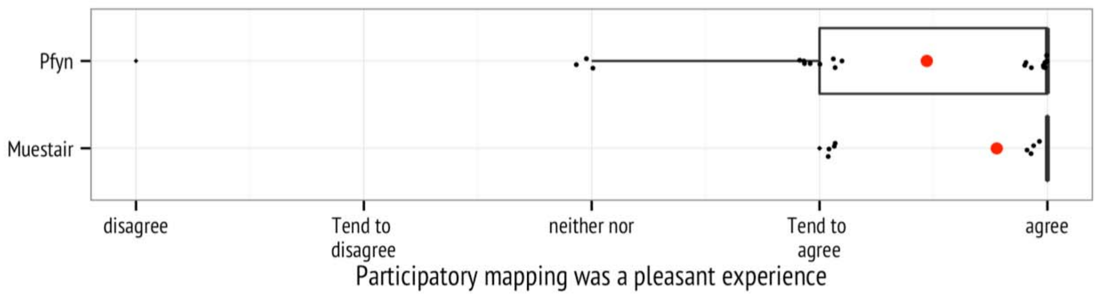


Figure 5-39: Perception of the pleasantness of PM
Boxplot of the evaluation pleasantness of the PM on a five point likert scale, with the larger red dot representing the mean and all the other points added with a slight jitter

6 Discussion

6.1 Sampling for Participatory Mapping Land Use Changes

In order to answer the first research question, in a preliminary stage the data is positioned descriptively within the appropriate context; subsequently, the first part of the research question is answered, together with the estimation of the required sample size. Thereafter, discussion is centred on the consensus amongst participants and its implications on sampling prior to investigating the influence of the scale on data quality. The research question discussed here is as follows:

1. How can the required sample size in participatory mapping be assessed using land use change as an example? How does scale influence the data quality?

Study Characteristics

Our study yielded a higher amount of mapped polygons per participant per tasks. In the Val Müstair, participants mapped an average (median) of 19 or 9 polygons for the historic and the future arable farming, respectively, and in Pfyn-Finges 11 or 9 polygons for the sustained and the threatened vineyards, respectively. Comparable studies report to have mapped an overall median of 1.6 polygons per participant per task *(Brown & Pullar 2012; Darvill & Lindo 2015; Klain & Chan 2012)*. Following the rationale presented in the study by Brown and colleagues *(2012b)*, the larger numbers of input features per participant in the study likely represent a bigger mapping effort by the participants; however, this does not communicate much about the actual quality of the data, as will be described in the following parts.

Saturation

For the data mapped in the Val Müstair, we were able to assess the required number of participants to saturate correctness and completeness on a numerical basis. In order to do so, we used Jackknifing, which enables the assessment of the impact on the outcome, if there were one or several participant less. By creating subsamples of the entire sample, containing fewer and fewer participants, we were well positioned to assess the gain in F1-value by additional participants. We subsequently define the point of saturation as the point when F1-value increases by less than 1 % with an additional participant. Morse *et al. (2014)* used a similar procedure with resampling, albeit without the inclusion of all possible combinations. They further defined saturation as the point when subsample covers 90 % of the whole group, applying a geometric union of all polygons. This definition, however, lacks consideration to different densities of polygonal overlays and is not based on a GIScience data quality measure *(Veregin*

1999) as it does not compare the PM data with a ground truth. Therefore, we consider our approach as suitable in assessing the required sample size in PM in an effort to reach saturation.

We found that the required sample for assessing the historical state is somewhat lower, with only 7 participants, than that for the predictive assessment with 9 participants. This means that mapping the historic state was somewhat more correct and complete than forecasting future land use. Our results, however, are consistent with those reported on mapping street networks *(Haklay et al. 2010)*, stating that the first six participants add the highest amount of precision.

Completeness as defined in this study will never reach 100 %, as there always remain some areas that are not mapped: for example, the area in the middle of the PM of arable farming within the new agricultural policy, circled in Figure 5-4. Apparently, although our analysis suggests we reached saturation and hence additional participants would add only minor contributions to the F1-value, the complete sample did not include a participant, which would have mapped the missing piece of information; therefore, even a saturated sample reaches a completeness below 100 %. There also was an area in the eastern part of the valley that was not predicted by any participant as arable farming under the new agricultural policy. In this situation, only one participant saw the possibility that this once was used for arable farming; nonetheless, the prediction that this would be in use under the new agricultural policy was not made. However, there was a land ownership change in the year 2014, which probably introduced some unforeseen reaction of the new landowner, who decided to plant arable farming on land that others deemed unsuitable for such a purpose.

Therefore, we consider too high expectations in data collected by participatory mapped as risky. In our case, the possible pool of knowledgeable experts is limited, which in turn somewhat restricts the level of data quality PM could yield. In the case of the Val Müstair, currently, there are 50 active farmers, 7 of whom still perform arable farming; it therefore is impossible to significantly increase the sample size with knowledgeable experts. The state limit of knowledgeable participants adds to the limitations in the sense that the knowledge and motivation of participants often is overestimated *(Carver 2003)*. Increasing the sample size therefore does not necessarily yield a higher level of precision but rather adds more noise *(Chalmers & Fabricius 2007; Johnson 1990)*.

As shown in our research, through capturing local ecological knowledge in the Pfyn-Finges, there are areas with considerable uncertainty. In such instances, the best one can do is assessing the uncertainty, such as by asking mutually exclusive questions or by applying a resampling methodology. The uncertainty itself cannot be eliminated, as it is inherent to the process. Similar issues arise when PM is used to capture social values; they are vague or have some degree of inherent uncertainty and therefore can only be defined up to a certain degree. Our results, therefore, support the view that mapping vague concepts, such as sense of place, will not become crisp—even if one ever increases the amount of knowledgeable participants *(Brown 2012a)*.

Contrasting our Findings to the Concept of Cultural Competence

The level of consensus amongst the participants regarding which vineyards will no longer be used as vineyards in 25 years' time was much lower than the level of consensus regarding the vineyards that surely will be sustained. The level of consensus in the Val Müstair, regarding historic and future arable land, was somewhere in between the two other tasks. Taking into consideration the Concept of Cultural Competence *(Romney et al. 1986)*, this would indicate that we would require the least participants to map the persisting vineyards, somewhat more participants to map past or future arable farming in the Val Müstair and the most participants to map the threatened vineyards in Pfyn-Finges. However, as shown in Figure 5-9 and Figure 5-10, in the case of past arable farming on the scale of 1:25 000, the participants showed spatially complementary knowledge, whilst in the case of future arable farming, on the other hand, this did not seem to be the case to the same extent; therefore, in some cases, the participants have complementary knowledge, whilst in other cases, expertise is more evenly dispersed. In the latter case, choosing participants with the highest expertise yields the best results, whereas in the first case, the sampling of experts benefits from sampling for complementarity. In PM of past land use, the group of participants with the highest individual F1-value still benefitted from adding participants with lower individual F1-value, whilst in the PM of future land use, the group of participants with the highest individual F1-value showed a decline in the group's F1-value through the addition of individuals with a lower F1-value.

Further, the spatial distribution of individual participants' knowledge is important, even though the Concept of Cultural Competence, in its original form, does not take them into account. As we have shown, there might be regions where single opinions are not an outlier but rather are known to represent the best available knowledge for this place *(Rohrbach & Laube 2014)*. In such cases, additional sampling might complement the existing knowledge by focusing on those areas with little information and accordingly increasing strategic coverage *(Johnson 1990)*. In other situations, however, sampling participants with lesser domain knowledge could potentially blur the existing knowledge by adding information that is peculiar as it contradicts the general perception. In our case, there were not many opinions mapped in regions where there are not many more experts available: for example, in the western part of the Val Müstair and the eastern part of Pfyn-Finges, there was little information and only few experts available. Sampling in such regions therefore requires a great deal of time. In such circumstances, the use of other methods, such as a MCE, or a statistical model, could be considered more appropriate. Alternatively, the spatially varying data quality might be accepted and accordingly incorporated.

The Influence of Scale

Although there was only little effect of scale on the mapping of past land use, for forecasting the future land use, the two larger, more detailed scales (1:5 000 and 1:12 500) performed better than the smaller

1:25 000 scale. For mapping historical land use, more detailed scales were found to only slightly increase the average individual performance, but ultimately decreased the variability of the performance amongst the group. For forecasting arable farming across the entire valley, the coarser scale yields worse results than the larger ones, and even worse results than if one would use the data for prediction from the historical situation task. Such findings contradict those garnered in the work of Brown *(2012a)*, which failed to observe any change in mapping accuracy on scales equalling 1:100 000 and on more detailed scales. We, however, would argue that their study considered only a narrow range of scales; this gives evidence to support the need to use large-scale, detailed maps for mapping detailed features of a biological reality. This was particularly noticeable when comparing the individual prediction of arable farmland under the new agricultural policy with the observed arable area, as visible in Figure 5-8.

Limitations

When considering that the more detailed scales followed the coarser scale, there most likely is some level of learning and fatigue effect *(Cape 2012)*, which might cancel each other out. The fatigue usually lowers the effort people invest in answering the questions, and learning usually increases the overall quality of the answers. A more thorough research design could incorporate the possible learning and fatigue effects by randomly presenting a particular scale to participants whilst, at the same time, increasing the sample size. As each participant is assigned only a short task, there is no fatigue effect, and as each participant gets to see each map only once, there is no learning effect. However, this would require a case study with many more experts available.

The inherent uncertainty of land use predictions investigated in this research is not known; however, it influences the quality of the prediction. Inherent uncertainty describes the natural variation within a process *(Walker et al. 2003)* and cannot be eliminated notwithstanding how well one samples, observes and models, as it belongs to the process. Each prediction therefore has a limited certainty constrained by the natural variation of the process observed. As we do not know the significance of the inherent uncertainty of the prognosis of arable farming in the Val Müstair, we do not know the maximal data quality, the method could possibly comprise. In an effort to address this issue, one could validate the data on various time points and accordingly assess the decline in the predictive quality of the model *(Pontius & Spencer 2005)*. This, however, would require much more data, which was not available in this study.

The evaluation of the forecast of arable farming, under the new agrarian policy, is based on a scenario created by observations of the first two years following the enactment of the policy. As the policy will further develop in the coming years, it is likely that the data quality of the forecast will change during this period; however, the policy will be revised in the year 2017 and hence the prevailing conditions for the forecast might change, which, as a result, will invalidate the premises for the participants in our forecast. This possibly will invalidate the results of the PM, meaning the entire study would need to be repeated.

6.2 Comparison of PM with MCE

In this section, firstly, the MCE is discussed, with the results then compared to the PM, and lastly, the outcome of the evaluation workshop discussed. Therefore, we are able to address the second research question:

2. How do the results of participatory mapping differ from those originating from a Multi Criteria Evaluation? Which results are more valid? And how do the annotations in participatory mapping contrast with and complement the results from the Multi Criteria Evaluation and the participatory mapping?

Comparison

The results of PM and MCE were seen to show some overlap; particularly when selecting the areas with highest or lowest value, both methods showed a higher concurrence amongst each other than with a random model. As shown in the annotations, the reasoning amongst participants in PM builds on similar factors, as used in the MCE. However, sometimes, the weighting was found to be different, or additional factors, such as the social situation of the land-owner, the presence of dry-stone walls or cultural historic circumstances, were included in the PM. Importantly, PM did not only include additional factors; sometimes the very same factors were just weighted completely differently. For example, the importance of the distance to a street in a particular location, as shown in Figure 5-33, might be judged differently in PM than in the MCE. In particular, in PM, the weights of individual factors might vary within the study area in a non-explicit, non-formalised manner. In MCE, such variations need to be made explicitly.

The agreement between PM and MCE is larger than that between PM or MCE and a random model. Getis-Ord Gi* reduces the granularity of the prognosis by including the values of neighbouring units. It further indicates that such forecasts on finer spatial scales are less robust, which was found to be the case when evaluating land use models in general *(Pontius et al. 2004)*.

The combination with the non-spatial prognosis, as shown in Figure 5-25 makes sense. The non-spatial prognosis predicted a decline of 17 % and 51 % for the linear and the quadratic model, respectively. A decline of 17 % has shown to be in the range when the spatial methods concur better amongst each other than with the random distribution. When calculating Getis-Ord Gi* hotspots, significant hotspots between the MCE and the PM overlap in approximately 17 % of the area from an abandonment perspective and 43 % from a sustainment perspective. A decline of 51 % equals a sustainment of 49 % of the vineyard-area, which would be close to the upper limit of the significant hotspots under the sustainment perspective. Furthermore, the average Jaccard-Coefficient in other land use modelling approaches was found to be about 21 % *(Pontius et al. 2008)*. We therefore infer the combined models predictive power as highest in the range between the quadratic and linear trend extrapolation.

Involving a Group of Experts in a Spatial MCE

The method presented for the construction of value functions in MCE, by asking for four values (too high, too low, and the optimal range) yielded usable results. The procedure proposed further allowed the aggregation of the value functions of several experts; this was further based on a simple task, which well reflected experts' perceptions of the reality. Nevertheless, the criteria could be disentangled further in an effort to obtain monotonic functions. Thus, the altitude criterion, for example, could be disentangled into the maximum altitude for sufficiently high temperatures (long enough growing season) and the minimum altitude for suitably low temperatures (not too early ripening). However, this disentanglement could correspond to one expert's view whilst another one sees different underlying causes for optimal altitude (i.e. the maximum altitude depends more on the likelihood of serious frosts). Disentangling all the criteria for all possible views would likely increase the scientific quality of the study but might render the procedure impracticable as it elongates the questionnaire by requiring additional weighting and valuing. The additional complexity of such a procedure would further blur the comprehensibility and accessibility of the MCE model *(Goldstone & Janssen 2005; Mendoza & Martins 2006)*. Such an approach was considered inappropriate by other authors as it would reduce trust in the outcomes *(Jankowski 2009)* and further cause a cognitive overload for most stakeholders *(Stauffacher et al. 2008)*. Moreover, if all possible aspects were listed, we also would need to have them mentioned in the PM in order to ensure comparable situations for both the PM and MCE. The applied MCE therefore presents the situation at a suitable level of detail so as to facilitate the weighting and valuing of the key decisive factors.

Validation and Uncertainty Analysis

We found that covariances between different weighted criteria are high and therefore cannot be neglected in the analytical approach of calculating uncertainty for the MCE. Nevertheless, performing uncertainty assessment on a criteria by criteria basis is useful as it provides spatially explicit uncertainty assessment per model input *(Ligmann-Zielinska & Jankowski 2014)*.

Calculating relative standard deviations reduces the differences between the analytical and probabilistic approach, and further provides insights into areas that potentially have a high uncertainty associated with. In our case, the areas of lower MCE value, i.e. the areas that are more likely not to be used as vineyards in the future, showed a higher relative standard deviation; this indicates that there is a greater degree of uncertainty in forecasting areas, which likely will not be cultivated as a vineyard than areas that are likely a vineyard in the future. This, however, is contrasted by the higher Jaccard-Coefficients for lower thresholds in the abandonment perspective than in the sustainment perspective. Hence, the MCE and PM outcome concurs more for lower than for higher values. This shows that, even though there is a higher level of uncertainty within the MCE for areas with low values, generally, PM supports this prognosis. As a result, in locations with conditions for which the non-local experts expressed significant disagreement in values and weights, resulting in a high SD in the MCE, the local vine-growers largely agree with the average opinion of the experts. However, generally, the results, as well as the uncertainties of the MCE and PM, correlate. This indicates that the same reasoning might be underlying the two methods, with similar uncertainties of judgements.

The different opinions in an MCE as well as in PM lead to similar spatial patterns. This indicates an agreement between local participants' knowledge and non-local experts' more formalised knowledge. This is surprising when considering that both groups provided their expertise through different levels of formalisation and through different mediums; however, other than the more formalised knowledge of non-local experts, the local knowledge does provide additional information related to the social and historical context *(Chalmers & Fabricius 2007)*, as shown in Figure 5-34.

Annotations add a narrative to a place, which represents another way of integrating local knowledge with other knowledge sources. As has been shown in Section 5.3.3 'Adding another Layer of Information: Annotations from Participants in Pfyn-Finges', annotations might explain or contradict the other results. They add the layer that is missing in the MCE and might indicate location-specific specialities of utility functions or weights of certain criteria.

For the non-local experts of the MCE, as well as the local participants of the PM, both methods scored similarly in terms of plausibility, spatial detail and temporal accuracy, and both methods scored better than the random distribution. This nicely illustrates the complementarity of the two methods. Although the local and non-local experts can be said to hold different types of knowledge, the two groups are no more inclined towards either of the results. This is to say; neither expert prefers the results from themselves or the opposite group. Therefore, in this case, the two methods could possibly have yielded similar scores in the evaluation. However, we did not present participants with the hotspot analysis by Getis-Ord Gi* of both methods, the reason for which is due to the fact that the Getis-Ord Gi* procedure takes into account a spatial neighbourhood and thus results in a 'smoothing' effect. This could have made the two methods even more similar to one another by removing the high granularity of the MCE and creating similarly large-scale patterns for the PM and the MCE.

Limitations

We refrained from calculating the correlates of the PM outcomes with physical features with the final aim of further extrapolating the PM outcomes as done by Sherrouse ***et al.*** *(2011)*, for example. Such an approach reportedly is not very accurate and furthermore only makes sense if the PM builds on point data, which then needs to be extrapolated anyway. However, future work could seek to compare the spatial and non-spatial decision-making processes in greater detail; that is, a research question could be centred on whether participants' reasoning suffers judgemental biases as described in psychology, for example *(Tversky & Kahneman 1974)*: for instance, if the participants base their decision on physical features that are prominent on maps but are of little importance to participants in situations of non-spatial reasoning. In our combination of map annotations with the PM, we made a first step in the direction of including the reasoning behind arguments in the participants' assessment. When comparing the reasoning between the two methods, further research would need to do the same for the MCE *(Simão et al. 2009)*. We judge annotations to be of great value for evaluating other data based on local knowledge. The analysis of annotations, however, requires consideration to the spatial extent of annotations. In this situation, the annotations are not spatially well distributed. In future work, one would need to develop further methods to elicit spatially more evenly distributed annotations.

The different experts might not only have perceived different weights, value ranges and a different selection of decisive factors within the MCE, but also might have structured them differently. Figure 6-1 provides an example of an alternative decision tree, compared to the one used in our MCE, displayed in Figure 5-16. The exact designs of the decision tree within the group process will always be one representative amongst a set of valid alternatives. We hold no evidence that the used decision tree did not well represent experts' perceptions, and hence assume it to be valid; however, there was a need to make mention of the possibility of alternative decision trees, such as that in Figure 6-1, for further research.

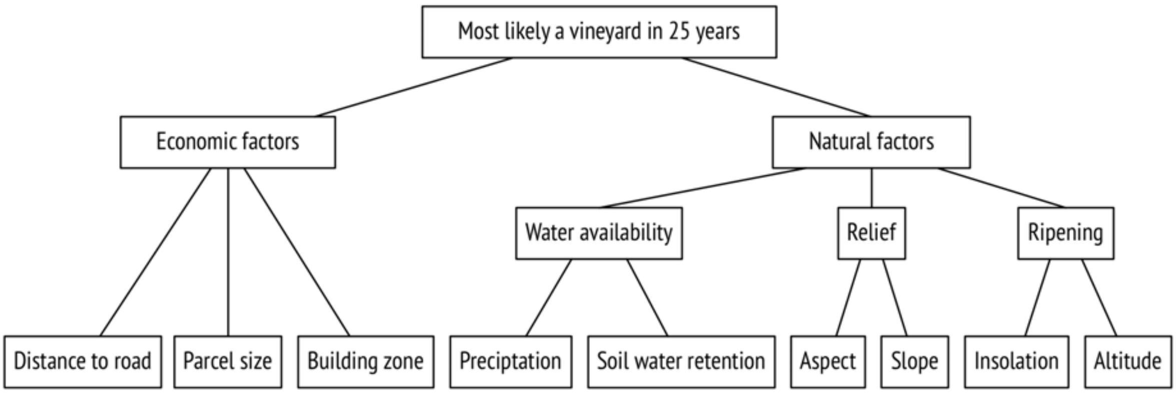


Figure 6-1: Possibly alternative decision tree for the MCE

6.3 Social Values connected to L-Use Change

We firstly discuss the perceptions of land use change and their implications on ecosystem services in general and crop genetic resources in particular. We then discuss the outcome of the questionnaire prior to and following the PM, and therefore are able to answer the third research question:

3. What type of social values do participants express with regards land use change? And does participatory mapping influence the perception of social norms, attitudes and perceived behaviour control?

Perceptions of Land Use Change

The perceived stressors on land use change, such as globalisation and technological advancements, and political context, are present in both areas of research. They are also described in similar research *(Aritia et al. 2015; Beilin et al. 2014; González-Puente et al. 2014)*. Besides these major drivers, in Pfyn-Finges, there was the additional driver of housing construction, whilst in the Val Müstair study area, the conversion from traditional to organic agriculture caused major disruptions. Generally, the decline in attractiveness of traditional land uses was mentioned in both areas of research. Changes in technology and social structure therefore indirectly influence the identification with arable farming in the Val Müstair. Moreover, in Pfyn-Finges, the decline of the unit price of grapes and the social cohesion menaces the identification with viticulture; however, according to theory, if such land use is to be retained, it requires that farmers be attached to the land use and experience feelings of social cohesion *(Beilin et al. 2014)*.

Reflections on Ecosystem Services

In the Val Müstair, the arable farming was evaluated as having great cultural importance and as being a beautiful landscape element. This was a reason for the payments for arable farming in the new agrarian policy. Those payments, however, were not motivated by the services they deliver to the urban population *(Abderhalden & Pedotti 2014)*. In terms of ecosystem services, the presented combination of perceived landscape beauty with arable farming for the local farmers represent a so-called ecosystem services bundle *(Fagerholm et al. 2012)*. As the new agrarian policy allows payments for arable farming in the Val Müstair, the new policy inexplicitly redistributes national money for local ecosystem services. Such a combination of ecosystem services for the locals simultaneously forms an ecosystem services conflict for people in urban areas. A sample of people living in cities did not evaluate a landscape without arable farming as more beautiful, even if the patches were small *(Lindemann-Matthies et al. 2010)*. Hence, for city people, landscape aesthetics are not bundled with arable farming; this, however, raises interesting issues in terms of ecosystem services flow caused by the new agrarian policy. This is to say, payments for arable farming in the Val Müstair bundle services and disservices together, depending on the perspective of the recipient.

In Pfyn-Finges, wine-growers perceive the loss of vineyards differently in line with their attachment to growing wine and their level of employment. Therefore, the perception of aesthetics in a productive environment influences the perception of change. The difference in perception subsequently influences the effects on Sense of Place (SOP). In Table 10, 'Expected change in SOP due to land use change', we have summarised that grape-farmers with weak attachment to wine-growing are expected to experience a weakening of their SOP in the case of a reduction of vineyards. However, this does not necessarily mean that the land use change is particularly disruptive to them; they might experience a declining importance of the viticulture for their SOP, but other aspects forming their SOP might well persist or increase.

The retention of a particular element of a specific way of life—in this case, in producing wine—does not necessarily retain the appearance of the landscape. Retaining wine-production as a first aim would require significant terrain movements. This, in turn, would not retain cultural values, and hence most likely would disrupt the social structure as it is nowadays. The socio-ecological system rather needs to adapt and possibly produce wine with different aims and on different scales.

Old Varieties and Biophysical Constraints

At present, old varieties are perceived as being out-dated and something not of any concern to the farmer in the Val Müstair. Generally speaking, the farmers very often did not know the varieties planted. Further is the importance of a productive farming environment in conflict with the typical characteristics of old varieties, which usually only perform well in niche markets. As has been shown in Section 5.3.1, there is a strong attachment to the production of agricultural goods. In line with theory, this thesis suggests that creating an attachment to old or locally important varieties calls for the farmers to perceive a particular product to be delivered by these varieties. This product does not necessarily need to be a physical one; however, it does need to make farmers proud. In the literature, Brush *(2004: 133)* highlights qualities besides those that are directly marketable as the biggest reasons for cultivating traditional varieties. Seidl and Böni *(2011)* have observed that economic viability was only a minor reason behind livestock farming in the alps, whilst culture and the presence of the livestock ranked highest. Moreover, Negri *(2003)* observed that taste and traditions were the major reasons behind farmers cultivating landraces. This thesis highlights the importance of pointing out the benefits of old varieties, might it be taste, marketing or cultural stewardship, if they are meant to be cultivated in the future.

In both areas of research, there are dynamics favouring land use change, which might be self-reinforcing: changes in social cohesion induce land use changes, which then lower existing place attachment, which, in turn, lowers social cohesion. In both study areas, there was little importance reported, by the management of the natural park or the biosphere reserve respectively. Hence, the present activities were not coordinated or institutionalised within the protected areas' management, which, however, would be possible as a sustainable model region *(Lange 2011)*. A strategic, participatory planning for the smart conservation of the places with high cultural value through the farming of grapes or arable farming could be a solution. The creation of a label and a society in the name of cultural heritage, such as, for example, the 'Heida-Wine' in the town of 'Visperterminen' or the 'Gran Alpin' for arable farming, would be an option. Visperterminen is recognised as one of the highest vineyards in Europe, extending to greater than 1 100 metres above sea level, with steep dry-stone walls and small parcels. The economic viability of the land there is limited due to the biophysical constraints. The cooperative of local wine-growers, however, built enough marketing power and attracts sufficient resources to still produce in an economically viable fashion within the biophysically unfavourable conditions *(Rodewald 2007: 40)*. 'Gran Alpin', on the other hand, is a farmer cooperative devoted to the cultivation of grains within the Alps. Many farmers report increased marketing potential, but the ecological benefit seems to be more important, besides local production, the community and the fun associated with producing for 'Gran Alpin' *(Bardsley & Bardsley 2014)*. 'Gran Alpin' therefore supports farming in the alps by strengthening cultural identity *(Bardsley & Bardsley 2014)*. Both examples of the 'Visperterminen' and the 'Gran Alpin' show how further values become attached to traditional products.

The Effect of PM on Values and Attitudes

The understanding of culture in the written questionnaire differs from that in the interviews: in the interviews, as an example, whilst the attachment of Val Müstair farmers to arable farming was debated and sometimes distress expressed, the tick-box questionnaire showed a high cultural importance afforded to arable farming. Although a participant might state that for his or her particular land use is not that important, nonetheless, he would encourage it if other people would do it; therefore, the questionnaire was understood more at the level of the entire valley, providing aggregated views. The interviews gave a more differentiated view on the importance of viticulture or arable farming for the particular participants.

As the analysis of the questionnaire has shown (Figure 64), PM seems to make people more aware of what other people do; therefore, it might be useful to bring other options of action to participants' minds and therefore overcome 'ipsative constraints'. However, the analysis, as clearly shown, emphasises that PM does give new insights concerning the possibilities one has, whereas neither seems to be able to change behaviour. Programmes for a behaviour change could benefit from PM, but it would take longer and a more continuous monitoring for observation, as shown by Cheng and Mattor *(2010)*. PM, however, did not decrease attitudes or norms in regard to the subject. PM did not seem to increase conflicts in other studies *(Reyes-García et al. 2012)*, and neither did it seem to do so in our work. Hence, one could say that PM did not perform badly on social learning, nor was there much influence at all to be reported *(Blackstock et al. 2007)*.

In our study, PM was reported as having been a pleasant experience, which shows that participants were comfortable with the setup. However, this evaluation should be read with caution as it might well include a social desirability bias as the questionnaire was filled in in the presence of the PI. Nonetheless, the study was not perceived as a bad experience, and PM was easily accessible to most participants.

Limitations

There might be several biases in terms of the farmers answering the questions. Although the farmers greatly appreciate any development that helps them to facilitate their work, it remains that modern machinery does somewhat conflict with their self-image *(Speich & Blumer 2000)*. The farmers rather perceive themselves as hard working *(Girtler 2012: 172–174)* and perceive the principal investigator as being in favour of arable farming in the mountains or traditional wine farming, respectively, as well as cultural heritage in general. They further might have associated this study with a possible influence on political measures.

7 Conclusion

The presented thesis has studied two social-ecological systems by using and investigating tools and concepts originating from GIScience, public participation and social science research. The thesis more specifically contributes to the advancement in Participatory Mapping (PM) and, thus, participatory GIS and public participatory GIS. The following sections summarise the key methodological contributions and content-based insights, and provides guidelines for future research using PM, as well as an outlook for future work.

7.1 Contributions

Advancements in PM

This thesis investigated possible methods to estimate saturation in PM. The thesis therefore provides an operational method to estimate the 'information gain' per participant by measuring the increasing completeness and correctness of PM data when including more participants. In an effort to calculate the gain made by an individual participant, the thesis applies Jackknifing, which is well-known for its application in parameter estimations in the biological sciences, but never was, to the best of our knowledge, used in the context of sample saturation. Assessing the required number of participants in participatory mapping using Jackknifing is the first key contribution made by this thesis.

For the fieldwork, this research provided a simple, low-cost and easily accessible PM method. The method not only allowed the collection of spatial data, but also helped in capturing the reasoning of participants whilst also providing the spatial information, which was helpful in gathering spatially explicit information about social and historical events. Generally, the participants found the method to be enjoyable; this PM method provides the possibility for integrating qualitative and quantitative data by using geographical space as a unifying ground.

Within this thesis, we advanced the method to aggregate polygonal PM data not only by counting overlaps but also by seeking to establish the presence and the absence of a feature, representing two mutually exclusive questions. Thus, we were able to calculate the proportion of conflicting opinions. Conflicting opinions indicate that the participants of the study do not agree, and the results therefore are uncertain for the particular location.

Advancements in Understanding and Predicting Land Use Changes

This thesis has provided theoretically sound conceptual connections between ecosystem services, resilience and place attachment. The framework, proposed in the introduction, could serve further studies analysing land use changes and the impacts associated with social values. The framework accounts for feedback loops within the human environment interactions. It was successfully applied within this thesis.

For the Multi Criteria Evaluation, the thesis presents a new way of eliciting and aggregating value functions amongst different experts. The proposed method requires the experts to provide two ranges with which they were familiar: the range of optimal and the range of acceptable values. Using the proposed methodology, the aggregation of the values function of various experts was easily possible.

We evaluated comparable results of the MCE and PM in a participatory manner. We further compared the results to a randomly generated baseline scenario; this facilitated the evaluating of the results from a user's perspective. By allowing the participants to define the evaluation criteria themselves, we provided the possibility to the users to define themselves what a land use prediction needs to be. This procedure gave better insights into the strengths and weaknesses associated with each method.

7.2 Insights

Insights in PM

Our research has shown that, already, few participants yielded similarly high precision and completeness as a larger group in PM. Saturation was defined as the point at which additional participants only increase precision or completeness by less than one percent. This point was reached with 5 participants for the mapping of past arable land and 9 participants when mapping arable land under a new agricultural policy on the scale of 1:5 000. Our study showed that more detailed scales and more concrete tasks of the historic state required fewer participants to reach saturation. On the scale of 1:25 000, saturation was achieved with 7 and 11 participants for the historic and predictive arable farming, respectively. Further, the maximum data quality, expressed by the F1-value, declines with scale from the 1:5 000 scale to the 1:25 000. However, the highest data quality achievable by PM for uncertain tasks, such as the prediction of arable farmland, remained below 100 % due to the uncertainty inherent in the process.

Theory suggests that the inclusion of more participants with less domain knowledge blurs the outcome of a study; however, a sampling strategy aiming at only the most knowledgeable experts does not neglect the possible information gain through the complementarity of knowledge. We showed that, in the case of mapping past arable land, the participants showed complementary knowledge, which was not observed in the case of mapping arable land under the new agricultural policy. We therefore advocate a sampling scheme that considers complementary knowledge within a well-selected group of experts as most feasible in participatory mapping.

Insights concerning the Comparison of PM and MCE

Whilst PM and MCE are two different methods, following different rationales, both methods deliver spatially concurring results. They concur particularly well within the range of a non-spatial extrapolation of land use change. Both local and non-local experts preferred the high spatial resolution of the MCE but ultimately deemed the PM to be more plausible. Furthermore, both methods are evaluated as better than a spatially random distribution offered for comparison. Therefore, both methods are considered suitable for land use prognosis, and the decision as to whether to choose an MCE or a PM can be based on preferences and the appropriateness of either method. For example, we have shown that PM can collect spatially explicit narratives and cultural values, whilst an MCE builds on a fully traceable sequence of explicit calculations. In some cases, those narratives helped to understand differences between the two methods.

The share of conflicting opinions in PM and the relative uncertainty in the MCE are spatially distributed in a comparable way. This indicates that the evaluation is most likely based on similar factors in both methods—despite them being fundamentally different.

Insights concerning Social Values and Land Use Change

The two study areas are highly complex social-ecological systems. The presence of ecosystem services within those areas is spatially and temporally varying. We have shown that, in the Pfyn-Finges area, the presence of sense of place is changing with land use change. In the Val Müstair, we have shown that a bundle of ecosystem services for one group of stakeholders is an ecosystem services trade-off for another group.

For sustainment of biocultural values, the farmers in the Val Müstair and the grape farmers in Pfyn-Finges are required to identify with their products. However, at the present time, they attribute a high cultural value to the practice of arable farming and wine-growing, respectively, but not to the products. We have shown that PM tends to increase the perception of the cultural importance.

7.3 Recommendations for Future PM Studies

We would like to condense the findings of this thesis into two key recommendations for future applications of PM:

- **Sampling:** Sampling should be performed in a strategically smart way, where the aim should not be the inclusion of as many people as possible, but rather on selecting those participants that can be expected to provide the information requested. Therefore, firstly, a topical and spatial universe of interest should be defined. Having set those boundaries, sampling should aim at a sufficiently high number of the most knowledgeable people whilst also covering the entire universe of interest.

However, one should be aware of spatial or topical gaps within the data, which should be listed in the limitations.

- **Data Quality:** The highest data quality in PM is reached through strategically smart sampling using detailed scales and when mapping observable issues. However, generally, it is important to define the required level of data quality and then assure that PM achieves that level, as PM will never yield results with 100 % correctness and completeness. However, as we have demonstrated, one can assess the uncertainty in PM by seeking mutually excluding information and accordingly quantifying the level and spatial distribution of uncertainty.

7.4 Outlook

Concerning PM, we recommend investigating the effect of the time lag between the study and the investigated situation on saturation and data quality. In this study, we investigated the situation at a time point 25 years in the past, a couple of years in the future and 25 years in the future. We hypothesise that data quality is declining with increasing time lag in either the future or the past. Within the research, a task would be centred on investigating the aspects of data quality most strongly affected by increases in the time lag. The effects on saturation are a further task to be researched. One question in this vein may be, 'Does the required number of participants increase linearly with declining data quality?'

Improvements could be made regarding the 'ground truth' of a scenario in the future, to which PM could be compared. An obvious task would be the comparison of the actual situation in Pfyn-Finges in the year 2040, with the results of MCE and PM, and a further set of evaluations applied. This, however, would require a long period of waiting. A second task would be to closely observe the development of arable farming in the Val Müstair under the new agricultural policy and accordingly contrast the development with the results of the PM of this study.

A third task would be developing an agent-based model for comparison with the results of the PM and the MCE. Many studies nowadays use Agent-Based Models (ABM) rather than an MCE for assessing land use changes *(Sohl & Claggett 2013)*. However, ABM are more data-intensive, more complex and therefore less easy to understand—and, if not understood generally, the results are less trusted *(Sohl & Claggett 2013; Zellner et al. 2012)*. However, future work possibly could evaluate the performance of PM versus MCE and ABM.

At the present time, PM studies do not account for a spatial variation of the sample size. This thesis only marginally touched on this issue as, in some parts of the study areas investigated, the number of knowledgeable participants was lower than in other parts. However, a methodologically sound concept to account for the varying information density within PM is still missing *(Rohrbach & Laube 2014)*. Such a procedure could be particularly important when researching larger areas.

8 References

ABDERHALDEN A., & PEDOTTI R. (2014): *Landschaftsqualitätsprojekt Engiadina Bassa, Samnaun, Val Müstair*. Online available under: http://www.blw.admin.ch/themen/00006/01714/01839/index.html?lang=de&download=NHzLpZeg7t,lnp6I0NTU042l2Z6ln1acy4Zn4Z2qZpnO2Yuq2Z6gpJCEeoB7fmym162epYbg2c_JjKbNoKSn6A-- [*Accessed September 7, 2015*].

AGRAWAL A. (1995): Dismantling the Divide Between Indigenous and Scientific Knowledge. In: *Development and Change*, vol. 26:3, 413–439.

AJZEN I. (1991): The theory of planned behavior. In: *Organizational Behavior and Human Decision Processes*, vol. 50:2, 179–211.

ALESSA L., KLISKEY A., & BROWN G. (2008): Social–ecological hotspots mapping: A spatial approach for identifying coupled social–ecological space. In: *Landscape and Urban Planning*, vol. 85:1, 27–39.

ANDERSON K., & ARYAL N. R. (2013): *Which Winegrape Varieties are Grown Where? A Global Empirical Picture*. University of Adelaide Press: Adelaide.

ANDRES F., PYTHON A., SCHIESS C., MARTIN M., & JOEHL R. (2009): *Vernetzungsprojekt Val Müstair - Leitbild*.

ARITIA A. T., VLIET J. VAN, & VERBURG P. H. (2015): Land-use and land-cover changes in the Central Rift Valley of Ethiopia: Assessment of perception and adaptation of stakeholders. In: *Applied Geography*, vol. 65, 28–37.

ARNSTEIN S. (1969): A ladder of citizenship participation. In: *Journal of the American Institute of planners*, 216–224.

BALMFORD A., FISHER B., GREEN R. E., NAIDOO R., STRASSBURG B., KERRY TURNER R., & RODRIGUES A. S. L. (2010): Bringing Ecosystem Services into the Real World: An Operational Framework for Assessing the Economic Consequences of Losing Wild Nature. In: *Environmental and Resource Economics*, vol. 48:2, 161–175.

BARDSLEY D. K., & BARDSLEY A. M. (2014): Organising for socio-ecological resilience: The roles of the mountain farmer cooperative Genossenschaft Gran Alpin in Graubünden, Switzerland. In: *Ecological Economics*, vol. 98, 11–21.

BARDSLEY D., & THOMAS I. (2004): In Situ Agrobiodiversity Conservation in the Swiss Inner Alpine Zone. In: *GeoJournal*, vol. 60:2, 99–109.

BARTHEL S., CRUMLEY C., & SVEDIN U. (2013): Bio-cultural refugia—Safeguarding diversity of practices for food security and biodiversity. In: *Global Environmental Change*, vol. 23:5, 1142–1152.

BEECO J. A., & BROWN G. (2013): Integrating space, spatial tools, and spatial analysis into the human dimensions of parks and outdoor recreation. In: *Applied Geography*, vol. 38, 76–85.

BEILIN R., LINDBORG R., STENSEKE M., MIGUEL H., LLAUSÀS A., SLÄTMO E., CERQUEIRA Y., NAVARRO L., RODRIGUES P., REICHELT N., MUNRO N., & QUEIROZ C. (2014): Analysing how drivers of agricultural land abandonment affect biodiversity and cultural landscapes using case studies from Scandinavia , Iberia and Oceania. In: *Land Use Policy*, vol. 36, 60–72.

BEINAT E. (1997): *Value functions for environmental management*. Kluwer Academic Publishers: Dordrecht.

BERGMANN M., JAHN T., KNOBLOCH T., KROHN W., POHL C., & SCHRAMM E. (2010): *Methoden transdisziplinärer Forschung. Ein Überblick mit Anwendungsbeispielen*. Campus Verlag: Frankfurt/New York.

BERKES F., FOLKE C., & GADGIL M. (1995): Traditional ecological knowledge, biodiversity, resilience and sustainability. In: *Biodiversity Conservation*, Perrings, C. A., Mäler, K.-G., Folke, C., Holling, C., & Jansson, B.-O. (Eds.), pp. 281–299. Kluwer Academing Pulblishers.

BIO SUISSE (2010): *Richtlinien für die Erzeugung, Verarbeitung und den Handel von Knospe-Produkten*. Online available under: http://www.bio-suisse.ch/media/de/pdf2010/RL-Ws/rl_2010_d.pdf [*Accessed April 20, 2010*].

BLACK A., & LILJEBLAD A. (2006): *Integrating social values in vegetation models via GIS: The missing link for the Bitterroot National Forest*. Aldo Leopold Wilderness Research Institute. Online available under: http://leopold.wilderness.net/research/fprojects/docs15/FinalReport04_2_1_114.pdf [*Accessed November 19, 2013*].

BLACKSTOCK K. L., KELLY G. J., & HORSEY B. L. (2007): Developing and applying a framework to evaluate participatory research for sustainability. In: *Ecological Economics*, vol. 60:4, 726–742.

BONAIUTO M., CARRUS G., MARTORELLA H., & BONNES M. (2002): Local identity processes and environmental attitudes in land use changes: The case of natural protected areas. In: *Journal of Economic Psychology*, vol. 23, 631–653.

BOSSHARD A., & GLASENAPP M. VON (2012): *CultivAlpe - Landwirtschaftliche Flächenaufgabe und Wiedernutzung im Schweizer Berggebiet. Ursachen, Instrumente und Perspektiven*. Oberwil-Lieli. Online available under: http://agraroekologie.ch/CultivAlpe_SB_April12_oA_def.pdf [*Accessed November 3, 2014*].

BRABHAM D. C. (2009): Crowdsourcing the Public Participation Process for Planning Projects. In: *Planning Theory*, vol. 8:3, 242–262.

BRANCHENVERBAND DER WALLISER WEINE (2015): *Viti Horizon 2020. Festlegung der Walliser Weinbaustrategie bis 2020*. Online available under: http://www.lesvinsduvalais.ch/data/documents/VITIHORIZON2020_rapportfinal_25mars2015_DE.pdf [*Accessed May 5, 2015*].

BRANS J.-P., & MARESCHAL B. (2005): PROMETHEE Methods. In: *Multiple criteria decision analysis: state of the art surveys*, Figueira, J., Greco, S., & Ehrgott, M. (Eds.), pp. 163–196.

BROWN A. H. D., & HODGKIN T. (2007): Measuring, Managing and Maintaining Crop Genetic Diversity on Farm. In: *Managing Biodiversity in Agricultural Ecosystems*, Jarvis, D. I., Padoch, C., & Cooper, H. D. (Eds.). Columbia University Press.

BROWN G. (2012a): An empirical evaluation of the spatial accuracy of public participation GIS (PPGIS) data. In: *Applied Geography*, vol. 34, 289–294.

–––– (2012b): Public Participation GIS (PPGIS) for regional and environmental planning: Reflections on a decade of empirical research. In: *URISA journal*, vol. 25:2, 7–18.

BROWN G., & CHIN S. Y. W. (2013): Assessing the Effectiveness of Public Participation in Neighbourhood Planning. In: *Planning Practice and Research*, vol. 28:5, 563–588.

BROWN G., DONOVAN S., PULLAR D., POCEWICZ A., TOOHEY R., & BALLESTEROS-LOPEZ R. (2014): An empirical evaluation of workshop versus survey PPGIS methods. In: *Applied Geography*, vol. 48, 42–51.

BROWN G., & FAGERHOLM N. (2014): Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. In: *Ecosystem Services*, 1–41.

BROWN G., KELLY M., & WHITALL D. (2013): Which "public"? Sampling effects in public participation GIS (PPGIS) and volunteered geographic information (VGI) systems for public lands management. In: *Journal of Environmental Planning and Management*, 1–25.

BROWN G., & KYTTÄ M. (2014): Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. In: *Applied Geography*, vol. 46, 122–136.

BROWN G., MONTAG J. M., & LYON K. (2012a): Public Participation GIS: A Method for Identifying Ecosystem Services. In: *Society & Natural Resources*, vol. 25:7, 633–651.

BROWN G., & PULLAR D. (2012): An evaluation of the use of points versus polygons in public participation geographic information systems using quasi-experimental design and Monte Carlo simulation. In: *International Journal of Geographical Information Science*, vol. 26:2, 231–246.

BROWN G., & RAYMOND C. (2007): The relationship between place attachment and landscape values: Toward mapping place attachment. In: *Applied Geography*, vol. 27:2, 89–111.

BROWN G., RAYMOND C. M., & CORCORAN J. (2015a): Mapping and measuring place attachment. In: *Applied Geography*, vol. 57, 42–53.

BROWN G., SMITH C., ALESSA L., & KLISKEY A. (2004): A comparison of perceptions of biological value with scientific assessment of biological importance. In: *Applied Geography*, vol. 24:2, 161–180.

BROWN G., & WEBER D. (2012): A place-based approach to conservation management using public participation GIS (PPGIS). In: *Journal of Environmental Planning and Management*, vol. 1:19, 37–41.

BROWN G., WEBER D., & DE BIE K. (2015b): Is PPGIS good enough? An empirical evaluation of the quality of PPGIS crowd-sourced spatial data for conservation planning. In: *Land Use Policy*, vol. 43, 228–238.

BROWN G., WEBER D., ZANON D., & DE BIE K. (2012b): Evaluation of an online (opt-in) panel for public participation geographic information systems surveys. In: *International Journal of Public Opinion Research*, vol. 24:4, 534–545.

BRUSH S. B. (2004): *Farmers' Bounty: Locating Crop Diversity in the Contemporary World*. Yale University Press Ltd: New Haven CT.

BURKHARD B., KROLL F., NEDKOV S., & MÜLLER F. (2012): Mapping ecosystem service supply, demand and budgets. In: *Ecological Indicators*, vol. 21, 17–29.

CACCIAPAGLIA M. A., YUNG L., & PATTERSON M. E. (2012): Place Mapping and the Role of Spatial Scale in Understanding Landowner Views of Fire and Fuels Management. In: *Society & Natural Resources*, vol. 25:5, 453–467.

CAPE P. (2012): *Questionnaire Length, Fatigue Effects and Response Quality Revisited*. Online available under: http://mrops.com/who-we-are/ssi-media/F0B02288A3AC46BF8EA8D64ACB4BBE89.ashx [*Accessed April 2, 2015*].

CARDINALE B. J., DUFFY J. E., GONZALEZ A., HOOPER D. U., PERRINGS C., VENAIL P., NARWANI A., MACE G. M., TILMAN D., WARDLE D. A, KINZIG A. P., DAILY G. C., LOREAU M., GRACE J. B., LARIGAUDERIE A., SRIVASTAVA D. S., & NAEEM S. (2012): Biodiversity loss and its impact on humanity. In: *Nature*, vol. 486:7401, 59–67.

CARRUS G., SCOPELLITI M., FORNARA F., BONNES M., & BONAIUTO M. (2014): Place Attachment, Community Identification and Pro-Environmental Engagement. In: *Place Attachment: Advances in Theory, Methods and Research*, Manzo, L. & Devine-Wright, P. (Eds.), pp. 154–164. Routledge.

CARRUZZO-FREY S., & DUBUIS P. (eds.) (2010): *Rebe und Wein im Wallis: die Geschichte von den Anfängen bis heute*. Walliser Reb- und Weinmuseum: Sierre-Salgesch.

CARVER S. (1991): Integrating multi-criteria evaluation with geographical information systems. In: *International journal of geographical information systems*, vol. 5:3, 321–339.

CARVER S. (2003): The Future of Participatory Approaches Using Geographic Information: developing a research agenda for the 21 st Century. In: *URISA Journal*, vol. 15, 61–71.

CARVER S., WATSON A., WATERS T., MATT R., GUNDERSON K., & DAVIS B. (2009): Developing Computer-Based Participatory Approaches to Mapping Landscape Values for Landscape and Resource Management. In: *Planning Support Systems Best Practice and New Methods*vol. 95, Geertman, S. & Stillwell, J. C. H. (Eds.), pp. 431–448. Springer: New York.

CASTREE N. (2009): Place: Connections and Boundaries in an Interdependent World. In: *Key concepts in geography*, Clifford, N., Holloway, S. L., Rice, S. P., & Valentine, G. (Eds.), pp. 153–172. SAGE Publications, Inc.: London.

CERONI M., LIU S., & CONSTANZA R. (2007): Ecological and Economic Roles of Biodiversity in Agroecosystems. In: *Managing Biodiversity in Agricultural Ecosystems*, Jarvis, D. I., Padoch, C., & Cooper, H. D. (Eds.). Columbia University Press.

CHALMERS N., & FABRICIUS C. (2007): Expert and Generalist Local Knowledge about Land-cover Change on South Africa ' s Wild Coast : Can Local Ecological Knowledge Add Value to Science ? In: *Ecology And Society*, vol. 12:1, 10.

Charta 2010/11 Regionaler Naturpark Biosfera Val Müstair (2009):Online available under: http://www.biosfera.ch/pdf/RNPChartaBiosferaValMuestair07.01.2010.pdf [*Accessed May 25, 2012*].

CHENG A. S., & MATTOR K. M. (2010): Place-Based Planning as a Platform for Social Learning: Insights From a National Forest Landscape Assessment Process in Western Colorado. In: *Society & Natural Resources*, vol. 23:5, 385–400.

CHERNICK M. R. (2007): *Bootstrap Methods: A Guide for Practitioners and Researchers.* 2nd ed. Wiley.

CHERRILL A., & MCCLEAN C. (1999): Between-observer variation in the application of a standard method of habitat mapping by environmental consultants in the UK. In: *Journal of Applied Ecology*, vol. 36:6, 989–1008.

CLIFFORD P., RICHARDSON S., & HEMON D. (1989): Assessing the Significance of the Correlation between 2 Spatial Processes. In: *Biometrics*, vol. 45:1, 123–134.

COCKS M. L., & WIERSUM F. (2014): Reappraising the Concept of Biocultural Diversity: a Perspective from South Africa. In: , 727–737.

COHEN J. (1992): Statistical Power Analysis. In: *Current Directions in Psychological Science*, vol. 1:3, 98–101.

COMBER A., CARVER S., FRITZ S., MCMORRAN R., WASHTELL J., & FISHER P. (2010): Different methods, different wilds: Evaluating alternative mappings of wildness using fuzzy MCE and Dempster-Shafer MCE. In: *Computers, Environment and Urban Systems*, vol. 34:2, 142–152.

COMBER A. J. (2013): Geographically weighted methods for estimating local surfaces of overall, user and producer accuracies. In: *Remote Sensing Letters*, vol. 4:4, 373–380.

CONDON E., GOLDEN B., & WASIL E. (2003): Visualizing group decisions in the analytic hierarchy process. In: *Computers & Operations Research*, vol. 30:10, 1435–1445.

CONGALTON R. G. (1991): A review of assessing the accuracy of classifications of remotely sensed data. In: *Remote Sensing of Environment*, vol. 37:October 1990, 35–46.

CORBURN J. (2003): Bringing Local Knowledge into Environmental Decision Making. In: *Journal of Planning Education and Research*, vol. 22, 420–433.

COSTANZA R., DE GROOT R., SUTTON P., VAN DER PLOEG S., ANDERSON S. J., KUBISZEWSKI I., FARBER S., & TURNER R. K. (2014): Changes in the global value of ecosystem services. In: *Global Environmental Change*, vol. 26, 152–158.

COUIX N., & HAZARD L. (2013): When the future of biodiversity depends on researchers' and stakeholders' thought-styles. In: *Futures*, vol. 53, 13–21.

COX C., MORSE W., ANDERSON C., & MARZEN L. (2014): Applying Public Participation Geographic Information Systems to Wildlife Management. In: *Human Dimensions of Wildlife*, vol. 19:2, 200–214.

CROSSMAN N. D., BURKHARD B., NEDKOV S., WILLEMEN L., PETZ K., PALOMO I., DRAKOU E. G., MARTÍN-LOPEZ B., MCPHEARSON T., BOYANOVA K., ALKEMADE R., EGOH B., DUNBAR M. B., & MAES J. (2013): A blueprint for mapping and modelling ecosystem services. In: *Ecosystem Services*, vol. 4, 4–14.

DALLIARD M. (2011): “Die Positionierung der Gemeinde Salgesch betreffend des Weines und des Territoriums der.” Haute ecole spécialisée de Suisse occidentale, Online available under: http://doc.rero.ch/record/31075/files/Dalliard_M_TB_2011.pdf [*Accessed June 1, 2015*].

DARVILL R., & LINDO Z. (2015): Quantifying and mapping ecosystem service use across stakeholder groups: Implications for conservation with priorities for cultural values. In: *Ecosystem Services*, vol. 13, 153–161.

DAVENPORT T., & PRUSAK L. (1998): *Working knowledge: How organizations manage what they know*. Harvard Business School Press: Boston, MA.

DEBOLINI M., MARRACCINI E., RIZZO D., GALLI M., & BONARI E. (2013): Mapping local spatial knowledge in the assessment of agricultural systems: A case study on the provision of agricultural services. In: *Applied Geography*, vol. 42, 23–33.

DELYSER D., & SUI D. (2014): Crossing the qualitative-quantitative chasm III: Enduring methods, open geography, participatory research, and the fourth paradigm. In: *Progress in Human Geography*, vol. 38:2, 294–307.

DENT B. D., TORGUSON J. S., & HODLER T. W. (2009): *Cartography: Thematic Map Design*. 6th ed. McGraw-Hill Higher Education: Boston, MA.

DEVINE-WRIGHT P. (2009): Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. In: *Journal of Community and Applied Social Psychology*, vol. 19, 426–441.

DEVINE-WRIGHT P. (2012): Explaining “NIMBY” Objections to a Power Line: The Role of Personal, Place Attachment and Project-Related Factors. In: *Environment and Behavior*, vol. 45:6.

DIETZ T., & STERN P. C. (eds.) (2008): *Public Participation in Environmental Assessment and Decision Making*. National Academies Press: Washington, D.C.

DOMENICONI E., SCHNEIDER J., & RABOUD-SCHÜLE I. (2010): L’attachement à la vigne: la transmission du savoir e patrimonie. In: *Vignes et viticulteurs de montagne: histoire, pratiques, savoirs et paysages: Valais, Alpes occidentales, Pyrénées, Mont-Liban*vol. 22, Dubuis, P. (Ed.), pp. 277–290. Archives de l’Etat du Valais: Sion.

DORMANN F. C., MCPHERSON M. J., ARAÚJO B. M., BIVAND R., BOLLIGER J., CARL G., DAVIES G. R., HIRZEL A., JETZ W., DANIEL KISSLING W., KÜHN I., OHLEMÜLLER R., PERES-NETO R. P., REINEKING B., SCHRÖDER B., SCHURR M. F., & WILSON R. (2007): Methods to account for spatial autocorrelation in the analysis of species distributional data: a review. In: *Ecography*, vol. 30:5, 609–628.

DUCKHAM M., & SHARP J. (2005): Uncertainty and Geographic Information: Computational and Critical Convergence. In: *Re-Presenting GIS*, Fisher, P. & Unwin, D. J. (Eds.), pp. 113–124. John Wiley & Sons Inc.

DUDLEY N., SANDWITH T., & BELOKURV A. (2010): Climate Change: The Role of Protected Areas in Mitigating and Adapting to Change. In: *Arguments for Protected Areas: Multiple Benefits for Conservation and Use*, Stolton, S. & Dudley, N. (Eds.), pp. 205–224. earthscan: London, Washington.

DUJMOVIC J., DE TRE G., & DRAGICEVIC S. (2009): Comparison of Multicriteria Methods for Land-use Suitability Assessment. In: *Proceedings of the Joint 2009 International Fuzzy Systems Association World Congress and 2009 European Society of Fuzzy Logic and Technology Conference*, pp. 1404–1409. IFSA-EUSFLAT.

EASTMAN J. R., JIANG H., & TOLEDANO J. (1998): Multi-criteria and multi-objective decision making for land allocation using GIS. In: *Multicriteria Analysis for Land-Use Management*vol. 9, *Environment & Management*, Beinat, E. & Nijkamp, P. (Eds.), pp. 227–251. Springer Netherlands.

EEA (2013): Common International Classification of Ecosystem Services. Online available under: http://cices.eu [*Accessed September 16, 2014*].

EIKELBOOM T., & JANSSEN R. (2013): Interactive spatial tools for the design of regional adaptation strategies. In: *Journal of environmental management*, vol. 127 Suppl, S6–S14.

EMERY S. (2001): *Zukunftsaussichten für die Weinberge auf Terrassen und an Steillagen im Kanton Wallis*. Online available under: http://www.vs.ch/Press/DS_3/CP-2001-09-07-40/de/Emery_f.pdf [*Accessed November 3, 2014*].

ENENGEL B., MUHAR A., PENKER M., FREYER B., DRLIK S., & RITTER F. (2012): Co-production of knowledge in transdisciplinary doctoral theses on landscape development—An analysis of actor roles and knowledge types in different research phases. In: *Landscape and Urban Planning*, vol. 105:1-2, 106–117.

EYLES J. (1985): *Sense of Place*. Silverbrook Press: Cheshire, England.

FAGERHOLM N., KÄYHKÖ N., NDUMBARO F., & KHAMIS M. (2012): Community stakeholders' knowledge in landscape assessments – Mapping indicators for landscape services. In: *Ecological Indicators*, vol. 18, 421–433.

FAO (2010): *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*. Rome, Italy. Online available under: http://www.fao.org/docrep/013/i1500e/i1500e.pdf [*Accessed November 3, 2014*].

–––– (2011): *Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture*. Rome, Italy. Online available under: http://www.fao.org/docrep/015/i2624e/ [*Accessed November 3, 2014*].

FEIZIZADEH B., SHADMAN ROODPOSHTI M., JANKOWSKI P., & BLASCHKE T. (2014): A GIS-based extended fuzzy multi-criteria evaluation for landslide susceptibility mapping. In: *Computers & Geosciences*, vol. 73, 208–221.

FISHBEIN M., & AJZEN I. (2010): *Predicting and Changing Behavior: The Reasoned Action Approach*. Psychology Press. Taylor and Francis Group: New York.

FLECK L. (1935): *Entstehung und Entwicklung einer wissenschaftlichen Tatsache : Einführung in die Lehre vom Denkstil und Denkkollektiv*. 1980th ed. Schäfer, L. & Schnelle, T. (Eds.). Suhrkamp: Frankfurt.

FLYVBJERG B. (2006): Five Misunderstandings About Case-Study Research. In: *Qualitative Inquiry*, vol. 12:2, 219–245.

FOLEY J. A., RAMANKUTTY N., BRAUMAN K. A., CASSIDY E. S., GERBER J. S., JOHNSTON M., MUELLER N. D., O'CONNELL C., RAY D. K., WEST P. C., BALZER C., BENNETT E. M., CARPENTER S. R., HILL J., MONFREDA C., POLASKY S., ROCKSTRÖM J., SHEEHAN J., SIEBERT S., TILMAN D., & ZAKS D. P. M. (2011): Solutions for a cultivated planet. In: *Nature*, vol. 478:7369, 337–342.

FRANCIS J. J., JOHNSTON M., ROBERTSON C., GLIDEWELL L., ENTWISTLE V., ECCLES M. P., & GRIMSHAW J. M. (2010): What is an adequate sample size? Operationalising data saturation for theory-based interview studies. In: *Psychology & health*, vol. 25:10, 1229–45.

FRANEK J., & KRESTA A. (2014): Judgment Scales and Consistency Measure in AHP. In: *Procedia Economics and Finance*, vol. 12:March, 164–173.

GALLUZZI G., DUIJVENDIJK C. VAN, COLLETTE L., AZZU N., & HODGKIN T. (eds.) (2011): *Biodiversity for Food and Agriculture - Contributing to food security and sustainability in a changing world*. Food and Agriculture Organization of the United Nations and the Platform for Agrobiodiversity Research: Rome, Italy. Online available under: http://www.fao.org/fileadmin/templates/biodiversity_paia/PAR-FAO-book_lr.pdf [*Accessed November 3, 2014*].

GALLUZZI G., EYZAGUIRRE P., & NEGRI V. (2010): Home gardens: neglected hotspots of agro-biodiversity and cultural diversity. In: *Biodiversity Conservation*, vol. 19, 3635–3654.

GEIGER W., GÖTTIN T., GUIGNET E. M., HOFMANN C., & WILD F. (eds.) (2012): *Strategie Biodiversität Schweiz*. Online available under: www.bafu.admin.ch/ud-1060-d.

GERBER A., & HOFFMANN A. T. V. (2009): *Transdisziplinäre Umweltforschung*. Oekom Verlag GmbH.

GETIS A., & ORD J. K. (1992): The Analysis of Spatial Association. In: *Geographical Analysis*, vol. 24:3, 189–206.

GIRTLER R. (2012): *Aschenlauge : die alte Kultur der Bauern*. Böhlau: Wien.

GLÄSER J., & LAUDEL G. (2006): *Experteninterviews und qualitative Inhaltsanalyse als Instrumente rekonstruierender Untersuchungen*. VS Verlag für Sozialwissenschaften: Wiesbaden.

GOBSTER P. H., NASSAUER J. I., DANIEL T. C., & FRY G. (2007): The shared landscape: what does aesthetics have to do with ecology? In: *Landscape Ecology*, vol. 22:7, 959–972.

GOEPEL K. (2013): Implementing the Analytic Hierarchy Process as a Standard Method for Multi-Criteria Decision Making in Corporate Enterprises – a New AHP Excel Template with Multiple Inputs. In: *Proceedings of the International Symposium on the Analytic Hierarchy Process*. Online available under: http://www.isahp.org/uploads/29.pdf [*Accessed May 15, 2015*].

GOLDSTONE R. L., & JANSSEN M. A (2005): Computational models of collective behavior. In: *Trends in cognitive sciences*, vol. 9:9, 424–430.

GÓMEZ-DELGADO M., & TARANTOLA S. (2006): GLOBAL sensitivity analysis, GIS and multi-criteria evaluation for a sustainable planning of a hazardous waste disposal site in Spain. In: *International Journal of Geographical Information Science*, vol. 20:4, 449–466.

GONZÁLEZ-PUENTE M., CAMPOS M., MCCALL M. K., & MUÑOZ-ROJAS J. (2014): Places beyond maps; integrating spatial map analysis and perception studies to unravel landscape change in a Mediterranean mountain area (NE Spain). In: *Applied Geography*, vol. 52, 182–190.

GOOD P. (2005): *Resampling Methods - A Practical Guide to Data Analysis*. 3rd ed. Birkhäuser: Boston, Basel, Berlin.

GUEST G., BUNCE A., & JOHNSON L. (2006): How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. In: *Field Methods*, vol. 18:1, 59–82.

GUO Z., ZHANG L., & LI Y. (2010): Increased dependence of humans on ecosystem services and biodiversity. In: *PloS one*, vol. 5:10.

HAJJAR R., JARVIS D. I., & GEMMILL-HERREN B. (2008): The utility of crop genetic diversity in maintaining ecosystem services. In: *Agriculture, Ecosystems & Environment*, vol. 123:4, 261–270.

HAKLAY M. M., BASIOUKA S., ANTONIOU V., & ATHER A. (2010): How many volunteers does it take to map an area well ? The validity of Linus' law to volunteered geographic information. In: *The Cartographic Journal*, vol. 47:4, 315–322.

HALL T. E., FARNUM J. O., SLIDER T. C., & LUDLOW K. (2009): *New Approaches to Forest Planning: Inventorying and Mapping Place Values in the Pacific Northwest Region*. Portland, OR. Online available under: http://www.fs.fed.us/pnw/pubs/pnw_rn562.pdf [*Accessed November 27, 2015*].

HARVEY N. (2007): Use of heuristics: Insights from forecasting research. In: *Thinking & Reasoning*, vol. 13:1, 5–24.

HAUGE Å. (2007): Identity and Place: A Critical Comparison of Three Identity Theories. In: *Architectural Science Review*, vol. 50:1, 37–41.

HEIPKE C., MAYER H., & WIEDEMANN C. (1997): Evaluation of automatic road extraction_heipke1997. In: *IAPRS*vol. 32, pp. 151–160. Online available under: http://www.ifp.uni-stuttgart.de/publications/wg34/wg34_heipke.pdf [*Accessed September 17, 2014*].

HEPNER G. F. (1984): Use of Value Functions As a Possible Suitability Scaling Procedure in Automated Composite Mapping. In: *The Professional Geographer*, vol. 36:4, 468–472.

HERNÁNDEZ-MORCILLO M., PLIENINGER T., & BIELING C. (2013): An empirical review of cultural ecosystem service indicators. In: *Ecological Indicators*, vol. 29, 434–444.

HERWEG K., RIST S., LINIGER H., PRASHUN V., SCHNEIDER F., LEDERMANN T., FRY P., ZIMMERMANN A., HURNI H., & WIESMANN U. (2010): Transdisciplinarity: An Option for Applied Landscape Ecology in Complex and Uncertain Contexts. In: *Die Erde*, vol. 141:4, 321–339.

HEY J. D., NEUGEBAUER T., & SADRIEH A. (2009): An Experimental Analysis of Optimal Renewable Resource Management: The Fishery. In: *Environmental and Resource Economics*, vol. 44:2, 263–285.

HIGGINS-ZOGIB L., DUDLEY N., & KOTHARI A. (2010): Living Traditions: Protected Areas and Cultural Diversity. In: *Arguments for Protected Areas: Multiple Benefits for Conservation and Use*, Stolton, S. & Dudley, N. (Eds.), pp. 165–188. earthscan: London, Washington.

HOLLENSTEIN L., & PURVES R. (2010): Exploring place through user-generated content: Using Flickr to describe city cores. In: *Journal of Spatial Information Science*, vol. 1:1, 21–48.

HUBERT L. J., & GOLLEDGE R. G. (1982): Measuring Association between Spatially Defined Variables: Tjøstheim's Index and Some Extensions. In: *Geographical Analysis*, vol. 14:3, 273–278.

HUMMON D. M. (1992): Community Attachment: Local Sentiment and Sense of Place. In: *Place Attachment, Human behavior and environment*, Altman, I. & Low, S. M. (Eds.), pp. 253–277. Plenum Press: New York.

HUNZIKER M., FELBER P., GEHRING K., BUCHECKER M., BAUER N., & KIENAST F. (2008): Evaluation of Landscape Change by Different Social Groups. In: *Mountain Research and Development*, vol. 28:2, 140–147.

IAP2 (2007): IAP2 Spectrum of Public Participation. International Association for Public Participation. Online available under: www.iap2.org/resource/resmgr/imported/IAP2 Spectrum_vertical.pdf [*Accessed November 3, 2014*].

IRIMIA L., & PATRICHE C. (2010): Evaluating the ecological suitability of the vineyards, by using Geographic Information Systems (GIS). In: *Cercetări Agronomice în Moldova*, vol. XLIII:1.

ISHIZAKA A., & LABIB A. (2011): Review of the main developments in the analytic hierarchy process. In: *Expert Systems with Applications*, vol. 38:11, 14336–14345.

JACCARD P. (1908): Nouvelles recherches sur la distribution florale. In: *Bull. Soc. Vaudoise Sci. Nat*, vol. 44:163, 223–270.

JANKOWSKI P. (2009): Towards Participatory Geographic Information Systems for community-based environmental decision making. In: *Journal of environmental management*, vol. 90:6, 1966–71.

JANKOWSKI P., & NYERGES T. (2003): Toward a framework for research on geographic information-supported participatory decision-making. In: *URISA Journal*, vol. 15:1, 9–17.

JARVIS D. I., PADOCH C., & COOPER H. D. (2007): Biodiversity, Agriculture and Ecosystem Services. In: *Managing Biodiversity in Agricultural Ecosystems*, Jarvis, D. I., Padoch, C., & Cooper, H. D. (Eds.). Columbia University Press.

JOHNSON J. C. (1990): *Selecting Ethnographic Informants*. SAGE Publications, Inc.: Newbury Park, California.

JOHNSON R. B., & ONWUEGBUZIE A. J. (2004): Mixed Methods Research: A Research Paradigm Whose Time Has Come. In: *Educational Researcher*, vol. 33:14, 14–26.

JONES G. V., SNEAD N., & NELSON P. (2004): Geology and wine 8. Modeling viticultural landscapes: A GIS Analysis of the Terroir Potential in the Umpqua Valley of Oregon. In: *Geoscience Canada*, vol. 31:4, 167–178.

JORGENSEN B. S., & STEDMAN R. C. (2011): Measuring the spatial component of sense of place: a methodology for research on the spatial dynamics of psychological experiences of places. In: *Environment and Planning B: Planning and Design*, vol. 38:5, 795–813.

JUNGE X., LINDEMANN-MATTHIES P., HUNZIKER M., & SCHÜPBACH B. (2011): Aesthetic preferences of non-farmers and farmers for different land-use types and proportions of ecological compensation areas in the Swiss lowlands. In: *Biological Conservation*, vol. 144:5, 1430–1440.

KALELKAR A. S., & BROOKS R. E. (1978): Use of multidimensional utility functions in hazardous shipment decisions. In: *Accident Analysis and Prevention*, vol. 10:3, 251–265.

KAPLAN R., & KAPLAN S. (1989): *The Experience of Nature: A Psychological Perspective*. Cambridge University Press.

KAREIVA P., TALLIS H., RICKETTS T. H., DAILY G. C., & POLASKY S. (eds.) (2011): *Natural Capital: Theory and Practice of Mapping Ecosystem Services*. Oxford University Press, USA.

KARIMI A., BROWN G., & HOCKINGS M. (2015): Methods and participatory approaches for identifying social-ecological hotspots. In: *Applied Geography*, vol. 63, 9–20.

KAYE-BLAKE W., LI F., & MARTIN A. (2010): *Multi-agent Simulation Models in Agriculture: A Review of Their Construction and Uses*. Online available under: http://researcharchive.lincoln.ac.nz/dspace/handle/10182/1928 [*Accessed October 30, 2012*].

KEENEY R. L. (1992): *Value-Focused Thinking. A Path to Creative Decisionmaking*. Harvard University School Press: Cambridge.

KEENEY R. L., & RAIFFA H. (1993): *Decisions with Multiple Objectives: Preferences and Value Trade-Offs*. Cambridge University Press: Cambridge.

KLAIN S. C., & CHAN K. M. A. (2012): Navigating coastal values: Participatory mapping of ecosystem services for spatial planning. In: *Ecological Economics*, vol. 82, 104–113.

KLEIJER G., SCHORI A., & SCHIERSCHER-VIRET B. (2012): Die nationale Genbank von Agroscope ACW gestern , heute und morgen. In: *Agrarforschung Schweiz*, vol. 3:9, 408–413.

KODER W. (2014): Raron kämpft um seine Rebberge. In: *Walliser Bote*, March 5, 2.

LACH D. (2014): Challenges of Interdisciplinary Research: Reconciling Qualitative and Quantitative Methods for Understanding Human–Landscape Systems. In: *Environmental Management*, vol. 53:1, 88–93.

LAMARQUE P., TAPPEINER U., TURNER C., STEINBACHER M., BARDGETT R. D., SZUKICS U., SCHERMER M., & LAVOREL S. (2011): Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity. In: *Regional Environmental Change*, vol. 11:4, 791–804.

LAMNEK S. (2005): *Qualitative Sozialforschung: Lehrbuch*. Beltz: Weinheim.

LANE D. C., & HUSEMANN E. (2008): Steering without Circe: attending to reinforcing loops in social systems. In: *System Dynamics Review*, vol. 24:1, 37–61.

LANGE S. (2011): The Development of UNESCO's MAB Programme, with a Special Focus on Mountain Aspects. In: *Biosphere Reserves in the Mountains of the World Excellence in the Clouds?*, Austrian MAB Committee (Ed.). Austrian Sciences Academy Online available under: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/OAW_BR_Mountains_Excellence_in_the_Clouds_2011.pdf [*Accessed May 4, 2015*].

LECLERC C., & COPPENS D'EECKENBRUGGE G. (2012): Social Organization of Crop Genetic Diversity. The G × E × S Interaction Model. In: *Diversity*, vol. 4, 1–32.

LEE P. H., & YU P. L. (2013): An R package for analyzing and modeling ranking data. In: *BMC medical research methodology*, vol. 13:1.

LEI L., & HILTON B. (2013): A Spatially Intelligent Public Participation System for the Environmental Impact Assessment Process. In: *ISPRS International Journal of Geo-Information*, vol. 2, 480–506.

LENNÉ J., & WOOD D. (2011): *Agrobiodiversity Management for Food Security: A Critical Review*. CABI: Wallingford; Cambridge.

LENTZ S. (1990): *Agrargeographie der bündnerischen Südtaler Val Müstair und Val Poschiavo*. Mannheimer geographische Arbeiten: Mannheim.

LEWICKA M. (2005): Ways to make people active: The role of place attachment, cultural capital, and neighborhood ties. In: *Journal of Environmental Psychology*, vol. 25:4, 381–395.

–––– (2011): Place attachment: How far have we come in the last 40 years? In: *Journal of Environmental Psychology*, vol. 31:3, 207–230.

LIGMANN-ZIELINSKA A., & JANKOWSKI P. (2014): Spatially-explicit integrated uncertainty and sensitivity analysis of criteria weights in multicriteria land suitability evaluation. In: *Environmental Modelling and Software*, vol. 57, 235–247.

LIGTENBERG A., VAN LAMMEREN R. J. A., BREGT A. K., & BEULENS A. J. M. (2010): Validation of an agent-based model for spatial planning: A role-playing approach. In: *Computers, Environment and Urban Systems*, vol. 34:5, 424–434.

LINDEMANN-MATTHIES P., BRIEGEL R., SCHÜPBACH B., & JUNGE X. (2010): Aesthetic preference for a Swiss alpine landscape: The impact of different agricultural land-use with different biodiversity. In: *Landscape and Urban Planning*, vol. 98:2, 99–109.

LOWERY D. R., & MORSE W. C. (2013): A Qualitative Method for Collecting Spatial Data on Important Places for Recreation, Livelihoods, and Ecological Meanings. Integrating Focus Groups With Public Participation Geographic Information Systems. In: *Society & Natural Resources*, vol. 0, 1–16.

LYNAM T., JONG W. DE, SHEIL D., KUSUMANTO T., & EVANS K. (2007): A Review of Tools for Incorporating Community Knowledge, Preferences, and Values into Decision Making in Natural Resources Management. In: *Ecology and Society*, vol. 12:1.

LYON C. (2014): Place Systems and Social Resilience: A Framework for Understanding Place in Social Adaptation, Resilience, and Transformation. In: *Society & Natural Resources*, 1–15.

MAILLEFER C. (2013): Vielfalt der Kulturpflanzen im Alpenraum: Cadi Roggen, Parli Kartoffeln, Italienerspinat. In: *HOTSPOT*, vol. 27, 26–27, Online available under: http://www.biodiversity.ch/downloads/hotspot27dt.pdf [*Accessed November 3, 2014*].

MALCZEWSKI J. (1999): *GIS and Multicriteria Decision Analysis*. John Wiley & Sons Inc.

–––– (2006): GIS‐based multicriteria decision analysis: a survey of the literature. In: *International Journal of Geographical Information Science*, vol. 20:December, 703–726.

MALCZEWSKI J., & RINNER C. (2015): *Multicriteria Decision Analysis in Geographic Information*. Springer.

MARSHALL M. N. (1996): Sampling for qualitative research. In: *Family practice*, vol. 13:6, 522–5.

MASCARENHAS J., & KUMAR P. (1991): Participatory mapping and modelling users' notes. In: *RRA notes*, pp. 9–20. IIED: London Online available under: http://www.spore-subs.org/pla54/docs/addref/plan_01203.pdf [*Accessed April 25, 2013*].

MASON M. (2010): Sample Size and Saturation in PhD Studies Using Qualitative Interviews. In: *Forum Qualitative Sozialforschung*, vol. 11, Online available under: http://www.qualitative-research.net/index.php/fqs/article/view/1428/3027 [*Accessed October 27, 2012*].

MASSEY D. (2002): Globalisation: What does it mean for geography? In: *Geography*, vol. 87:4, 293–296.

MATHER R., BOER M. DE, GURUNG M., & ROCHE N. (1998): Aerial Photographs and Photo-Maps for Community Forestry. In: *Rural Development for Network (RDFN) papers*, *Rural Development for Network (RDFN) papers*. Online available under: http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/1188.pdf [*Accessed December 13, 2013*].

MAYRING P. (2003): *Qualitative Inhaltsanalyse: Grundlagen und Techniken*. Beltz: Basel.

–––– (2009): Qualitative Inhaltsanalyse. In: *Qualitative Forschung. Ein Handbuch*, Flick, U., v. Kardoff, E., & Steinke, I. (Eds.), p. 468. Rowohlt: Reinbek b. Hamburg.

MCCALL M. (2006): Precision for whom? Mapping ambiguity and certainty in (Participatory) GIS. In: *Participatory Learning and Action*, vol. 54, 114–119.

McLain R., Poe M., Biedenweg K., Cerveny L., Besser D., & Blahna D. (2013): Making Sense of Human Ecology Mapping: An Overview of Approaches to Integrating Socio-Spatial Data into Environmental Planning. In: *Human Ecology*, vol. 41:5, 651–665.

MEA (2003): *Ecosystems and Human Well-Being: A Framework for Assessment*. Alcamo, J. & Bennett, E. (Eds.). Island Press: Washington, D.C. Online available under: http://pdf.wri.org/ecosystems_human_wellbeing.pdf [*Accessed June 19, 2013*].

–––– (2005): *Ecosystems and Human Well-being: Synthesis*. In: *World Health*. Island Press: Washington, D.C. Online available under: http://www.maweb.org/documents/document.356.aspx.pdf [*Accessed November 3, 2014*].

Mendoza G. A., & Martins H. (2006): Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. In: *Forest Ecology and Management*, vol. 230:1-3, 1–22.

Meuser M., & Nagel U. (1991): ExpertInneninterviews — vielfach erprobt, wenig bedacht. Ein Beitrag zur qualitativen Methodendiskussion. In: *Qualitativ-empirische Sozialforschung: Konzepte, Methoden, Analysen*, Garz, D. & Kraimer, K. (Eds.), pp. 441–471. Westdeutscher Verlag: Opladen.

Meyfroidt P. (2013): Environmental Cognitions, Land Change and Social-Ecological Feedbacks: Local Case Studies of Forest Transition in Vietnam. In: *Human Ecology*, vol. 41, 367–392.

Mihaylov N., & Perkins D. D. (2014): Community Place Attachment and its Role in Social Capital Development in Response to Environmental Disruption. In: *Place Attachment: Advances in Theory, Methods and Research*, Manzo, L. & Devine-Wright, P. (Eds.), pp. 61–74. Routledge.

Milcu A. I., Hanspach J., Abson D., & Fischer J. (2013): Cultural Ecosystem Services: A Literature Review and Prospects for Future Research. In: *Ecology and Society*, vol. 18:3.

Moller H., & Berkes F. (2004): Combining science and traditional ecological knowledge: monitoring populations for co-management. In: *Ecology and Society*, vol. 9:3.

Monmonier M. (1993): *Mapping it out: expository cartography for the humanities and social sciences*. University of Chicago Press: Chicago.

Montello D., Goodchild M., Gottsegen J., & Fohl P. (2003): Where's Downtown ?: Behavioral Methods for Determining Referents of Vague Spatial Queries. In: *Spatial Cognition & Computation*, vol. 3:2-3, 185–204.

Morgan R. K. (1998): *Environmental Impact Assessment: A Methodological Approach*. Springer Science & Business Media.

Morse W. C. (2012): Changing Stakeholders and the Planning Process. In: *Urban-Rural Interfaces: Linking People and Nature*, Laband, D. N., Lockaby, B. G., & Zipperer, W. (Eds.), pp. 201–224. American Society of Agronomy: Madison.

Morse W. C., Lowery D. R., & Steury T. (2014): Exploring Saturation of Themes and Spatial Locations in Qualitative Public Participation Geographic Information Systems Research. In: *Society & Natural Resources*, vol. 27:5, 557–571.

Mounir A. (2008): *Salgesch und seine Vergangenheit*. Rotten-Verlag: Visp.

Muckel P. (2011): Die Entwicklung von Kategorien mit der Methode der Grounded Theory. In: *Grounded Theory Reader*, Mey, G. (Ed.), pp. 333–352. VS Verlag für Sozialwissenschaften: Wiesbaden.

Murray-Rust D., Dendoncker N., Dawson T. P., Acosta-Michlik L., Karali E., Guillem E., & Rounsevell M. (2011): Conceptualising the analysis of socio- ecological systems through ecosystem services and agent-based modelling. In: *Journal of Land Use Science*, vol. 6:2-3, 83–99.

NABHAN G. P., KEN WILSON, AKNAZAROV O., KASSAM K.-A., MONTI L., CAVAGNARO D., KELLY S., JOHNSON T., & SEKACUCU F. (2012): Agrobiodiversity Shifts on Three Continents Since Vavilov and Harlan: Assessing Causes, Processes, and Implications for Food Security. In: *Biodiversity in Agriculture*, Gepts, P., Famula, T. R., Bettinger, R. L., Brush, S. B., Damania, A. B., McGuire, P. E., & Qualset, C. O. (Eds.), pp. 407–425. Cambridge University Press: Cambridge.

NARLOCH U., DRUCKER A. G., & PASCUAL U. (2011): Payments for agrobiodiversity conservation services for sustained on-farm utilization of plant and animal genetic resources. In: *Ecological Economics*, vol. 70:11, 1837–1845.

NEGRI V. (2003): Landraces in central Italy : where and why they are conserved and perspectives for their on-farm conservation. In: *Genetic Resources and Crop Evolution*, vol. 50, 871–885.

NEßHÖVER C., TIMAEUS J., WITTMER H., KRIEG A., GEAMANA N., HOVE S. VAN DEN, & JULIETTE YOUNG A. W. (2013): Improving the Science-Policy Interface of Biodiversity Research Projects. In: *GAIA*, vol. 22:2, 99–103.

NIELSEN-PINCUS M. (2011): Mapping a Values Typology in Three Counties of the Interior Northwest, USA: Scale, Geographic Associations Among Values, and the Use of Intensity Weights. In: *Society & Natural Resources*, vol. 24:6, 535–552.

NORRIS F. H., STEVENS S. P., PFEFFERBAUM B., WYCHE K. F., & PFEFFERBAUM R. L. (2008): Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. In: *American Journal of Community Psychology*, vol. 41:1-2, 127–150.

OKALI C., SUMBERG J., & FARRINGTON J. (1994): *Farmer Participatory Research: Rhetoric and reality.* Intermediate Technology Publications Ltd: London.

OLSON D. L., & DELEN D. (2008): Performance Evaluation for Predictive Modeling. In: *Advanced Data Mining Techniques*, Olson, D. L. & Delen, D. (Eds.), pp. 137–147. Springer, Heidelberg: Berlin Heidelberg.

OORT P. VAN (2006): "Spatial data quality: from description to application." Wageningen University, Online available under: http://edepot.wur.nl/38987 [*Accessed February 6, 2015*].

OSORIO F., & VALLEJOS R. (2014): SpatialPack: Package for analysis of spatial data. , 0.2-3. Online available under: http://cran.r-project.org/package=SpatialPack [*Accessed July 4, 2015*].

OSTROM E. (2009): A general framework for analyzing sustainability of social-ecological systems. In: *Science*, vol. 325:5939, 419–422.

PAASI A. (1986): The institutionalization of regions: a theoretical framework for understanding the emergence of regions and the constitution of regional identity. In: *Fennia*, vol. 164:1, 106–146.

PADMANABA M., SHEIL D., BASUKI I., & LISWANTI N. (2013): Accessing Local Knowledge to Identify Where Species of Conservation Concern Occur in a Tropical Forest Landscape. In: *Environmental management*, vol. 52, 348–359.

PAETZOLD A., WARREN P. H., & MALTBY L. L. (2010): A framework for assessing ecological quality based on ecosystem services. In: *Ecological Complexity*, vol. 7:3, 273–281.

PALOMO I., MARTÍN-LÓPEZ B., POTSCHIN M., HAINES-YOUNG R., & MONTES C. (2013): National Parks, buffer zones and surrounding lands: Mapping ecosystem service flows. In: *Ecosystem Services*, vol. 4, 104–116.

PATTON M. Q. (2015): *Qualitative research & evaluation methods: integrating theory and practice*. 4th ed. Thousand Oaks: Sage Publications.

PAWLAK Z. (1982): Rough Sets. In: *International Journal of Computer and Information Science*, vol. 11:5, 341–356.

PAYTON R. W., BARR J. J. F., MARTIN A., SILLITOE P., DECKERS J. F., GOWING J. W., HATIBU N., NASEEM S. B., TENYWA M., & ZUBERI M. I. (2003): Contrasting approaches to integrating indigenous knowledge about soils and scientific soil survey in East Africa and Bangladesh. In: *Geoderma*, vol. 111:3-4, 355–386.

PERRINGS C., NAEEM S., & AHRESTANI F. (2010): Ecosystem services for 2020. In: *Science*, vol. 330, 323–324.

PLIENINGER T., DIJKS S., OTEROS-ROZAS E., & BIELING C. (2013): Assessing, mapping, and quantifying cultural ecosystem services at community level. In: *Land Use Policy*, vol. 33, 118–129.

POCEWICZ A., NIELSEN-PINCUS M., BROWN G., & SCHNITZER R. (2012): An Evaluation of Internet Versus Paper-based Methods for Public Participation Geographic Information Systems (PPGIS). In: *Transactions in GIS*, vol. 16:1, 39–53.

PONTIUS R. G., BOERSMA W., CASTELLA J.-C., CLARKE K., DE NIJS T., DIETZEL C., DUAN Z., FOTSING E., GOLDSTEIN N., KOK K., KOOMEN E., LIPPITT C. D., MCCONNELL W., MOHD SOOD A., PIJANOWSKI B., PITHADIA S., SWEENEY S., TRUNG T. N., VELDKAMP A. T., & VERBURG P. H. (2008): Comparing the input, output, and validation maps for several models of land change. In: *The Annals of Regional Science*, vol. 42:1, 11–37.

PONTIUS R. G., HUFFAKER D., & DENMAN K. (2004): Useful techniques of validation for spatially explicit land-change models. In: *Ecological Modelling*, vol. 179:4, 445–461.

PONTIUS R. G., & SPENCER J. (2005): Uncertainty in extrapolations of predictive land-change models. In: *Environment and Planning B: Planning and Design*, vol. 32:2, 211–230.

POTSCHIN M. B., & HAINES-YOUNG R. H. (2011): Ecosystem services: Exploring a geographical perspective. In: *Progress in Physical Geography*, vol. 35:5, 575–594.

QIU F., CHASTAIN B., ZHOU Y., ZHANG C., & SRIDHARAN H. (2014): Modeling land suitability/capability using fuzzy evaluation. In: *GeoJournal*, vol. 79, 167–182.

R CORE TEAM (2015): R: A Language and Environment for Statistical Computing. Vienna, Austria. Online available under: http://www.r-project.org/.

RAYMOND C. M., BRYAN B. A., MACDONALD D. H., CAST A., STRATHEARN S., GRANDGIRARD A., & KALIVAS T. (2009): Mapping community values for natural capital and ecosystem services. In: *Ecological Economics*, vol. 68:5, 1301–1315.

RAYMOND C. M., FAZEY I., REED M. S., STRINGER L. C., ROBINSON G. M., & EVELY A. C. (2010): Integrating local and scientific knowledge for environmental management. In: *Journal of Environmental Management*, vol. 91:8, 1766–1777.

RAYMOND C. M., SINGH G. G., BENESSAIAH K., BERNHARDT J. R., LEVINE J., NELSON H., TURNER N. J., NORTON B., TAM J., & CHAN K. M. A. (2013): Ecosystem Services and Beyond. In: *BioScience*, vol. 63:7, 536–546.

REED M. S. (2008): Stakeholder participation for environmental management: A literature review. In: *Biological Conservation*, vol. 141:10, 2417–2431.

RELPH E. (1976): *Place and placelessness*. Pion: London.

RERKASEM K., & PINEDO-VASQUEZ M. (2007): Innovation in Smallholder Systems in Response to Environmental and Economic Changes. In: *Managing Biodiversity in Agricultural Ecosystems*, Jarvis, D. I., Padoch, C., & Cooper, H. D. (Eds.). Columbia University Press.

REYES-GARCÍA V., ORTA-MARTÍNEZ M., GUEZE M., LUZ A. C., PANEQUE-GÁLVEZ J., MACÍA M. J., & PINO J. (2012): Does participatory mapping increase conflicts? A randomized evaluation in the Bolivian Amazon. In: *Applied Geography*, vol. 34, 650–658.

RICHNER M. (2011): Direktzahlungen sollen auch Landschaftsqualität fördern. In: *Forum Raumentwicklung*, February, vol. 2, 17–18.

RIEDER P. (1996): Die Landwirtschaft im Schweizer Alpenraum. In: *Landwirtschaft im Alpenraum : unverzichtbar, aber zukunftslos*, Bätzing, W. & Barberis, C. (Eds.), pp. 117–139.

RIEDER P., EGGER U., & FLÜCKIGER S. (1992): *Schweizerische Agrarmärkte*. Verlag der Fachvereine: Zürich.

RILEY R. B. (1992): Attachment to the Ordinary Landscape. In: *Place Attachment, Human behavior and environment*, Altman, I. & Low, S. M. (Eds.), pp. 13–36. Plenum Press: New York.

RODEWALD R. (2007): *Instrumente zur nachhaltigen Entwicklung der Terrassenlandschaften. Eine Studie im Rahmen von Proterra - Aktion zur Erhaltung der Terrassenlandschaften der Schweiz*. Online available under: www.sl-fp.ch/getdatei.php?datei_id=615 [*Accessed December 27, 2015*].

RODGERS J. L. (1999): The Bootstrap, the Jackknife, and the Randomization Test: A Sampling Taxonomy. In: *Multivariate Behavioral Research*, vol. 34:4, 441–456.

ROHRBACH B., ANDERSON S., & LAUBE P. (2015): The effects of sample size on data quality in participatory mapping of past land use. In: *Environment and Planning B: Planning and Design*.

ROHRBACH B., & LAUBE P. (2014): Spatial variation of participants ' coverage in participatory mapping. In: *Proceedings of the GIScience 2014*, pp. 390–395.

ROMNEY A. K., WELLER S. C., & BATCHELDER W. H. (1986): Culture as Consensus: A Theory of Culture and Informant Accuracy. In: *American Anthropologist*, vol. 88:2, 313–338.

RUEF D., & LADURNER U. (1998): *Bauern am Berg*. Offizin: Zürich.

RYKIEL E. J. (1996): Testing ecological models: the meaning of validation. In: *Ecological modelling*, 229–244.

SAATY T. L. (1995): *Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*. 3rd ed. RWS Publications.

SALO A. A, & HÄMÄLÄINEN R. P. (1997): On the measurement of preferences in the analytic hierarchy process. In: *Journal of Multi-Criteria Decision Analysis*, vol. 6:6, 309–319.

SCANNELL L., & GIFFORD R. (2010): Defining place attachment: A tripartite organizing framework. In: *Journal of Environmental Psychology*, vol. 30:1, 1–10.

SCHLEGEL W. (1973): *Der Weinbau in der Schweiz*. Franz Steiner Verlag GmbH: Wiesbaden.

SCHLOSSBERG M., & SHUFORD E. (2005): Delineating "public" and "participation" in PPGIS. In: *Urisa Journal*, vol. 16:2, 15–26.

SCHNEIDER L. C., & PONTIUS R. G. (2001): Modeling land-use change in the Ipswich watershed, Massachusetts, USA. In: *Agriculture, Ecosystems and Environment*, vol. 85, 83–94.

SCHWARTZ S. H. (1973): Normative explanations of helping behavior: A critique, proposal, and empirical test. In: *Journal of Experimental Social Psychology*, vol. 9:4, 349–364.

SCOLOZZI R., SCHIRPKE U., DETASSIS C., ABDULLAH S., & GRETTER A. (2014): Mapping Alpine Landscape Values and Related Threats as Perceived by Tourists. In: *Landscape Research*, 1–15.

SEE L., MCCALLUM I., FRITZ S., PERGER C., KRAXNER F., OBERSTEINER M., BARUAH U. D., MILI N., & KALITA N. R. (2013): Mapping Cropland in Ethiopia Using Crowdsourcing. In: *International Journal of Geosciences*, vol. 4, 6–13.

SEIDL I., & BŐNI R. (2011): *Alpprodukte und Alpdienstleistungen in ausgewählten Regionen der Schweiz. Ergebnisse einer Angebotserhebung und einer Befragung von Alpbewirtschaftern in sechs Fallstudienregionen*. Eidg. Forschungsanstalt für Wald, Schnee und Landschaft WSL: Birmensdorf. Online available under: www.wsl.ch/dienstleistungen/publikationen/pdf/11259.pdf [*Accessed November 3, 2014*].

SEPPELT R., FATH B., BURKHARD B., FISHER J. L., GRÊT-REGAMEY A., LAUTENBACH S., PERT P., HOTES S., SPANGENBERG J., VERBURG P. H., & VAN OUDENHOVEN A. P. E. (2012): Form follows function? Proposing a blueprint for ecosystem service assessments based on reviews and case studies. In: *Ecological Indicators*, vol. 21, 145–154.

SHERROUSE B. C., CLEMENT J. M., & SEMMENS D. J. (2011): A GIS application for assessing, mapping, and quantifying the social values of ecosystem services. In: *Applied Geography*, vol. 31:2, 748–760.

SIEBER R. (2004): A PPGIScience? In: *Cartographica*, vol. 38:3&4, 2–5.

SIEBER R. (2006): Public Participation Geographic Information Systems: A Literature Review and Framework. In: *Annals of the Association of American Geographers*, vol. 96:3, 491–507.

SIMÃO A., DENSHAM P. J., & HAKLAY M. M. (2009): Web-based GIS for collaborative planning and public participation: an application to the strategic planning of wind farm sites. In: *Journal of environmental management*, vol. 90:6, 2027–40.

SIMMONS I. G. (1996): *Humanity and Environment: A Cultural Ecology*. Longman Pub Group.

SIRAJ S., MIKHAILOV L., & KEANE J. A. (2015): Contribution of individual judgments toward inconsistency in pairwise comparisons. In: *European Journal of Operational Research*, vol. 242:2, 557–567.

SLOCUM T. A. (2014): *Thematic cartography and geovisualization*. 3rd, inter. Upper Saddle River : Pearson Prentice Hall.

SOHL T. L., & CLAGGETT P. R. (2013): Clarity versus complexity: Land-use modeling as a practical tool for decision-makers. In: *Journal of Environmental Management*, vol. 129, 235–243.

SOWIŃSKA-ŚWIERKOSZ B., & CHMIELEWSKI T. J. (2014): Comparative assessment of public opinion on the landscape quality of two biosphere reserves in europe. In: *Environmental management*, vol. 54:3, 531–56.

SPEICH M., & BLUMER W. (2000): *Wir Bergler sind zäh*. Schweizer Patenschaft für Berggemeinden.

STAUB C., OTT W., HEUSI F., KLINGLER G., JENNY A., HÄCKI M., & HAUSER A. (2011): *Indicators for Ecosystem Goods and Services. Framework, methodology and recommendations for a welfare-related environmental reporting*. Online available under: http://www.bafu.admin.ch/publikationen/publikation/01587/index.html?lang=en [*Accessed September 25, 2012*].

STAUFFACHER M., FLÜELER T., KRÜTLI P., & SCHOLZ R. W. (2008): Analytic and Dynamic Approach to Collaboration: A Transdisciplinary Case Study on Sustainable Landscape Development in a Swiss Prealpine Region. In: *Systemic Practice and Action Research*, vol. 21:6, 409–422.

STEDMAN R. C. (2002): Toward a Social Psychology of Place: Predicting Behavior from Place-Based Cognitions, Attitude, and Identity. In: *Environment and Behavior*, vol. 34:5, 561–581.

STEPHENSON J. (2008): The Cultural Values Model: An integrated approach to values in landscapes. In: *Landscape and Urban Planning*, vol. 84, 127–139.

STERMAN J. D. (1994): Learning in and about complex systems. In: *System Dynamics Reivew*, vol. 10:2-3, 291–330.

STEWART E. J., JACOBSON D., & DRAPER D. (2008): Public participation geographic information systems (PPGIS): Challenges of implementation in Churchill, Manitoba. In: *Canadian Geographer*, vol. 52:3, 351–366.

STOLTON S., MAXTED N., FORD-LLOYD B., KELL S., & DUDLEY N. (2006): *Arguments for Protection. Food Stores: Using Protected Areas to Secure Crop Genetic Diversity*. In: *Wild*. WWF – World Wide Fund for Nature. Online available under: http://awsassets.panda.org/downloads/food_stores.pdf [*Accessed July 31, 2012*].

STRAUSS A. L. (2004): Methodologische Grundlagen der Grounded Theory. In: *Methodologie interpretativer Sozialforschung. Klassische Grundlagentexte*, *UTB*, Strübing, J. (Ed.). UVK-Verlagsgesellschaft: Konstanz.

SWISS FEDERAL STATISTICAL OFFICE (2010): Arealstatistik 2004/09. Online available under: https://www.pxweb.bfs.admin.ch [*Accessed June 30, 2015*].

–––– (2015): Landwirtschaftliche Strukturerhebung. Online available under: http://www.bfs.admin.ch/bfs/portal/de/index/infothek/erhebungen__quellen/blank/blank/lb/01.html [*Accessed December 16, 2015*].

TANNER A. (2010): Anbauschlacht. In: *Historisches Lexikon der Schweiz (HLS)*. Online available under: http://www.hls-dhs-dss.ch/textes/d/D13783.php [*Accessed December 16, 2015*].

TANNER C. (1999): Constraints on Environmental Behaviour. In: *Journal of Environmental Psychology*, vol. 19:2, 145–157.

TEEB (2010): *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*. Kumar, P. (Ed.). Earthscan: London, Washington.

TERMORSHUIZEN J. W., & OPDAM P. (2009): Landscape services as a bridge between landscape ecology and sustainable development. In: *Landscape Ecology*, vol. 24:8, 1037–1052.

TONIETTO J., & CARBONNEAU A. (2004): A multicriteria climatic classification system for grape-growing regions worldwide. In: *Agricultural and Forest Meteorology*, vol. 124, 81–97.

TOWERS G. (1997): GIS versus the community. In: *Applied Geography*, vol. 17:2, 111–125.

TULLOCH D. (2008): Public Participation GIS (PPGIS). In: *Encyclopedia of Geographic Information Science*, 352–355.

TVERSKY A., & KAHNEMAN D. (1974): Judgment under Uncertainty: Heuristics and Biases. In: *Science*, vol. 185:4157, 1124–1131.

TYRVÄINEN L., MÄKINEN K., & SCHIPPERIJN J. (2007): Tools for mapping social values of urban woodlands and other green areas. In: *Landscape and Urban Planning*, vol. 79:1, 5–19.

VALLAT J. (2010): Enquête sur l'avenier de la viticulture dans trois régions alpines: Valais (CH), Valléö d'Aoste (I) et Chautagne (F). In: *Vignes et viticulteurs de montagne: histoire, pratiques, savoirs et paysages: Valais, Alpes occidentales, Pyrénées, Mont-Liban*vol. 22, Dubuis, P. (Ed.), pp. 263–270. Archives de l'Etat du Valais: Sion.

VELDKAMP A., & LAMBIN E. . (2001): Predicting land-use change. In: *Agriculture, Ecosystems & Environment*, vol. 85:1-3, 1–6.

VERBRUG P. H., VELDKAMP A., ESPALDON V., & MASTURA S. A. (2002): Modelling the Spatial Dynamics of Regional LandUse: The CLUE-S Model. In: *Environmental Management*, vol. 30:3, 391–405.

VEREGIN H. (1999): Data quality parameters. In: *Geographical information systems*, Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (Eds.), pp. 177–190. Wiley: New York.

VERGARA-ASENJO G., SHARMA D., & POTVIN C. (2015): Engaging Stakeholders: Assessing Accuracy of Participatory Mapping of Land Cover in Panama. In: *Conservation Letters*, vol. In Press.

VORKINN M., & RIESE H. (2001): Environmental Concern in a Local Context: The Significance of Place Attachment. In: *Environment and Behavior*, vol. 33:2, 249–263.

WAGENAAR W. A., & SAGARIA S. D. (1975): Misperception of exponential growth. In: *Perception & Psychophysics*, vol. 18:6, 416–422.

WALKER W. E., HARREMOËS P., ROTMANS J., VAN DER SLUIJS J. P., VAN ASSELT M. B. A., JANSSEN P., & KRAYER VON KRAUSS M. P. (2003): Defining Uncertainty: A Conceptual Basis for Uncertainty Management in Model-Based Decision Support. In: *Integrated Assessment*, vol. 4:1, 5–17.

WARTMANN F. M. (2016): "From Space to Place in the Bolivian Amazon – Exploring and Representing Folk Landscape Categories with Ethnographic and GIS Approaches." University of Zurich.

WEINERNTEBERICHT 2004-2014 (2015): *Weinernteberricht 2004-2014*. Online available under: https://www.vs.ch/de/web/scav/publikationen/berichte [*Accessed January 8, 2016*].

WHITEHEAD A. L., KUJALA H., IVES C. D., GORDON A., LENTINI P. E., WINTLE B. A., NICHOLSON E., & RAYMOND C. M. (2014): Integrating Biological and Social Values When Prioritizing Places for Biodiversity Conservation. In: *Conservation Biology*, vol. 28:4, 992–1003.

WILLEMEN L., VELDKAMP A., VERBURG P. H., HEIN L., & LEEMANS R. (2012): A multi-scale modelling approach for analysing landscape service dynamics. In: *Journal of environmental management*, vol. 100, 86–95.

WINTERFELDT D. VON, & EDWARDS W. (1986): *Decision analysis and behavioral research*. Reprint. Cambridge University Press: Cambridge.

WORBOYS M., & DUCKHAM M. (2004): *GIS a computing perspective*. 2nd ed. CRC Press LLC: Boca Raton, Florida.

YAGER R. R. (1988): On ordered weighted averaging aggregation operators in multi criteria decision making. In: *IEEE Trans. Syst. Man Cybern.*, vol. 18:1, 183–190.

YATES K. L., & SCHOEMAN D. S. (2013): Spatial access priority mapping (SAPM) with fishers: a quantitative GIS method for participatory planning. In: *PloS one*, vol. 8:7, e68424.

YAU I.-H., DAVENPORT J. R., & MOYER M. M. (2014): Developing a Wine Grape Site Evaluation Decision Support System for the Inland Pacific Northwestern United States. In: *HortTechnology*, vol. 24:1, 88–98.

ZELLNER M. L., LYONS L. B., HOCH C. J., WEIZEORICK J., KUNDA C., & MILZ D. C. (2012): Modeling , learning , and Planning together : An Application of Participatory Agent-based Modeling to Environmental Planning. In: *Urisa Journal*, vol. 24:1, 77–92.

ZHU X., PFUELLER S., WHITELAW P., & WINTER C. (2010): Spatial differentiation of landscape values in the Murray river region of Victoria, Australia. In: *Environmental Management*, vol. 45:5, 896–911.

ZIMMERMANN N. E., & KIENAST F. (1999): Predictive mapping of alpine grasslands in Switzerland: Species versus community approach. In: *Journal of Vegetation Science*, vol. 10, 469–482.

DI ZIO S., & PACINELLI A. (2011): Opinion convergence in location: A spatial version of the Delphi method. In: *Technological Forecasting and Social Change*, vol. 78:9, 1565–1578.

Appendix A: ‘Pre Questionnaires’

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PARMESAN
PARticipatory Mapping of Ecosystem Service poteNtials

a) Persönliche Daten

Vorname: ____________________ Nachname: ______________________________

Befasse mit mit Ackerbau seit: ___ Jahren Jahrgang: ______________

b) Betriebsdaten

BesitzerIN von ca. ___ ha LN (ohne Wald) PächterIN von ___ ha LN (ohne Wald)

Bewirtschaftete ca. ___ ha Ackerfläche im 2012 total ca. ___ Vollzeit-Stellen

Ich habe im 2013 ca. ___ ha Acker geplant Ich kann mir im 2017 ca. ___ ha Acker vorstellen

c) Einstellung

Bitte kreuzen Sie das passendste Feld an, von trifft zu bis trifft überhaupt nicht zu.

	Stimmt	Stimmt teilweise	Weder Noch	Stimmt eher nicht	Stimmt nicht	Weiss nicht
Bergackerbau ist ein wichtiger Teil unserer Kultur	☐	☐	☐	☐	☐	☐
Bergackerbau ist wichtig für die Vielfalt an Kulturpflanzen	☐	☐	☐	☐	☐	☐
Ackerbau lohnt sich für mich	☐	☐	☐	☐	☐	☐
Bergackerbau zu betreiben ist eine gute Sache	☐	☐	☐	☐	☐	☐
Personen, die mir wichtig sind (Familie, Freunde) finden Bergackerbau sinnvoll	☐	☐	☐	☐	☐	☐
Ackerbau erhöht mein Ansehen	☐	☐	☐	☐	☐	☐
Andere Landwirte in meiner Situation betreiben Ackerbau	☐	☐	☐	☐	☐	☐
Ackerbau ist auf dem von mir bewirtschafteten Land möglich	☐	☐	☐	☐	☐	☐
Die Situation (finanziell, betrieblich…) erlaubt mir Bergackerbau zu betreiben	☐	☐	☐	☐	☐	☐
Ich habe das Wissen und die Möglichkeiten für Bergackerbau	☐	☐	☐	☐	☐	☐

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PARMESAN
PARticipatory Mapping of Ecosystem Service poteNtials

a) Persönliche Daten

Vorname: ____________________ Nachname: ______________________________

Befasse mich mit Weinbau seit ca. ___ Jahren Jahrgang: _____________

b) Betriebsdaten

Ich bewirtschafte ca. ___ ha Weinbaufläche Ich beziehe von ca. ___ a Trauben

Ich schätze im 2025 ca. ___ a zu bewirtschaften

Der Betrieb hat ca. ___ Vollzeit-Stellen im Weinbau. Ich keltere selbst: ☐ Ja ☐ Nein

Alter der eigenen Bestockung im Durchschnitt: ca. ___ Jahre | von ___ bis ___ Jahren

c) Einschätzung

Bitte kreuzen Sie das passendste Feld an, von trifft zu bis trifft überhaupt nicht zu.

	Stimmt	Stimmt teilweise	Weder Noch	Stimmt eher nicht	Stimmt nicht	Weiss nicht
Der Weinbau ist ein wichtiger Teil unserer Kultur	☐	☐	☐	☐	☐	☐
Der Weinbau ist wichtig für die Vielfalt an Kulturpflanzen	☐	☐	☐	☐	☐	☐
Weinbau lohnt sich für mich	☐	☐	☐	☐	☐	☐
Weinbau zu betreiben ist eine gute Sache	☐	☐	☐	☐	☐	☐
Personen, die mir wichtig sind (Familie, Freunde) finden Weinbau sinnvoll	☐	☐	☐	☐	☐	☐
Weinbau erhöht mein Ansehen	☐	☐	☐	☐	☐	☐
Andere Personen in meiner Situation betreiben Weinbau	☐	☐	☐	☐	☐	☐
Weinbau ist auf dem von mir zugänglichen Land möglich	☐	☐	☐	☐	☐	☐
Die Situation (finanziell, organisatorisch…) erlaubt mir Weinbau zu betreiben	☐	☐	☐	☐	☐	☐
Ich habe das Wissen und die Möglichkeiten für den Weinbau	☐	☐	☐	☐	☐	☐

Appendix B: ‘Post Questionnaires’

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PARMESAN
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a) Das Kartieren

	Stimmt	Stimmt teilweise	Weder Noch	Stimmt eher nicht	Stimmt nicht	Weiss nicht
Die Flächen auf dem Luftbild einzuzeichnen war einfach						
Grober Massstab	☐	☐	☐	☐	☐	☐
Mittlerer Massstab	☐	☐	☐	☐	☐	☐
Feiner Massstab	☐	☐	☐	☐	☐	☐
Die Flächen auf dem Luftbild einzuzeichnen hat mir:						
Spass gemacht	☐	☐	☐	☐	☐	☐
Neue Ideen gegeben	☐	☐	☐	☐	☐	☐
Die genannten Fördermöglichkeiten haben mich auf neue Ideen gebracht	☐	☐	☐	☐	☐	☐

Für das Kartieren wurden gewisse Kulturen genannt. Welche anderen Kulturen wären Ihrer Meinung nach wichtig?

____________________ ____________________

____________________ ____________________

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b) Einstellung

Ich habe im 2013 ___ ha Ackerbau geplant Ich kann mir im 2017 ___ ha Ackerbau vorstellen

Bitte kreuzen Sie das passendste Feld an, von trifft zu bis trifft überhaupt nicht zu.

	Stimmt	Stimmt teilweise	Weder Noch	Stimmt eher nicht	Stimmt nicht	Weiss nicht
Bergackerbau ist ein wichtiger Teil unserer Kultur	☐	☐	☐	☐	☐	☐
Bergackerbau ist wichtig für die Vielfalt an Kulturpflanzen	☐	☐	☐	☐	☐	☐
Ackerbau lohnt sich für mich	☐	☐	☐	☐	☐	☐
Bergackerbau zu betreiben ist eine gute Sache	☐	☐	☐	☐	☐	☐
Personen, die mir wichtig sind (Familie, Freunde) finden Bergackerbau sinnvoll	☐	☐	☐	☐	☐	☐
Ackerbau erhöht mein Ansehen	☐	☐	☐	☐	☐	☐
Andere Landwirte in meiner Situation betreiben Ackerbau	☐	☐	☐	☐	☐	☐
Ackerbau ist auf dem von mir bewirtschafteten Land möglich	☐	☐	☐	☐	☐	☐
Die Situation (finanziell, betrieblich…) erlaubt mir Bergackerbau zu betreiben	☐	☐	☐	☐	☐	☐
Ich habe das Wissen und die Möglichkeiten für Bergackerbau	☐	☐	☐	☐	☐	☐

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PARMESAN
PARticipatory Mapping of Ecosystem Service poteNtials

a) Das Kartieren

	Stimmt	Stimmt teilweise	Weder Noch	Stimmt eher nicht	Stimmt nicht	Weiss nicht
Die Flächen auf dem Luftbild einzuzeichnen war einfach	☐	☐	☐	☐	☐	☐
Die Flächen auf dem Luftbild waren zu klein	☐	☐	☐	☐	☐	☐
Die Flächen auf dem Luftbild einzuzeichnen hat mir:						
Spass gemacht	☐	☐	☐	☐	☐	☐
Neue Ideen gegeben	☐	☐	☐	☐	☐	☐

b) Landnutzungswandel

Bitte geben Sie bis zu 3 wichtigste Gründe an, eine Parzelle erneut zu bestocken an, und bewerten Sie diese nach Wichtigkeit.

	Ausschluss-kriterium	Sehr wichtig	wichtig	bedingt wichtig	keine Angabe
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

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c) Einschätzung

Ich schätze im 2025 ca. ___ a zu bewirtschaften

Bitte kreuzen Sie das passendste Feld an, von trifft zu bis trifft überhaupt nicht zu.

	Stimmt	Stimmt teilweise	Weder Noch	Stimmt eher nicht	Stimmt nicht	Weiss nicht
Der Weinbau ist ein wichtiger Teil unserer Kultur	☐	☐	☐	☐	☐	☐
Der Weinbau ist wichtig für die Vielfalt an Kulturpflanzen	☐	☐	☐	☐	☐	☐
Weinbau lohnt sich für mich	☐	☐	☐	☐	☐	☐
Weinbau zu betreiben ist eine gute Sache	☐	☐	☐	☐	☐	☐
Personen, die mir wichtig sind (Familie, Freunde) finden Weinbau sinnvoll	☐	☐	☐	☐	☐	☐
Weinbau erhöht mein Ansehen	☐	☐	☐	☐	☐	☐
Andere Personen in meiner Situation betreiben Weinbau	☐	☐	☐	☐	☐	☐
Weinbau ist auf dem von mir zugänglichen Land möglich	☐	☐	☐	☐	☐	☐
Die Situation (finanziell, organisatorisch…) erlaubt mir Weinbau zu betreiben	☐	☐	☐	☐	☐	☐
Ich habe das Wissen und die Möglichkeiten für den Weinbau	☐	☐	☐	☐	☐	☐

Appendix C: ‘MCE- Questionnaires’

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PARMESAN
PARticipatory Mapping of Ecosystem Service poteNtials

a) Persönliche Daten

Vorname: ________________ Nachname: ________________________

Befasse mich mit Weinbau seit ca. ____ Jahren

b) Einschätzung

In der Region Pfyn, Salgesch, Leuk, Varen gibt es Prognosen, dass die Gesamtfläche von Rebparzellen abnehmen wird. Woran hängt es ab, ob ein Weingarten weiterhin bewirtschaftet wird? Bitte vergleichen Sie die Kriterien A und B und entscheiden Sie welches davon wichtiger ist für die der Weiterbewirtschaftung einer Rebparzelle. Beispielsweise: Ist es wichtiger, dass die Parzelle gross ist oder dass Sie eine Zufahrtsstrasse hat? Bitte machen Sie auf jeder Zeile genau ein Kreuz, analog zum Musterbeispiel. Der Kriterienbaum auf der nächsten Seite illustriert, wie die Kriterien miteinander in Bezug stehen.

Kriterium A	A Dominierend	A sehr viel wichtiger	A viel wichtiger	A etwas wichtiger	A und B gleich wichtig	B etwas wichtiger	B viel wichtiger	B sehr viel wichtiger	B Dominierend	Kriterium B
Natürliche Faktoren										Wirtschaftliche Faktoren
Parzellengrösse										Parzelle ist in Bauzone
Parzellengrösse										Zufahrtsstrasse
Zufahrtsstrasse										Parzelle ist in Bauzone
Exposition, Boden, Hangneigung										Klima (Sonne, Regen, Höhe)
Exposition										Hangneigung
Exposition										Boden (Wasserspeicherung)
Hangneigung										Boden (Wasserspeicherung)
Sonneneinstrahlung										Niederschlag Juli-Oktober
Sonneneinstrahlung										Höhe über Meer
Höhe über Meer										Niederschlag Juli-Oktober

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c) Wertebereich

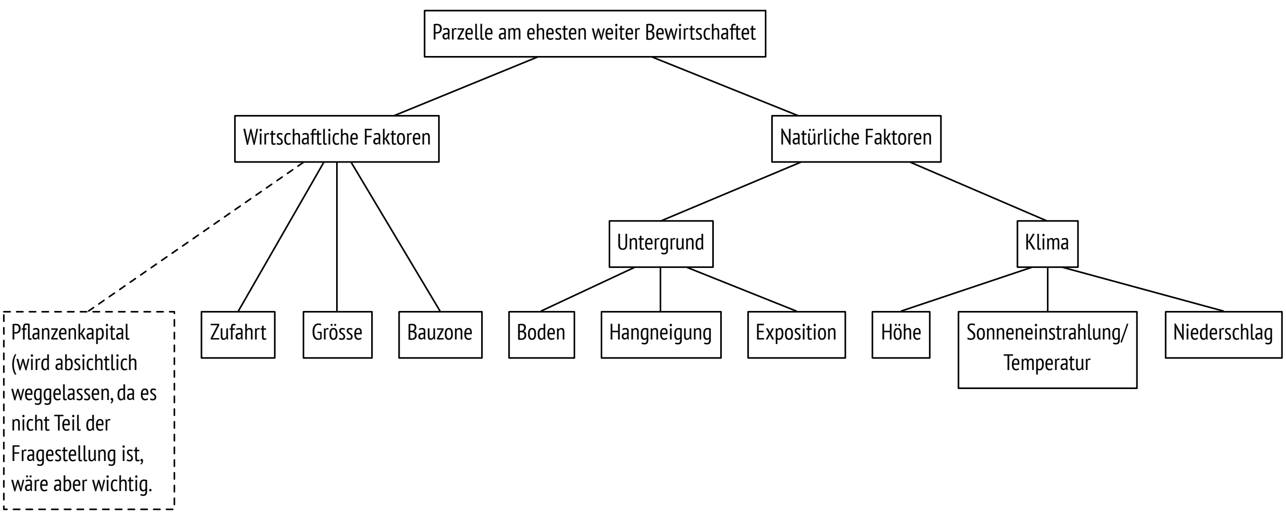
Geben Sie hier bitte den numerischen Werte pro Kriterium für eine sehr wahrscheinlich weiter bewirtschaftete Parzelle an. Beispielsweise: Welches ist die optimale Hangneigung (in Prozent), wann ist diese zu gross und wann zu klein? Bitte geben Sie falls möglich für jedes Kriterium entsprechende Wertebereiche an, analog zum Musterbeispiel. Sie müssen nicht jedes Feld füllen, beispielsweise kann eine Zufahrtsstrasse nicht zu nahe sein.

Kriterium	Zu tief	Optimal	Zu hoch
Hangneigung (%)			
Parzellengrösse, Bewirtschaftungseinheit (m^2)			
Exposition			
Abstand zur Zufahrtsstrasse (m)			
Bodenwasserspeicher (mm)			
Sonneneinstrahlung (h oder Kj/Kcal)			
Höhe M.ü.M. (m)			
Niederschlag Juli-Oktober (mm)			

Fehlen in der Liste oben wichtige Kriterien fehlen? Schreiben Sie diese bitte hier auf und ordnen Sie diese anhand der behandelten Kriterien ein: Beispielsweise könnte das neue Kriterium wichtiger als die Höhe, aber weniger wichtiger als die Parzellengrösse sein. Sie können die Tabelle unten aber auch leer lassen.

Kriterium	wichtiger als	weniger wichtig als

d) Der Kriterienbaum



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a) Données Personelle

Prénom: ________________ Nom: ________________________

Je pratique la viticulture depuis environ _____ ans.

b) Évaluation

Il y a des prévisions que les surfaces viticoles totales des régions de Finges, Salquenen, Leuk et Varen vont diminuer. Quels sont les facteurs critiques pour la poursuite d'une exploitation viticole ? Veuillez comparer les critères A et B et choisissez ceux qui vous semblent les plus importants pour la poursuite de l'exploitation d'un vignoble. Par exemple: Est-il plus important qu'une parcelle soit grande ou qu'elle ait une route d'accès ? Veuillez faire qu'une seule croix par ligne comme illustré dans l'exemple type (en allemande). Sur la prochaine page, un diagramme des critères illustre comment ces critères s'articulent.

Critère A	A extrêmement plus important	A beaucoup plus important	A plus important	A un peu plus important	A et B importance égale	B un peu plus important	B plus importante	B beaucoup plus importante	B extrêmement plus important	Critère B
Facteurs naturels	○	○	○	○	○	○	○	○	○	Facteurs économiques
Taille de la parcelle	○	○	○	○	○	○	○	○	○	Parcelle est dans la zone à bâtir
Taille de la parcelle	○	○	○	○	○	○	○	○	○	Route d'accès
Route d'accès	○	○	○	○	○	○	○	○	○	Parcelle est dans la zone à bâtir
Exposition, sol et inclinaison	○	○	○	○	○	○	○	○	○	Climat (soleil, pluie, altitude)
Exposition	○	○	○	○	○	○	○	○	○	Inclinaison de la pente
Exposition	○	○	○	○	○	○	○	○	○	Sol (capacité du rétention de l'eau)
Inclinaison de la pente	○	○	○	○	○	○	○	○	○	Sol (capacité du rétention de l'eau)
Ensoleillement	○	○	○	○	○	○	○	○	○	Pluie Jul.-Oct.
Ensoleillement	○	○	○	○	○	○	○	○	○	Altitude (A.S.L)
Altitude (A.S.L)	○	○	○	○	○	○	○	○	○	Pluie Jul.-Oct.

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c) Gamme de valeurs

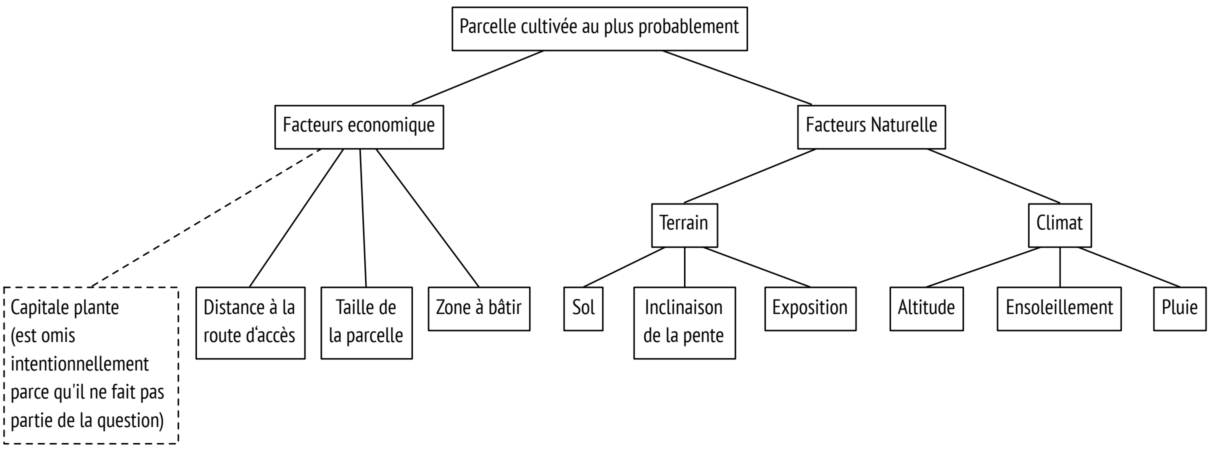
Donnez ci-dessous des valeurs chiffrées dans les unités correspondante aux critères dans le cas d'une poursuite très probable de l'exploitation d'une parcelle. Par exemple: Quelle est l'inclinaison optimale en pour-cent d'une parcelle et à partir de quel moment celle-ci est-t-elle trop faible ou au contraire trop importante ? Donnez si possible une fourchette de valeurs pour chaque critères comme illustré dans l'exemple type (en allemande). Vous ne devez pas remplir tous les champs, par exemple, une route d'accès ne peut pas être trop proche.

Critère	Trop petite	Optimale	Trop grande
Inclinaison de la pente (%)			
Taille de la parcelle, unité de gestion (m^2)			
Exposition			
Distance à la route d'accès (m)			
Sol: capacité du rétention de l'eau (mm)			
Ensoleillement (h ou Kj/Kcal)			
Altitude (A.S.L) (m)			
Pluie Jul.-Oct. (mm)			

Manque-t-il dans cette liste des critères importants ? Écrivez-les dans le tableau ci-dessous et classez les sur la base des critères traités: Par exemple, le nouveau critère est plus importante que l'altitude, mais moins important que la taille de la parcelle. Vous pouvez également laisser le tableau vide.

Critère	Plus important que	Moins important que

d) L'arbre des critères



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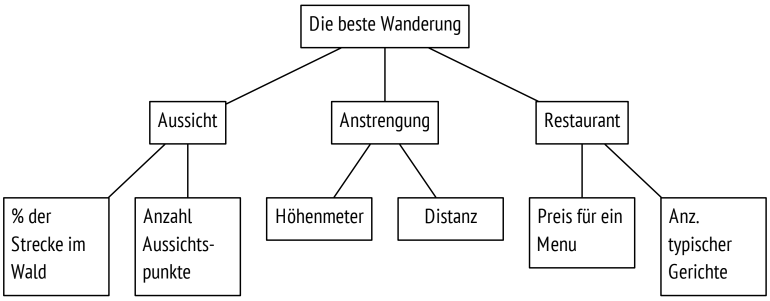
Musterbeispiel einer multikriteriellen Analyse

Im folgenden wird ein Musterbeispiel für eine multikriterielle Analyse vorgestellt. Dies soll Ihnen a) einen Einblick in die Methode geben und b) helfen den Fragebogen auszufüllen und Missverständnisse auszuräumen. Um die Studie nicht zu beeinflussen wurde absichtlich ein komplett anderes Beispiel gewählt.

a) Der Entscheidungsbaum

Stellen Sie sich vor, sie hätten für am kommenden Wochenende eine Wanderung geplant und müssen nun zwischen verschiedenen Alternativen entscheiden. Sie möchten dabei die Aussicht auf der Strecke, die Anstrengung und ein mögliches Restaurant auf der Strecke berücksichtigen. Sie haben also drei grundsätzlich unterschiedliche Anforderungen, welche Sie gegeneinander abwägen müssen. Damit Abgewogen werden kann, müssen Sie die einzelnen Anforderungen Gewichten und anhand messbarer Kriterien bewerten. Beispielsweise messen Sie für die Aussicht sowohl welchen Teil der Strecke im Wald zurückgelegt wird, als auch wie viele Aussichtspunkte sie passieren und wägen diese beide Eigenschaften gegeneinander ab. Dem liegt also folgender hierarchischer Entscheidungsbaum zugrunde:



b) Die Gewichtung

Um die Wichtigkeit jedes Kriteriums zu ermitteln, müssen Sie die **Kriterien gegeneinander abwägen**. Hierzu benutzen Sie die untenstehende Maske. Sie überlegen Folgendes: Weil es eine nicht überaus anstrengende Tour werden darf, ist die Anstrengung am wichtigsten, während das Restaurant etwas weniger und die Aussicht viel weniger wichtig ist. Das Restaurant ist wichtiger als die Aussicht. Die anderen Kriterien bewerten sie analog.

Kriterium A	A Dominierend	A sehr viel wichtiger	A viel wichtiger	A etwas wichtiger	A und B gleich wichtig	B etwas wichtiger	B viel wichtiger	B sehr viel wichtiger	B Dominierend	Kriterium B
Anstrengung	☐	☒	☐	☐	☐	☐	☐	☐	☐	Aussicht
Anstrengung	☐	☐	☒	☐	☐	☐	☐	☐	☐	Restaurant
Aussicht	☐	☐	☐	☐	☐	☒	☐	☐	☐	Restaurant
% der Strecke im Wald	☐	☒	☐	☐	☐	☐	☐	☐	☐	Anzahl Aussichtspunkte
Höhenmeter	☐	☐	☐	☐	☐	☐	☒	☐	☐	Distanz
Preis für ein Menu	☐	☐	☐	☐	☐	☐	☐	☒	☐	Anz. typischer Gerichte

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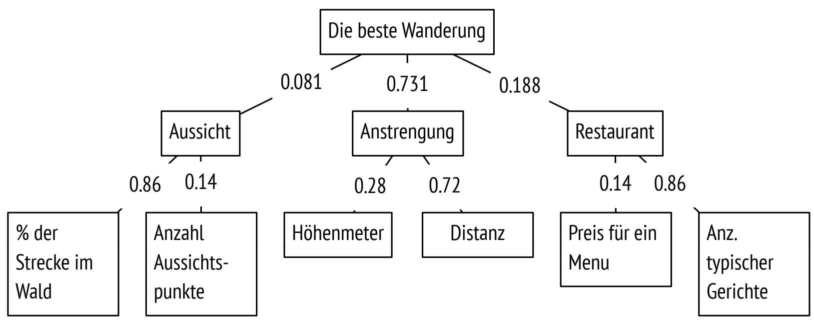
Aufgrund der paarweisen Vergleiche in der obigen Maske berechnen wir nun die Gewichte im Entscheidungsbaum. Durch Multiplikation der Werte entlang der Äste ergeben sich die finalen Gewichte der messbaren Kriterien in Prozenten. Die Summe der finalen Gewichte muss 100% ergeben.

Baum



Messbare Kriterien	Finale Gewichte
% der Strecke im Wald	7 %
Aussichtspunkte	1 %
Höhenmeter	20 %
Distanz	53 %
Preis für ein Menu	3 %
Anz. typischer Gerichte	16 %
Summe	100 %

c) Der Wertebereich

Bisher ist noch nicht klar, welches die **optimalen Werte** für die jeweiligen Kriterien sind. Beispielsweise sind 300-500 Höhenmeter eine optimale Anstrengung, während mehr als 1200 Höhenmeter definitiv zu viel wären.

Kriterium	Zu tief	Optimal	Zu hoch
% der Strecke im Wald	0	5	10
Aussichtspunkte	0	2	
Höhenmeter	0	300-500	1200
Distanz	10km	12-17km	25km
Preis für ein Menu		CHF 15	CHF 35
Anz. typischer Gerichte	0	3	

d) Eignung

Die Wertebereiche von Schritt c) helfen dann nach graphischer Interpretation in einen „Eignungswert“ übersetzt. Dieser reicht von 0 bis 1, wobei o gar nicht geeignet und 1 optimal geeignet bedeutet.

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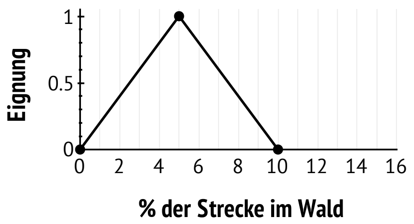
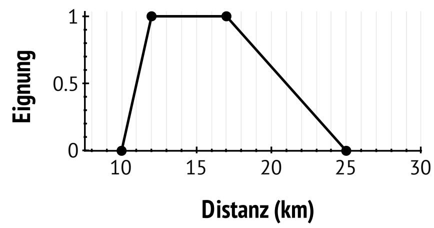
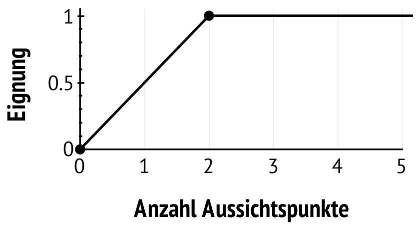
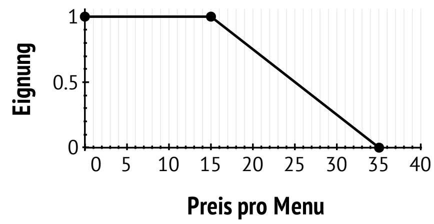
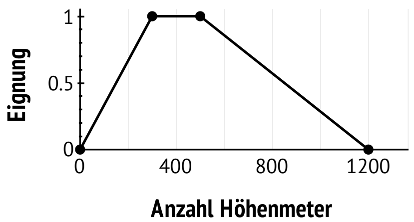
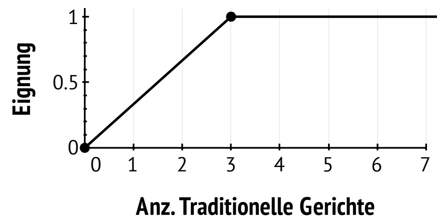
Kriterium	Eignungsfunktion	Kriterium	Eignungsfunktion
% der Strecke im Wald		**Distanz**	
Aussichtspunkte		**Preis für ein Menu**	
Höhenmeter		**Anz. typischer Gerichte**	

e) Die Alternativen

Nun können Sie Routen miteinander vergleichen. Hier exemplarisch zwei Routen mit folgenden Werten für die vorgängig gewichteten Kriterien.

	Route A	Route B
% der Strecke im Wald	7	15
Aussichtspunkte	3	1
Höhenmeter	850	650
Distanz	20km	15km
Preis für ein Menu	CHF 35	CHF 18
Anz. typischer Gerichte	5	1

f) Die Analyse

Als ersten Schritt wird pro Kriterium die Eignung jeder Variante bestimmt. Dies wird auf der folgenden Seite graphisch dargestellt.

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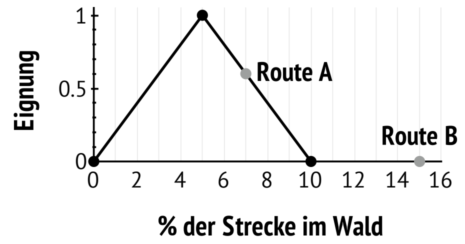
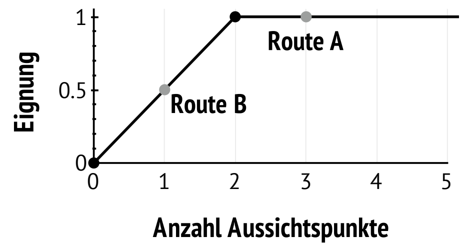
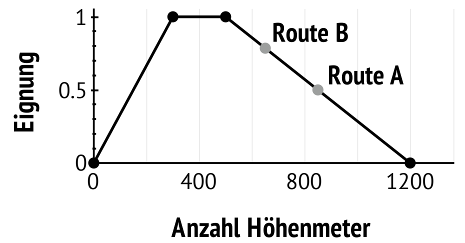
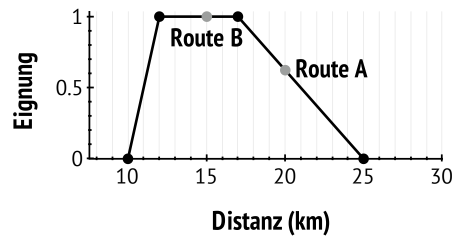
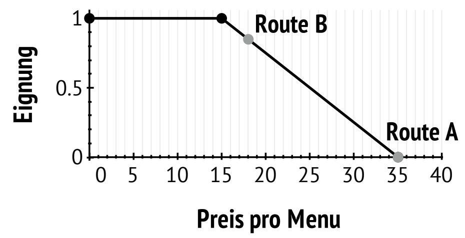
	Route A		Route B		Eignung (gemäss graphischer Interpretation der Wertebereiche)
Kriterium	**Wert**	**Eignung**	**Wert**	**Eignung**	
% der Strecke im Wald	7	0.6	15	0	
Aussichtspunkte	3	1	1	0.5	
Höhenmeter	850	0.5	650	0.8	
Distanz	20km	0.62	15km	1	
Preis für ein Menu	CHF 35	0	CHF 18	0.85	

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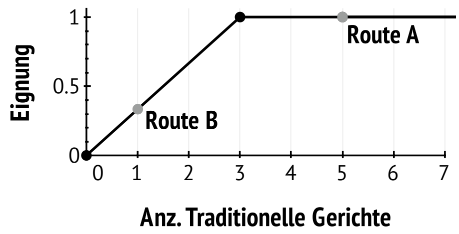
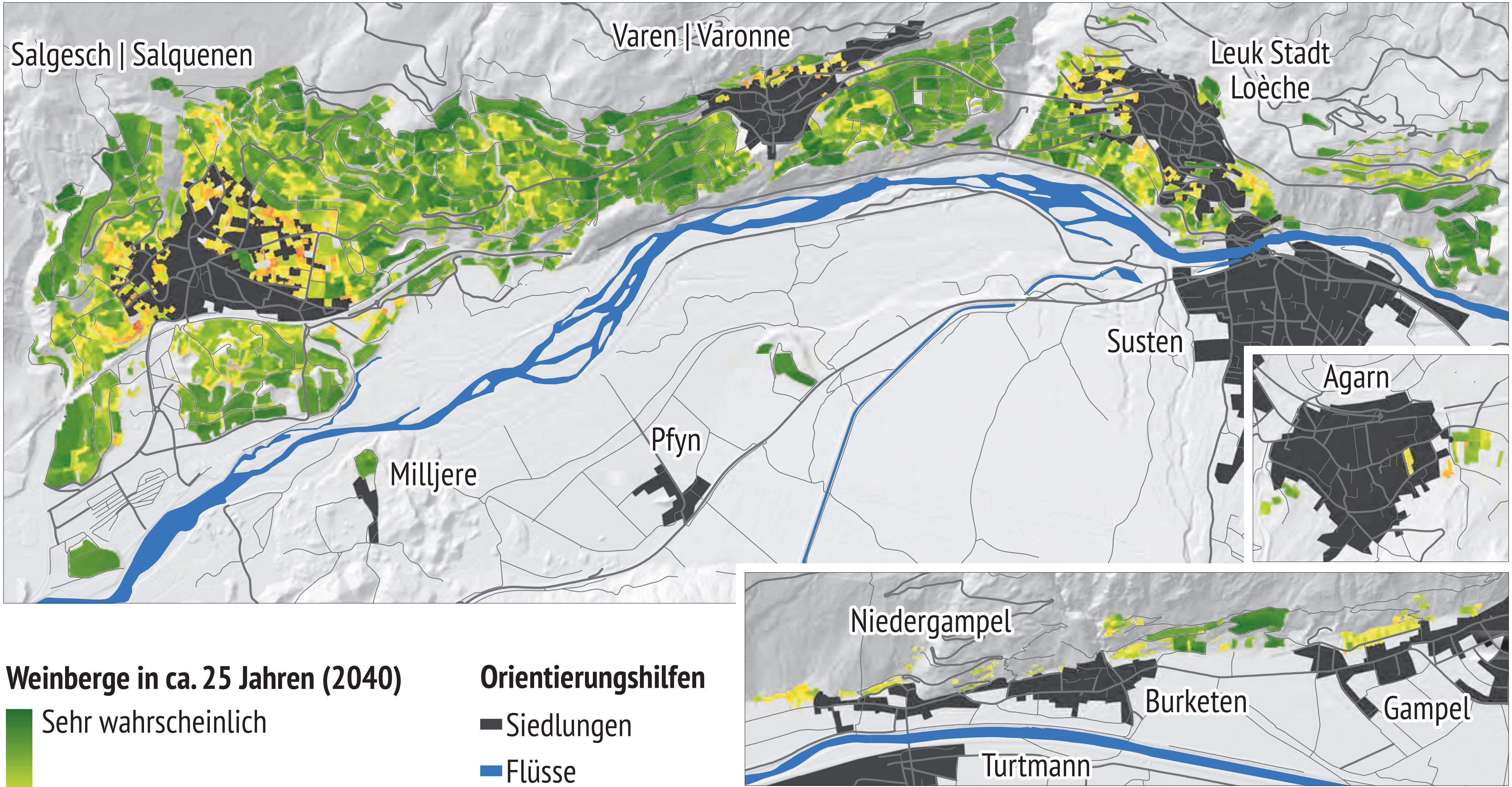
	Route A		Route B		Eignung (gemäss graphischer Interpretation der Wertebereiche)
Kriterium	**Wert**	**Eignung**	**Wert**	**Eignung**	
Anz. typischer Gerichte	5	0.33	1	1	



Danach wird die Eignung der jeweiligen Routen pro messbaren Kriterium gemäss dem Resultat von Schritt b) gewichtet. Um die Routen zu vergleichen wird die Summe der gewichteten Eignungswerte berechnet. Es zeigt sich also, dass die Route B besser einer idealen Wanderung entspricht, insbesondere da sie eher dem Ideal von Distanz und Höhenmetern entspricht. Sie bietet zwar weniger Aussicht, aber das wird weniger stark gewichtet. Nun steht nichts mehr im Weg für eine gemütliche Wanderung mit einem guten Restaurant.

Messbare Kriterien	Eignung Route A	Eignung Route B	Finale Gewichte	Gewichtete Eignung Route A	Gewichtete Eignung Route B
% der Strecke im Wald	0.6	0	7 %	0.04	0.00
Aussichtspunkte	1	0.5	1 %	0.01	0.01
Höhenmeter	0.5	0.8	20 %	0.10	0.16
Distanz	0.62	1	53 %	0.33	0.53
Preis für ein Menu	0	0.85	3 %	0.00	0.02
Anz. typischer Gerichte	0.33	1	16 %	0.05	0.16
Summe				**0.54**	**0.88**

Appendix D: ‘Workshop materials’



Weinberge in ca. 25 Jahren (2040)

Sehr wahrscheinlich

Unsicher

Orientierungshilfen

Siedlungen

Flüsse

Erschliessungen

Fahrweg

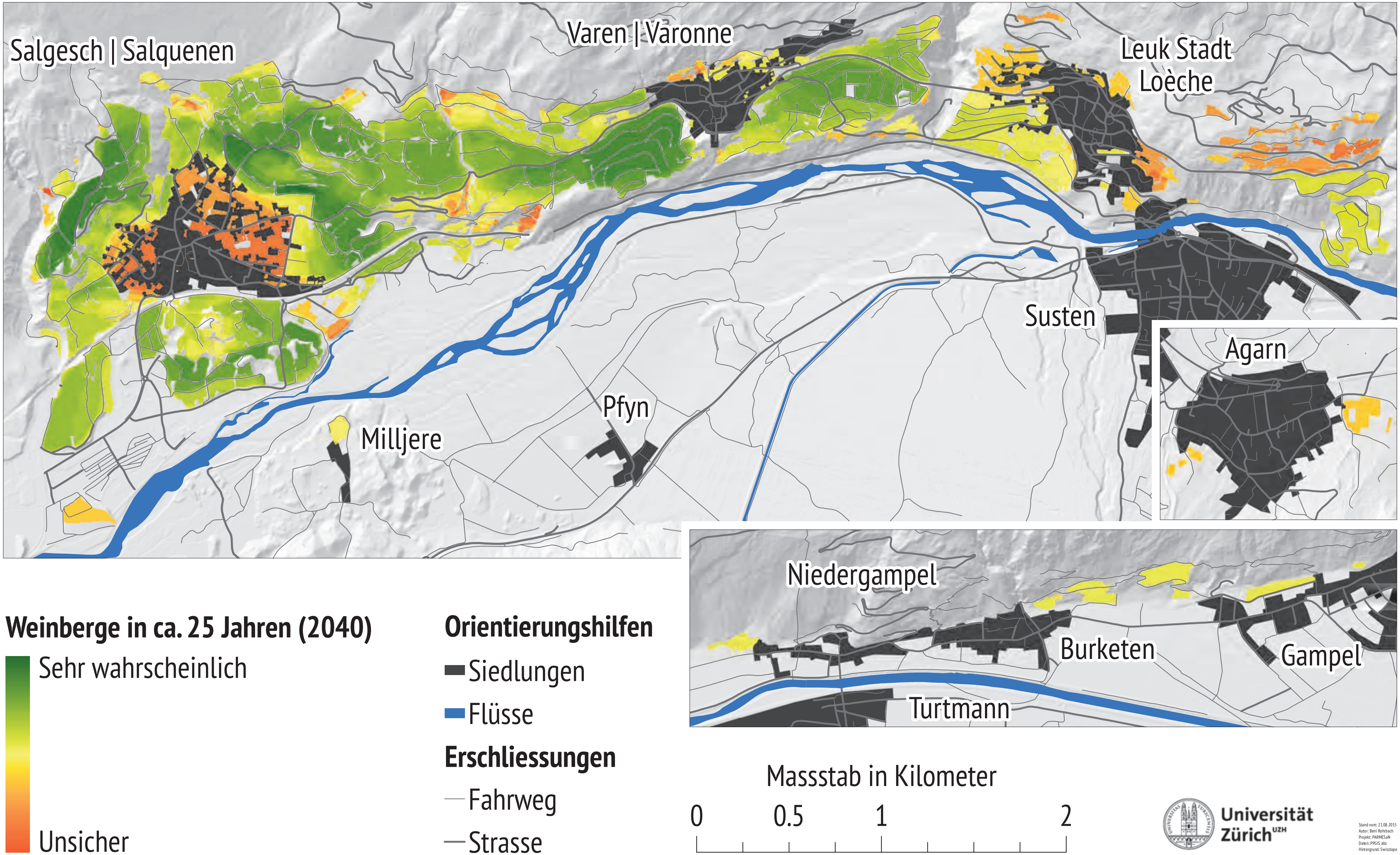
Strasse

Massstab in Kilometer

0 0.5 1 2

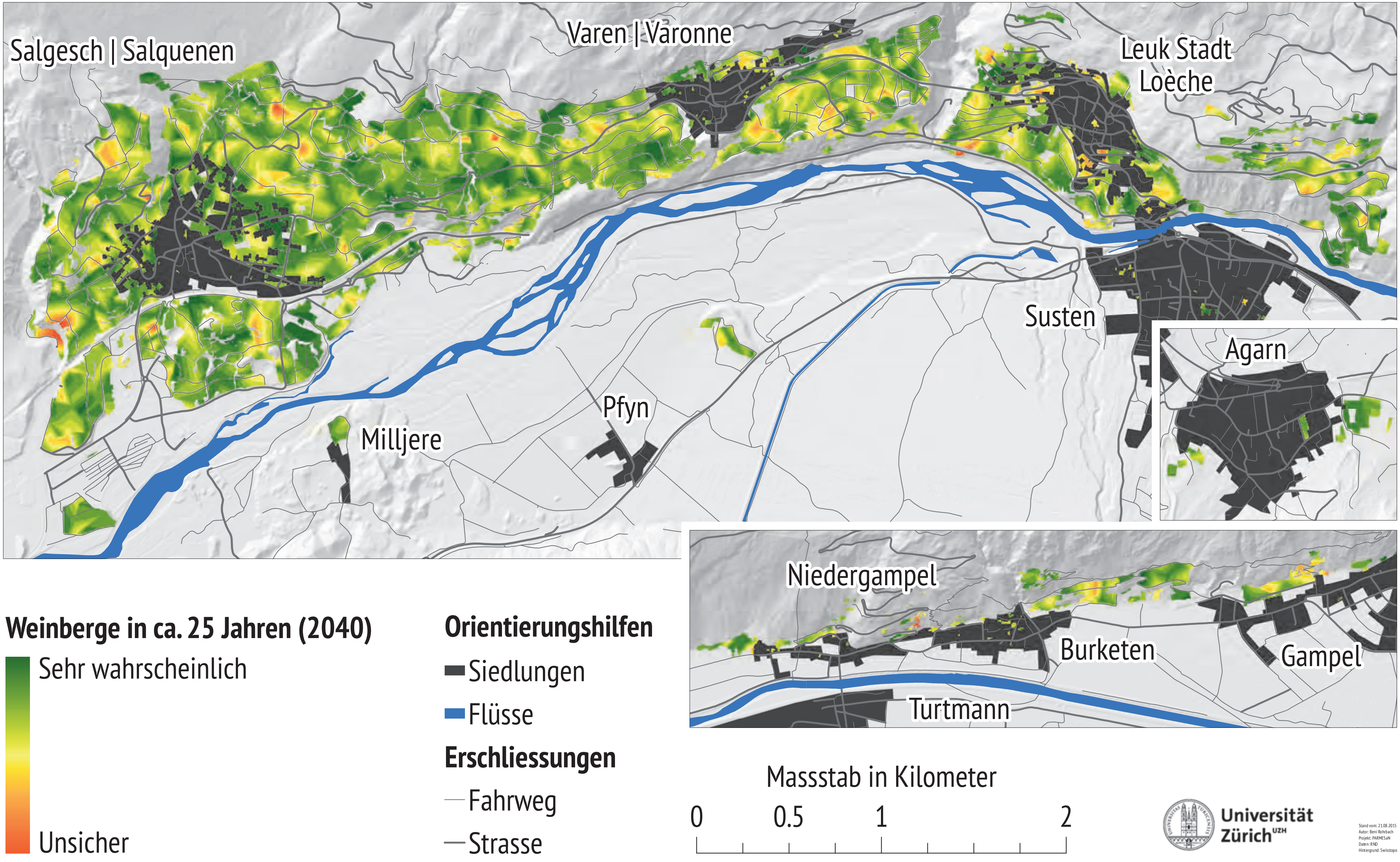
Universität Zürich[UZH]

Stand vom: 21.08.2015
Autor: Beni Rohrbach
Projekt: PARMESaN
Daten: MCA
Hintergrund: Swisstopo



Universität Zürich[UZH]

Stand vom: 21.08.2015
Autor: Beni Rohrbach
Projekt: PARMESaN
Daten: PPGIS abs
Hintergrund: Swisstopo



Stand vom: 21.08.2015
Autor: Beni Rohrbach
Projekt: PARMESaN
Daten: RND
Hintergrund: Swisstopo

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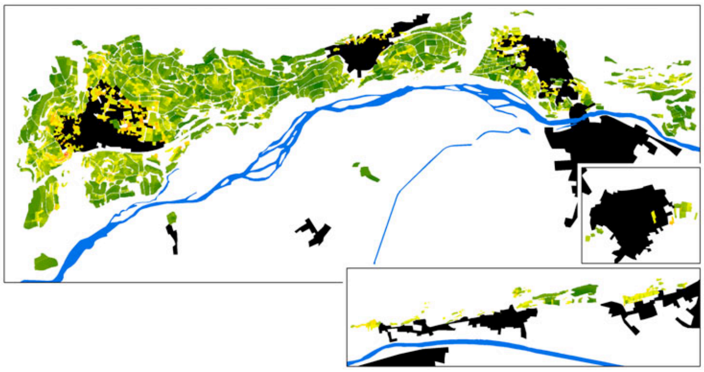
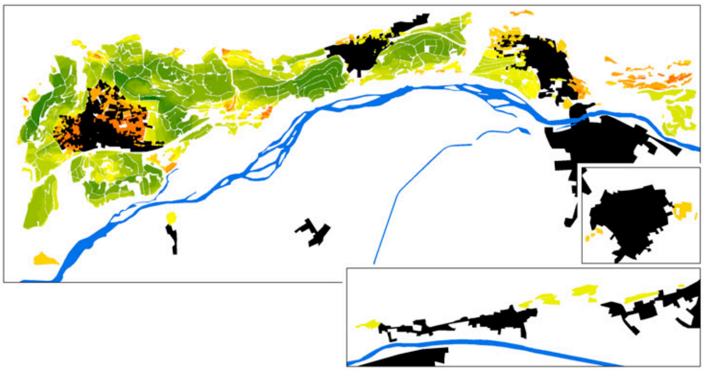
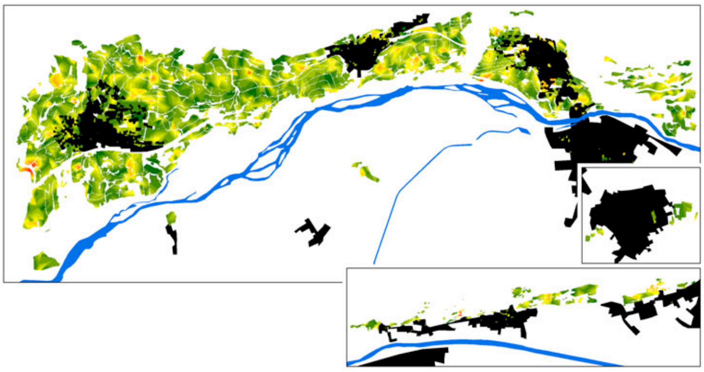
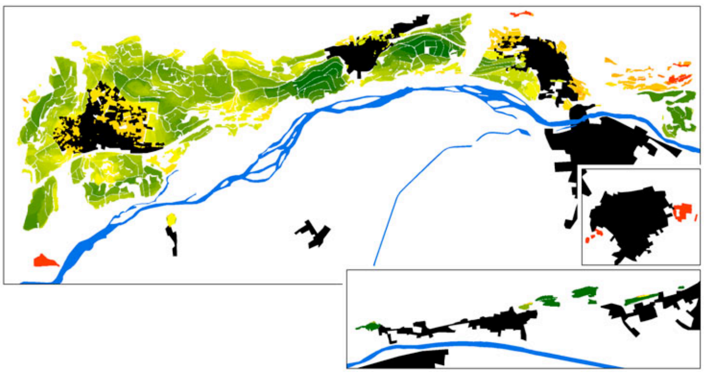
Übersicht

	Bild	Note	Kommentar zur Note
Methode 1			
Methode 2			
Methode 3			
Methode 4			

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Eigene Kriterien

Für mich selbst sind folgende Kriterien wichtig:

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Methode 1

	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität	☐	☐	☐	☐	☐	☐
Detailierungsgrad	☐	☐	☐	☐	☐	☐
Kriterium 3	☐	☐	☐	☐	☐	☐
Kriterium 4	☐	☐	☐	☐	☐	☐
Kriterium 5	☐	☐	☐	☐	☐	☐

Kommentare:

Methode 2

	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität	☐	☐	☐	☐	☐	☐
Detailierungsgrad	☐	☐	☐	☐	☐	☐
Kriterium 3	☐	☐	☐	☐	☐	☐
Kriterium 4	☐	☐	☐	☐	☐	☐
Kriterium 5	☐	☐	☐	☐	☐	☐

Kommentare:

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Methode 3

	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität	☐	☐	☐	☐	☐	☐
Detailierungsgrad	☐	☐	☐	☐	☐	☐
Kriterium 3	☐	☐	☐	☐	☐	☐
Kriterium 4	☐	☐	☐	☐	☐	☐
Kriterium 5	☐	☐	☐	☐	☐	☐

Kommentare:

Methode 4

	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität	☐	☐	☐	☐	☐	☐
Detailierungsgrad	☐	☐	☐	☐	☐	☐
Kriterium 3	☐	☐	☐	☐	☐	☐
Kriterium 4	☐	☐	☐	☐	☐	☐
Kriterium 5	☐	☐	☐	☐	☐	☐

Kommentare:

Appendix E: ‘Evaluation Questionnaire’

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Methode 1

Kriterium	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität, Glaubwürdigkeit [1]	☐	☐	☐	☐	☐	☐
Räumliche Auflösung, Parzellenschärfe [2]	☐	☐	☐	☐	☐	☐
Darstellung der Situation im angegebenen Zeitraum [3]	☐	☐	☐	☐	☐	☐
[4]	☐	☐	☐	☐	☐	☐

Kommentare:

Methode 2

Kriterium	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität, Glaubwürdigkeit [1]	☐	☐	☐	☐	☐	☐
Räumliche Auflösung, Parzellenschärfe [2]	☐	☐	☐	☐	☐	☐
Darstellung der Situation im angegebenen Zeitraum [3]	☐	☐	☐	☐	☐	☐
[4]	☐	☐	☐	☐	☐	☐

Kommentare:

[1] Plausibilität, Glaubwürdigkeit: Ist das Resultat korrekt und entspricht die Karte ihren Vorstellungen?

[2] Räumliche Auflösung, Parzellenschärfe: Hat das Resultat die richtige Genauigkeit für den Sachverhalt? Werden zu viele, oder zu wenige Details dargestellt?

[3] Darstellung der Situation im angegebenen Zeitraum: Zeigt das Resultat die Situation in 25 Jahren und nicht früher oder später, beispielsweise in 10 oder 25 Jahren?

[4] Hier können Sie ein eigenes Kriterium hinschreiben.

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Methode 3

Kriterium	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität, Glaubwürdigkeit [1]	☐	☐	☐	☐	☐	☐
Räumliche Auflösung, Parzellenschärfe [2]	☐	☐	☐	☐	☐	☐
Darstellung der Situation im angegebenen Zeitraum [3]	☐	☐	☐	☐	☐	☐
[4]	☐	☐	☐	☐	☐	☐

Kommentare:

Methode 4

Kriterium	Top	Gut	Genügend	Schlecht	Flop	Weiss nicht
Plausibilität, Glaubwürdigkeit [1]	☐	☐	☐	☐	☐	☐
Räumliche Auflösung, Parzellenschärfe [2]	☐	☐	☐	☐	☐	☐
Darstellung der Situation im angegebenen Zeitraum [3]	☐	☐	☐	☐	☐	☐
[4]	☐	☐	☐	☐	☐	☐

Kommentare:

[1] Plausibilität, Glaubwürdigkeit: Ist das Resultat korrekt und entspricht die Karte ihren Vorstellungen?

[2] Räumliche Auflösung, Parzellenschärfe: Hat das Resultat die richtige Genauigkeit für den Sachverhalt? Werden zu viele, oder zu wenige Details dargestellt?

[3] Darstellung der Situation im angegebenen Zeitraum: Zeigt das Resultat die Situation in 25 Jahren und nicht früher oder später, beispielsweise in 10 oder 25 Jahren?

[4] Hier können Sie ein eigenes Kriterium hinschreiben.

Curriculum Vitae

Personal Details

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Place of Citizenship:	Rüeggisberg (BE)

Education

1998–2004	Matura Typus C. Kantonsschule Wetzikon. Specialisation in Biology and Chemistry
2006–2009	Bachelor in Social Sciences and Geography at the University of Basel
2009–2010	Bachelor in Geosciences with Specialisation in Environmental Geosciences at the University of Basel. Thesis-Title: 'Biologische Lebensmittel in Discountern Wahrnehmung, Akzeptanz und Wirkungen der Distributionspolitik von BioSuisse'
2010–2011	Master in Environmental Management and Technology. International Program at Aalborg Universitet in Denmark, FOOH Emden in Germany and De Montford University in the UK. Thesis Title: 'The closed loop economy and socio- technical dynamics'
2012-2016	PhD in Geography at the University of Zürich. Employed as scientific assistant

Publications as a Result of this PhD

ROHRBACH B., ANDERSON S., & LAUBE P. (2015): The effects of sample size on data quality in participatory mapping of past land use. In: *Environment and Planning B: Planning and Design*.

ROHRBACH B., & LAUBE P. (2014): Spatial variation of participants ' coverage in participatory mapping. In: *Proceedings of the GIScience 2014*, pp. 390–395.

ROHRBACH B. (2013): Participatory Mapping: An application for agrobiodiversity conservation. *Poster for the Swiss Inter- and Transdisciplinary Day 2013*.

ROHRBACH B., & LAUBE P. (2013): A participatory method for agrobiodiversity conservation. In: *5th Symposium for Research in Protected Areas. 10 to 12 June 2013, Mittersill*, pp. 669–670.

Presentations held within this PhD

ROHRBACH, B. (2015): Cultural Ecosystem Services, Resilience and Place Attachment Within Vineyards Threatened to be Abandoned. In: PECS 2015 Conference. Socio-ecological dynamics in the Antropocene, Stellenbosch SA, November 4, 2015

ROHRBACH, B. (2015): Social value change as land use changes: Methodological pluralism to assess reasons, current trends and future scenarios. In: Deutscher Kongress für Geographie 2015, Berlin DE, October 4, 2015

ROHRBACH, B. (2015): Lokales Wissen zur Abschätzung von zukünftiger Landnutzung: Top oder Flop? In: Junge Landschaftsforschung an der WSL, Birmensdorf CH, March 26, 2015

ROHRBACH, B. (2015): Vineyards: Change in extent and location of grape production. In: CCES Winterschool Science meets Practice, Wislikofen CH, January 10, 2015

ROHRBACH, B. (2014): Spatial variation of participants' coverage in participatory mapping. In: GIScience. Vienna, September 25, 2014

ROHRBACH, B. (2014): Participatory mapping: A tool for participatory policy development in protected areas. In: Graubünden Forscht. Davos, September 11, 2014

ROHRBACH, B. (2014): Sampling in participatory mapping. An example on collaborative policy making to support cultural identity. In: Internatonal Symposium on Society and Resource Management, Hannover, June 10, 2014

ROHRBACH, B. (2013): Participatory mapping: A tool for policy assessment. In: RegioResources 21, Catania (IT), September 20, 2013

ROHRBACH, B. (2013): Conserving Plant Genetic Resources. Rare species in the mountains: A contribution to food security?. In: enviro.13 Du bist was du isst, Hischwil, October 26, 2013

ROHRBACH, B. (2013): Participatory Mapping. An application for agrobiodiversity conservation.. In: 5th Symposium for Research in Protected Areas, Nationalpark Hohe Tauern Mittersill, June 10, 2013

ROHRBACH, B. (2013): Participatory Mapping Ecosystem Service Potentials. In: Conference on Transdisciplinary Research and Modeling, Munich, 10, April 2013