Factors affecting farmers’ acceptance of conservation measures—A case study from north-eastern Germany

Claudia Sattler a,∗, Uwe Jens Nagel b

a Institute of Socio-Economics, Leibniz-Centre for Agricultural Landscape Research (ZALF) e.V., Müncheberg, Germany
b Department of Agricultural Economics and Social Sciences, Faculty of Agriculture and Horticulture, Humboldt University of Berlin, Germany

A R T I C L E   I N F O

Article history:
Received 7 August 2007
Received in revised form 25 February 2008
Accepted 26 February 2008

Keywords:
Farmers’ survey
Acceptance
Innovations
Adoption of conservation measures

A B S T R A C T

Intensive forms of agriculture have been proven to cause severe environmental effects, such as soil erosion by water and wind, or the pollution of ground and surface water with nutrients and pesticides contributing to the deterioration of natural habitats and the loss in biodiversity. In order to avoid or mitigate these detrimental environmental effects, a number of conservation measures can be undertaken by farmers. However, the adoption of these measures is highly dependent on the assumed benefits and risks attached as well as the personal perception and attitude of the individual farmer.

This paper presents the outcome of a survey conducted in north-eastern Germany aimed at analysing farmers’ acceptance of different conservation measures. Eleven farmers, managing more than 80% (about 13,000 ha) of the agricultural land in the chosen case study region were interviewed. Respondents were asked about their personal experiences with different environmental measures and requested to assess these measures, e.g., regarding costs, time and labour demands, attached risks, or effectiveness. They also ranked these factors in terms of importance for decision making on adoption or rejection of a new measure. The findings show that, despite of the general assumption that farmers’ decisions are mostly driven by economic rationality, costs were not the most important factor. Other factors, like associated risks, effectiveness, or time and effort necessary to implement a certain measure were equally or even more important depending on the specific situation.

Introduction

Intensive forms of agriculture have been proven to cause severe environmental damages, such as soil erosion by water or wind (e.g., Evans, 2005; Deumlich et al., 2006), pollution of ground and surface water by nutrients (e.g., Hansen et al., 2000; Bohlke, 2002; Pieterse et al., 2003) or pesticides (e.g., Worrall and Besien, 2005; Craven and Hoy, 2005) as well as contributing to the deterioration of natural habitats and losses in biodiversity (e.g., Büchs et al., 2003; Firbank, 2005). In order to avoid or mitigate these detrimental environmental effects, a number of conservation measures can be undertaken by farmers. Conservation measures such as catch crops will improve soil coverage, thus lowering erosion risks (Barkusky, 1990) or nitrate leaching (Thomsen, 2005; Askegaard et al., 2005). The use of GPS (global positioning system) in precision agriculture helps to reduce the input of fertilisers or pesticides and, therefore, decreases environmental pollution (Kokuryu et al., 2004). Changes in the timing of critical management procedures may allow the consideration of biodiversity issues. For instance field birds can be better protected by avoiding disturbances during their sensitive breeding periods (Wilson et al., 1997; Donald et al., 2002). The farmers’ choice of conservation measures will depend on three main aspects: firstly, the characteristics of the conservation measures themselves; secondly, the personal attitudes and preferences of the individual farmer and, thirdly, the frame conditions such as the financial situation of the farm, the specific climatic and regional site conditions or the general legal restrictions and policy settings (cf. Lucke, 1995; Esser, 1999 and Prager, 2002).

Analytical framework

In accordance with Esser (1999: 37 et sqq.), acceptance is the result of an interrelated decision making process depending on the subject of acceptance (the farmer), the object of acceptance (the conservation measures), and the surrounding context (the frame conditions). Fig. 1 shows the interdependencies between these three entities in the process of acceptance. Any single conservation measures, i.e., the object of acceptance, will show different characteristics regarding, e.g., costs, time...
requirements or the attached risks (e.g., Lettmann, 1994; Dietrich, 1993). At first sight, precision farming may appear to be very costly due to the necessary technical investments. However, it stands a good chance of being profitable to a farmer in the long run. The integration of catch crops might be considered risky as the sowing is not always successful, particularly in regions with occasional summer droughts. Although it will help to fight erosion when established successfully, the expenditures for additional seeds, fuel and labour might be spent in vain if the establishment fails under the conditions mentioned above.

The personal attitude of the single farmer, i.e., the subject of acceptance, is of utmost importance (e.g., Ajzen, 1988; Macombe, 2004). Attitudes can be defined as: “...the more or less permanent feelings, thoughts and predispositions a person has about aspects of his environment. Components are knowledge, feelings and inclination to act” (Van den Ban and Hawkins, 1996, p. 81). A risk-averse farmer will hardly implement conservation measures that bear a high risk of failure. And, given the opportunity, a farmer who takes interest in nature protection issues might rather opt for a more environmental-friendly measure, even if the respective measure is more expensive than a farmer who is more orientated on cost-effectiveness.

Finally, the whole process is affected by the frame conditions such as the financial situation of the farm, the specific climatic and regional site conditions or the general legal restrictions and policy settings (e.g., Katz, 1961; McIsaac and Morey, 1998). A farmer without capital surplus who is economically not doing very well at the time will most probably not decide in favour of a measure that requires major investments. A farm with a high proportion of land in Natura 2000 areas has to deal with the corresponding legal restrictions while a neighbouring farm with no such areas will not.

In addition to the above outlined definitions following Esser (1999, cf. Fig. 1), focusing on the object- and subject-orientated aspect of innovation uptake, i.e., a single farmer (the subject) adopts a single innovative conservation measure (the object), other authors place more emphasis on the process of social learning taking into account more than one actor (e.g., Ison et al., 2007; Rist et al., 2006). In this sense, the acceptance of an innovation is the result of the interaction and mutual learning within a group of individuals or a community rather than the outcome of an one-to-one interaction between a single adopter and an innovation (cf. Derkzen and Bock, 2007; Leeuwis, 2004; Allaire and Boiffin, 2004). However, in this paper, the analysis will be based upon the definitions of Esser (1999).

According to Rogers (2003, p. 229 et sqq.) five main factors regarding the characteristics of an innovation are of importance: relative advantage, compatibility, complexity, trialability and observability. Relative advantage is the degree to which a measure is perceived to be difficult to understand or use. Trialability signifies to which degree an innovation can be tested before eventually adopted. Finally, observability refers to the degree of visibility of the results. Depending on his or her personal preferences and attitudes and the current frame conditions, these factors are decisive for a farmer when he or she makes a decision to adopt or reject a certain measure.

### Methods

To analyse which of these factors are mainly influencing the acceptance of conservation measures by farmers a survey was done in the region ‘Prenzlau-West’. This region was chosen, because, on the one hand, agriculture is the predominant form of land use, but, on the other hand, a high share of the area is covered with biotopes that are in the focus of nature protection issues. Hence, the increased adoption of conservation measures is both, a major objective for environmentalists and a challenge for the farmers of the region.

#### Case study region

The case study region ‘Prenzlau-West’ is situated in northeastern Germany, in the federal state of Brandenburg. The region covers an area of about 200 km². About 70% of the region’s area is in agricultural use. Nevertheless, there is also a high share (about 7%) of natural and semi-natural areas, which are protected in accordance with the Federal German Nature Protection Act (BNatSchG, 2002, § 32). The area is particularly rich in water areas which cover approximately 3% of the region. These water areas are especially vulnerable to nutrient and pesticide entries as a great share is directly located within or adjacent to arable fields. Furthermore, a part of the region (about 8%) is threatened by water erosion, due to the occurrence of steep slopes and heavy rainfall in periods of insufficient soil coverage during spring and fall. Yearly soil losses up to 170 tons per hectare have been measured (Frielinghaus et al., 1997).

#### Selection of farms

The aim of the survey was to reach as many full-time farmers in the region as possible to enable statements valid for the whole region. For this purpose, all 15 full-time farmers were contacted by phone and asked if they would take part in a personal interview. Finally, 11 out of 15 farmers managing more than 80% (about 13,000 ha) of the agricultural land in the region agreed to act as interview partners. Four of these farms were arable farms while on the remaining also animals were kept. All farmers were conventional farmers as there is no organic farming in the region so far. The labour input per land unit varied between 0.4 and 2.6 workers per 100 ha in dependency on the number of animals. The size of the farms varied between 187 and 4200 ha, with a high share of tenant land (up to 80%). The share of tenant land was higher for corporate farms than for individual farms which own most of their land. All respondents had a professional training in agriculture, with four of them having an university degree. The age of the respondents varied between 34 and 69 years.

#### Timing and survey setup

Based upon a literature review on interview techniques and survey design (e.g., Lamnek, 2005) a first version of the questionnaire was elaborated and discussed with several social scientists and revised according to their comments. The questionnaire in its final form was structured into 6 sections. In the first section the aim...
of the survey was shortly explained. The second section contained all farm-related questions regarding their legal form, land owned and rented, kind and number of animals kept, etc. The third section asked for conservations measures already implemented on the farms and the fourth section was meant to identify how important different conservation aims were seen by the farmers. In the fifth section the interviewees were asked to give their assessment about the importance of the different factors influencing the acceptance of conservation measures. For this purpose, 30 single criteria were grouped into categories in accordance with the factors suggested by Rogers (2003), i.e., relative advantage, compatibility, complexity, trialability and observability. In section four and five, the interviewees always had the choice between five assessment classes from ‘very important’ to ‘completely unimportant’. In section six, respondents were requested to evaluate the conservation measures according to the different criteria, e.g., whether a measure would be neutral regarding costs, risks, etc., or whether these would decrease or increase. Again, respondents could chose from a five class scale, e.g., measure ‘slightly decreased’, ‘slightly increased’, ‘didn’t affect at all’, ‘slightly increased’ or ‘considerably increased’ the costs, time need, risks, etc.

The questionnaire was sent to all farmers who had agreed to take part in the survey. The survey itself was conducted from February until March 2004. The individual interviews took between 60 and 90 min. Survey data were analysed during April 2004. In early May, a summary of the results was sent to all participants of the survey for feedback.

Analysis of the survey results

For the quantitative analysis of the survey the mean value and standard deviation per answer category was calculated. Because of the limited number of cases a statistical analysis of the results was not considered feasible. In order to obtain a measurement for the acceptance of the single conservation measures by farmers based upon the survey results an equation was used for aggregation and calculation of an overall index value ranging between zero and one (Omron, 1996).

\[
d_j = \frac{\sum_{i=1}^{j} y_{ij} \times \delta_i}{\sum_{i=1}^{j} \delta_i}
\]

with \(d_j\) = overall index of acceptance scored for measure \(j\); \(y_{ij}\) = suitability score regarding criteria \(i\) for measure \(j\); \(\delta_i\) = weight factor for criteria \(i\).

The higher the calculated index value per measure the higher the degree of acceptance of the measure.

Results—presentation and discussion

Adoption of conservation measures by farmers

All farmers stated that they were already implementing a number of conservation measures from the list of all 14 measures presented (see Appendix A). Each measure was at least applied by two farmers and two measures were conducted on all farms. One measure (M6), reduction of fertiliser input, has already been adopted for the whole area of arable land. All farms applied fertiliser depending on the crops' nutrient uptake; they regularly sent soil sample for analysis in accordance with the German fertilisation decree (DüngesV, 1996). Two further measures, application of flotation tires (M3) and reduction of pesticide input (M7) were applied on more than one-half of the agricultural land. Four out of the 14 measures that were listed were only applied on an experimental basis, on less than 5% of the land managed by the respective farms. Farmers allotted more arable land to be set aside than the required 5% enforced by the EU regulations in 2004, i.e., almost 7%. Several farms had taken part in a specific agri-environmental programme in Brandenburg, based upon EU regulation No. 2078/1992. For this programme patches of arable land between the size of 0.05 and 0.3 ha that provided good conditions for nature protection issues were permanently taken out of production and managed in accordance with different conservation aims (cf. MLUR, 2000).

An intention to increase the land under conservation measures during the following years was proclaimed for four measures, namely reduced tillage (M1), mulch tillage (M2), reduced input of pesticides (M7), and combination of operations (M10). Asked about the extent, the farmers stated that they would like to enlarge the areas under conservation measures by about 300–500 ha per measure.

Importance of conservation aims

Fig. 2 shows how farmers assessed the importance of different conservation aims both, in general as well as on their own farm. While protection of water resources was seen as the most important overall conservation aim, soil protection was assessed to be the most crucial on-farm objective. This might be due to the fact that the soil is seen as the primary resource in agricultural production and the protection of its fertility is of utmost importance to ensure high yields. Conservation of habitats and biodiversity were in both cases assessed to be important, but less important compared to the other conservation aims.

These findings are supported by results of other studies (e.g., Autsch, 1992; Pongratz, 1992). Pongratz (1992, p. 207) also points out that the farmers' prime interest in soil conservation differs from the point of view held by society or experts who put more weight on agriculture's role in enhancing landscape features and the protection of flora and fauna species as well as the protection of water resources due to agricultural pollution.

Importance of different factors affecting the acceptance of conservation measures

The respondents also assessed the importance of 30 different factors regarding their impact on the farmers' acceptance of conservation measures. These criteria were grouped into seven categories in accordance to those listed by Rogers (2003: 219 et sqq.): compatibility, trialability, complexity and observability and relative advantage. The latter category was sub-divided into costs, time need, and risks (Fig. 3).
Cost neutrality or cost reduction as well as the compatibility with the local conditions in terms of climate and soil characteristics were chosen as the most important factors. Thus, subsidy payments or economic benefits are not always of primary interest to farmers as commonly stated (cf. Holm-Müller et al., 2002). Furthermore, it was seen as important that conservation measures did not decrease the yield, or impair the quality of the products. Likewise, the adoption of a measure should not be linked to a higher work load in periods when the labour input is already high, such as in spring or fall (cf. Kusemann, 2004). By contrast, a higher work load in general was not classified as crucial. Additionally, the farmers felt that a measure is important if it can help to protect resources for future generations, improve the farmers' image in society, challenge their knowledge and therefore add to the farmers' satisfaction with his or her work. In the farmers' point of view it is of lesser importance whether or not a new measure may require additional training or electronic data processing, as in the case of yield mapping. Similarly, the effect that the adoption of a new measure might have on their reputation among fellow farmers was judged to be less important.

The heterogeneity in the assessment, in terms of the calculated standard deviation, was highest regarding the willingness to undergo an additional training for a new measure, both, for the farmers themselves as well as their employees. The same applied to the willingness of spending time with electronic data processing. Furthermore, the risks that the adoption of a conservation measure might cause problems with the land owners, the impacts on their reputation in the farm community, or the possible effects on the attractiveness of the agricultural landscape were seen very differently. Natural conditions and the political frame conditions being comparable for all interviewed farmers, this heterogeneity in the assessment is largely dependent on the personal attitudes of the individual farmer, which again are influenced by family-related and farm-specific factors. The personal attitude of the individual farmer is reflected in his or her risk tolerance, environmental awareness, innovativeness, adaptability and strongly influenced by own experiences and acquired knowledge. For instance, the preparedness to deal with measures that require an electronic data processing was highly dependent on the farmer’s enthusiasm for computers. Regarding farm-related factors, e.g., the availability of financial resources, farm machinery, manpower and farm-specific work peaks as well as off-farm activities play a decisive role. Farmers who have tourism activities as an additional source of income assessed the factor ‘measure enhances the attractiveness of the agricultural landscape’ as more important than those without tourist activities. In addition, family-related factors such as marital status, existence of children, family members employed on the farm can have a high impact. The factor ‘measure does not imply time shortage for family and hobbies’ was graded more important by farmers with children. According to Salamon et al. (1997) and Rossier (2004), the impact of family-related factors are often underestimated, as the farmer commonly is seen as an independent and free decision maker taking only into account the economic prosperity of the farm. But especially on smaller farms, family and farm are not only closely connected but form, in fact, a unity (Kusemann, 2004).
If the assessment is aggregated for each of the defined main categories, the following ranking of the main categories in sequence of decreasing overall importance is obtained: Risks > Observability > Costs > Compatibility > Time need > Trialability > Complexity. Thus, risks and the visibility of the intended results followed by the costs are the main drivers when decisions are made to adopt new conservation measures. Compatibility, time need, trialability and complexity were assessed as important factors, too, but less important by comparison. However, if the farms are further sub-divided into groups along different criteria, such as farm type, farm size, farm tenure, or age pattern of farmers, importance of the main categories gets affected (see Table 1).

The farm type (mixed vs. arable farming) shows no influence on the first ranked category which is risk for both farm types. Nevertheless, mixed farms show a higher interest that a new measure is compatible with the whole farming system, since the inter-dependencies between crop and animal production are closely linked and the adoption of new cropping measures might affect forage availability, while on arable farms more emphasis is given to the trialability of new measures. When farms were grouped according to their size into smaller (<1000 ha) and bigger (>1000 ha) holdings, first rankings are affected significantly. While bigger farms take prior interest in cost aspects, smaller farms in the first place are concerned by risk issues. The same pattern can be found when farms are grouped by the percentage of rented land. Farmers with high shares of leased land are more considerate about financial issues as tenancy payments have to be paid on top of other expenses. Finally, the age of the interviewed farmers seems to play a role as well. While older farmers are more concerned by related risks of new measures, younger farmers pay more attention to the cost aspect.

Assessment of conservation measures regarding the different influencing factors

Table 2 shows how the different conservation measures were ranked by the farmers in relation to their suitability regarding the seven main categories. The calculated weight (Table 2, third column) gives an estimate of the overall importance of each category as compared to the others.

High risks, for instance were linked especially to set aside land (M13) due to problems with weed control on these plots. Reduced and mulch tillage (M1 and M2) are also assessed as risk-associated measures. Farmers reported that they had initial problems with these measure related to weed management, fungal diseases, slugs, and mice resulting in lower yields. Furthermore, the combination of operations (M10) was seen as critical. The use of heavy equipment might increase the risk of soil compaction when applied on wet soils. Reduction of pesticide input (M7) was estimated as risky because the omission of prophylactic pesticide applications increased the risk of pest calamities under unfavourable weather conditions.

Regarding the main category observability, especially reduced and mulch tillage (M1 and M2) were assessed positively as these measures are assumed to be very effective in diminishing detrimental environmental effects such as soil erosion or nitrate leaching and help to improve the image of farmers in society. Yield mapping (M9) was also graded as a highly effective measure in terms of results. According to the farmers this measure is the pre-condition for the site-specific management of their plots and the efficient input of fertilisers and pesticides.

Due to less expenditures for fuel and labour if fields are not ploughed, M2 and M1 were seen as suitable measures to reduce costs. Likewise, the reduction of fertiliser and pesticide input (M6 and M7) and the combination of operations (M10) help to reduce costs. Higher costs were assessed for yield mapping (M9) and flotation tills (M3), both requiring high investments at the beginning, which only amortise over time. The integration of catch crops (M4 and M5) causes additional expenditures for seeds and sowing. Depending on the fertility of the set aside land the assessment of this measure (M13) was very diverse. In case the farms had set aside land of low productivity they assumed a cost reduction. By contrast, farms on which also productive sites were taken out of production saw M13 as a costly measure due to the lost harvest.

A low suitability regarding compatibility was estimated for yield mapping (M9), integration of under-sown crops (M4) and...
Table 3
Overall ranking of the conservation measures due to their index of acceptance

<table>
<thead>
<tr>
<th>Conservation measure</th>
<th>M2</th>
<th>M1</th>
<th>M10</th>
<th>M6</th>
<th>M13</th>
<th>M7</th>
<th>M12</th>
<th>M3</th>
<th>M14</th>
<th>M11</th>
<th>M8</th>
<th>M5</th>
<th>M4</th>
<th>M9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Index of acceptance [0–1]</td>
<td>0.645</td>
<td>0.638</td>
<td>0.617</td>
<td>0.584</td>
<td>0.570</td>
<td>0.551</td>
<td>0.540</td>
<td>0.530</td>
<td>0.515</td>
<td>0.505</td>
<td>0.497</td>
<td>0.461</td>
<td>0.436</td>
<td>0.393</td>
</tr>
<tr>
<td>Acreage, in 2004 [ha]</td>
<td>3,087</td>
<td>5,244</td>
<td>3,830</td>
<td>10,739</td>
<td>875</td>
<td>10,087</td>
<td>268</td>
<td>7,383</td>
<td>98</td>
<td>198</td>
<td>4,704</td>
<td>20</td>
<td>415</td>
<td>2,532</td>
</tr>
<tr>
<td>Intended enlargement [ha]</td>
<td>500</td>
<td>500</td>
<td>392</td>
<td>0(^b)</td>
<td>0(^c)</td>
<td>314</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^a\) M1–M14 listed and explained in Appendix A.
\(^b\) M6 is already implemented on 100% of the arable land.
\(^c\) Share of M13 depends on EU regulations. The percentage of land farmers are obliged to set aside differs from year to year.

inter crops (M5) as well as for mulch tillage (M2). In case of M9, the farmers had to learn to deal with the electronic analysis and interpretation of the produced yield maps. The integration of under-sown crops implied an adaptation of the production procedure of the main crop to prevent yield depression, and for the integration of inter crops changes might be necessary in the crop rotation. Conversion from conventional to mulch tillage systems included direct drilling techniques. Here, the seeds are sown directly into a slit in the unprepared land, which was reported to be especially tricky in the beginning when the farmers had to test suitable machinery and right settings to ensure a successful sowing. This factor was seen as unproblematic for reduced tillage (M1) as a cultivator usually is used for seedbed preparation.

The time need can be reduced by conservation tillage measures (M2 and M1) as the time-consuming ploughing is omitted. The combination of operations (M10) was also assessed to be suitable in saving time. The same goes for set aside land (M13), as these plots are usually mown just once a year. Yield mapping (M9) was estimated to be the measure with the highest time need due to the time needed for data analysis and interpretation.

Yield mapping (M9) was also the measure assessed to be the least suitable in terms of trialability. This measure is based upon satellite navigation and requires a full technology package that cannot be experimented with piece by piece.

Finally, a high complexity was assumed for measures M7 and M6, reduction of pesticides and fertilisers. These two measures are closely correlated to crop yield and any faulty decision will cause an immense loss in profit. The same applies for measures M1 and M2. According to the farmers, conservation tillage is a matter of the right timing and the appropriate use of machinery. The handling requires a lot of attention from the farmer’s side. Again, also yield mapping (M9) was seen as a crucial measure. The difficulty here lay in the proper interpretation of the data and their correct implementation.

Acceptance of conservation measures based upon the survey results

In order to find out which measures are more acceptable than others an index of acceptance was calculated, based on the survey results. For this purpose, the suitability score per measure was calculated for each of the main categories. To do so, the answer categories on the scale from 1 to 5 were reclassified on a scale from 0 to 1. Taking into account the weight factor assigned to each main category (see Table 2, third column) an overall index of acceptance was calculated in accordance with Eq. (1). Table 3 shows the ranking of all conservation measures on the basis of the calculated index of acceptance. Additionally, the acreage in 2004 and the intended enlargement regarding individual measures within the next 2 years by the farmers in the case study region are listed.

Mulch tillage (M2) and reduced tillage (M1) show a high index of acceptance due to their potential of reducing costs and time and a high environmental efficiency. The combination of operations (M10) is likewise short-listed. It is assessed as highly compatible and can be easily integrated into present farm practices. A high share of land is currently allotted to these three measures: 49% for M1, 29% for M2, and 36% for M10, respectively. In addition, the farmers are planning to enlarge the area under management for these measures. An enlargement is also foreseen for M7, the reduction of pesticide input. Yield mapping (M9) ranked last. Although it is rated as highly effective, the farmers assessed it as time-consuming and very costly with heavy investments to be made. According to farmers’ opinion, this measure is not easily integrated into the farm’s routine, as the farmer has to get used to handle the technology, the data analysis and deal with the data interpretation.

M6, reduction of fertiliser input, is already fully implemented in the area, thus no enlargement is intended. Set aside (M13) is highly dependent on the political settings. The farmers are obliged to set aside around 5–10% of their land. To what extent they go beyond this share depends on their soil conditions. Farmers, who manage land of low productivity, tend to take more land out of production than farmers who have highly productive land.

Conclusions

The findings show that despite the general assumption that farmers’ decisions are mostly driven by economic rationality, costs were regarded as an important but not the most important factor. Other factors, like associated risks, effectiveness, or time and effort necessary to implement a certain measure were equally or even more important depending on the respective conservation measure and the specific situation of the farm. In particular, conservation measure that combine all, economic, social and ecological requirements, were assessed most favourable. For instance, the three first ranked measures were all assessed as suitable to decrease time requirements, so the farmer will have more time to spend with his or her family. All three measures were likewise found helpful in reducing costs, a classical economic aim, and all three were seen as measures with a high environmental impact.

It should be stressed that the ranking of the conservation measures did not comply in every case with the amount of area on which a certain measure is presently implemented. Rather, it corresponded well with the announced enlargement of the measures. The assessment given seems therefore to be valid for decision making regarding future plans, such as whether or not which measure should be enlarged. For decisions made in the past and which have led to the current area allotted to each conservation measure, the assessment might well have been different. It is likely, that for future decisions, the situation may again change as farmers will make new experiences and the knowledge thus gained will again influence their judgement.
Appendix A. Adoption of conservation measures on the farms in the case study region

<table>
<thead>
<tr>
<th>Measure</th>
<th>Conservation aims (examples)</th>
<th>Number of farms [n]</th>
<th>Acreage [ha]</th>
<th>Share of the farms' total agricultural land [%]</th>
<th>Intention to increase this measure in the future?</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1—reduced tillage</td>
<td>- Improve soil coverage (15–30% residues) to lower risk of, e.g., nitrate leaching, pollution of surface water, or erosion</td>
<td>8</td>
<td>5,244</td>
<td>40.5</td>
<td>Yes</td>
</tr>
<tr>
<td>M2—mulch tillage</td>
<td>- Further improve soil coverage (&gt;30% residues)</td>
<td>7</td>
<td>3,087</td>
<td>23.9</td>
<td>Yes</td>
</tr>
<tr>
<td>M3—rotation</td>
<td>- Reduce soil compaction, especially when heavy machinery is used in wet periods</td>
<td>7</td>
<td>7,383</td>
<td>57.1</td>
<td>no</td>
</tr>
<tr>
<td>M4—inter crops</td>
<td>- Shorten periods without soil coverage</td>
<td>6</td>
<td>415</td>
<td>3.2</td>
<td>No</td>
</tr>
<tr>
<td>M5—under-sown crops</td>
<td>- Improve soil coverage, especially in row crops such as sugar beets or corn</td>
<td>2</td>
<td>20</td>
<td>0.2</td>
<td>no</td>
</tr>
<tr>
<td>M6—reduced fertiliser input</td>
<td>- Lower risk of nitrate leaching, nutrient entries into surface water</td>
<td>11</td>
<td>10,739</td>
<td>83.0</td>
<td>No (100% of arable land)</td>
</tr>
<tr>
<td>M7—reduced pesticide input</td>
<td>- Lower risk of pesticide entries into ground and surface water</td>
<td>10</td>
<td>10,087</td>
<td>78.0</td>
<td>Yes</td>
</tr>
<tr>
<td>M8—substitution of inputs</td>
<td>- For example, replace broad spectrum pesticides by more specific ones that do not harm beneficial organisms</td>
<td>7</td>
<td>4,704</td>
<td>36.4</td>
<td>No</td>
</tr>
<tr>
<td>M9—yield mapping (GPS)</td>
<td>- Provide the basis for precision farming</td>
<td>5</td>
<td>2,532</td>
<td>19.6</td>
<td>No</td>
</tr>
<tr>
<td>M10—combine operations</td>
<td>- Reduce number of tracks, e.g., lower risk of soil compactions and water erosion</td>
<td>8</td>
<td>3,830</td>
<td>29.6</td>
<td>Yes</td>
</tr>
<tr>
<td>M11—adapt timing</td>
<td>- Reduce risk to harm or kill, e.g., amphibians during their migration periods by postponing operations</td>
<td>5</td>
<td>198</td>
<td>1.5</td>
<td>No</td>
</tr>
<tr>
<td>M12—adapt operations</td>
<td>- Reduce risk to harm or kill, e.g., breeding field birds by changing the cutting height so nests are spared</td>
<td>4</td>
<td>268</td>
<td>2.1</td>
<td>No</td>
</tr>
<tr>
<td>M13—set aside</td>
<td>- Due to the low disturbance potential set aside is beneficial for many wild flora and fauna species</td>
<td>11</td>
<td>875</td>
<td>6.8</td>
<td>(depends on EU regulations)</td>
</tr>
<tr>
<td>M14—permanent grassland</td>
<td>- Convert arable land to grassland to provide a permanent soil coverage, especially positive on sites sensitive to erosion or regular flooding</td>
<td>5</td>
<td>98</td>
<td>0.8</td>
<td>No</td>
</tr>
</tbody>
</table>

* Total number of farms: n = 11.

References


Ison, R., Roeling, N., Watson, D., 2007. Challenges to science and society in the sustain-
able management and use of water: investigating the role of social learning. Environ-

Katz, E., 1961. The social itinerary of social change: two studies on the diffusion of
innovation. In: Schramm, W. (Ed.), Studies of Innovation and Communica-
tion to the Public. Stanford University, Institute for Communication Research,
Stanford, CA.

on soil variability in the direct sowing precision paddy farming. Journal of the

Familienbetrieben. Kommunikation und Beratung—Sozialwissenschaftliche
Schriften zur Landnutzung und ländlichen Entwicklung 57, 1–168.


'socio-technical root-system' as a tool for identifying relevant cross-disciplinary
research questions. In: (Pre) Proceedings of the Sixth European IFSA Symposium,
vol. II, Vila Real, Portugal, 4–7 April, pp. 773–782.

Untersuchung bei Landwirten in Nordrhein-Westfalen. Dissertation Universität
Bonn. Witterschick, Verlag M. Wehle, Bonn.


Macombe, C., 2004. Learning new skills by French farmers. Evolution and uneven-
tness of the beliefs. In: (Pre) Proceedings of the Sixth European IFSA Symposium,

Mcsaac, G., Morey, N.C., 1998. Engineer’s role in sustainable development: consid-
ering cultural dynamics. Journal of Professional Issues in Engineering Education
and Practice 124, 110–119.

MLUR. (Ministerium für Landwirtschaft, Umweltschutz und Raumordnung des Lan-
des Brandenburg), 2000. Entwicklungsplan für den ländlichen Raum im Land
Brandenburg bezogen auf die Flankierenden Maßnahmen des Europäischen
Ausrichtungs- und Garantiefonds für die Landwirtschaft (EAGFL), Abteilung

Omron Advanced System, 1996. Fuzzy Logic Filtering Add-in for Microsoft
Excel—Flex Filter.

Pieterse, N.M., Bleuten, W., Jorgensen, S.E., 2003. Contribution of point sources and
diffuse sources to nitrogen and phosphorus loads in lowland river tributaries.

zum Umweltbewußtsein in der bundesdeutschen Landwirtschaft. Profil-Verlag,
München, Wien, 301 pp.

Prager, K., 2002. Akzeptanz von Maßnahmen zur Umsetzung einer umweltscho-
nenden Landwirtschaft bei Landwirten und Beratern in Brandenburg.

to Come to Mutual Understanding.”—The multidimensionality of social learn-
ing processes concerned with sustainable natural resource use in India, Africa and Latin America. Systematic Practice and Action Research 19, 219–
237.


Rossier, R., 2004. Role models and farm development options: a comparison of seven
Swiss farm families. In: (Pre) Proceedings of the Sixth European IFSA Sympo-

adoption of sustainable farming systems. Journal of Soil and Water Conservation
52, 265–271.

Thomsen, I.K., 2005. Nitrate leaching under spring barley is influenced by the pres-
ence of a ryegrass catch crop: results from a lysimeter experiment. Agriculture
Ecosystems & Environment 111, 21–29.

Science.

Wilson, J.D., Evans, J., Browne, S.J., King, J.R., 1997. Territory distribution
and breeding success of skylarks Alauda arvensis on organic and inten-
1478.

Worrall, F., Besien, T., 2005. The vulnerability of groundwater to pesticide contam-
ination estimated directly from observations of presence or absence in wells.