# THE ROLE OF LAND USE COMPETITION IN FARMERS' ENGAGEMENT IN RENEWABLE ENERGY PRODUCTION

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## Abstract

In German agriculture the renewable energy production from biogas is undergoing a dynamic expansion. However, farmers differ in their decision behavior concerning engagement in the biogas production. A better understanding of decision-making structures at the farm level is particularly important for policy-makers and local authorities to estimate the future investment potential of biogas production. Determinants of decision behavior are identified based on a survey of 160 German farmers. The study focuses on land use competition as a negative impact of the increased biogas production in agriculture. Using a multinomial logit regression we explore this impact on farmers' willingness to invest. Our findings indicate that the future potential of biogas production is determined by socio-economic patterns such as perceived conflict potential. Furthermore intrinsic factors e.g. ecological awareness were overlaid by the extrinsic factor of economical benefits provided by the funding policy. The knowledge of farmers' decision making structures is helpful revising the current funding policy as well as for the development of models forecasting the future potential of biogas production in agriculture.

**Key words:** *Biogas Production, Renewable Energy, Land Use Competition, Decision Behavior*

# THE ROLE OF LAND USE COMPETITION IN FARMERS' ENGAGEMENT IN RENEWABLE ENERGY PRODUCTION

## 1. Introduction

In the context world's advancing climate change the expansion of the production of renewable energies (renewables) has become a key factor as an adaptation strategy (IRENA, 2010). In Germany, the policy framework regarding renewables has been gradually improving in recent years. The interest of German entrepreneurs in investing in renewables like wind energy and anaerobic digestion (biogas production, BGP) has significantly increased since then (Reiche and Bechberger, 2006). Especially in the agricultural sector a steady expansion of BGP has been observed since 2000 (Plieninger et al., 2006).

A closer examination of indicates strong impacts on local agriculture through an increased demand for biomass. However, the supply is restricted by limited arable farmland. Consequently, energy and the food producing farmers are in competition which may have an influence on their current and future engagement in this sector. Thus, the expansion of BGP might be threatened. This paper aimed to estimate the impact of land use competition (LUC) on the decision-making behavior in renewables, and particular in BGP. The following questions are discussed:

1. What are the negative effects of BGP perceived by the farmers and to what extent is the level of LUC among farmers related to biogas?
2. To what extent does LUC influence farmers' decision behavior regarding investments in BGP compared to other determinants?

Without a detailed knowledge of this impact the energy and environmental policy are running the risk in over- or underestimation the investment potential. For local stakeholders who are preparing biogas projects, the decision making in this specific context is relevant to estimate farmers' response and investment behavior more accurately. This is particularly important because the German policy has set ambitious goals to increase the bioenergy production in form of biogas in the coming years. The regulation on access to gas supply networks contains objectives for the substitution of natural fossil through biogas. According to § 31, BGP should be expanded to 6 billion cubic meters by 2020 to support this substitution (JURIS, 2011). By the end of 2010 approximately 40,000 cubic meters will have been substituted (DENA, 2011).

## 2. Diffusion of Renewable Energies and state of the art

Politic measures have improved the economic conditions for the production of energy from renewables in the last decade. The compensation rates for produced energy have been gradually increasing since the introduction of the Electricity Feed Act in 1991 and the several times amended Renewable–Energy-Act, REA, which has been used as an example internationally and adopted in many other European countries. The current REA provides purchase for the produced energy for a period of 20 years for a comparatively high and fix price (§ 21). Thus, energy producers can calculate the revenue side very precisely which creates a strong incentive for investors (DBFZ, 2010).

The first engagement of farmers in the production of renewables was the installation of wind turbines in 1990s. After the millennium, the funding scheme of the REA changed in favor of other renewables, such as energy from biomass and photovoltaic systems. The subsidies of the REA can in principle be accessed by all investors. However, farms have certain structural advantages for bioenergy production such as land ownership, appropriate existing machinery and storage facilities, access to credits, etc. Farms have existing infrastructure, such as barn roofs for the installation of photovoltaic systems as well as already having access to direct supply with biomass (energy crop cultivation) as a raw material for biogas generation. Farmers have great expectations regarding renewables. Hence, alternative strategies such as diversification by producing energy from renewables have diffused among farms in recent years comparing to other sectors (Heissenhuber and Berenz, 2006; Rosenbaum et al., 2005; Schaper and Theuvsen, 2006).

Considering the changed REA and the structural advantages on farms, this led to greater diffusion of two forms of renewables in German agriculture: energy from biomass in form of anaerobic digestion (BGP) and energy production from solar (photovoltaics) (ibid.). Currently, in Germany there are as of the end of 2009 4,960 operating biogas plants are, almost all of which are located on farms (DBFZ, 2010). The photovoltaic market is more heterogeneous, and the agricultural share of the total produced photovoltaic energy is only 19% (BS and EUPD, 2009). Considering the greater number of qualified enterprises from other sectors, however, this agricultural market share is remarkably high.

The diffusion process of renewables is extremely rapid. The biogas expansion for instance and the strong investment activities of German farmers are closely linked to the changes in REA (Ehlers, 2008; Mendonca, 2007). Therefore the biogas market is not only being subjected by market-based aspects, but rather shaped largely by the policy (Jacobsson and Lauber, 2006; Reiche and Bechberger, 2006).

## 3. Land use competition at the farm level

Wibberley (1959) investigated the competition for rural land caused by urban growth. However, in recent years the discussion changed into bioenergy as competitive drivers. The production has positive effect on the projections for climate change (Berndes et al., 2003). However, certain negative impacts on nature, economics and social networks are becoming ever more apparent (Domac et al., 2005; Dornburg et al., 2010).

In Germany the increasing expansion of bioenergy production is forced by policy. The REA was created as an incentive to increase bioenergy production in order to achieve the political objectives in renewables production. However, in Germany negative effects are also being perceived more frequently (Dehnhardt and Petschow, 2004; Mautz et al., 2007). Competitive conditions intensify due to differences in interests and limitations of available resources such as environmental goods or production factors and may result in negative social, ecological or economical consequences (DBFZ, 2009; Mautz et al., 2007; SRU, 2007). Within the bioenergy pathways, BGP is the focus of discussions regarding negative effects (DBFZ, 2009). The negative intra-sectoral effects are closely related to the biomass production for digestion process (WBA, 2007). Food and biogas producing farmers are in competition because of the relatively high and secure revenues from the BGP provided by the REA. This is demonstrated by biogas producing farmers having a higher ability to pay for production factors (e.g. farmland) compared to their food producing colleagues, leading to an increase of land lease rates (Berenz et al., 2008; Heissenhuber et al., 2008). An excessive subsidization of BGP compared to food production leads to politically induced competitive distortions between the two (ibid.). We observe farms restructuring their production portfolio in favor of biogas. In some German regions, e.g. North-West, the displacement of cash crop and animal husbandry had meanwhile reached a level that the BGP dominates on some farms. Some of those farms are becoming exclusive energy producers.

We focus on the socio-economic impacts of increased BGP in Germany at the farm level, keeping in mind the global relevance of this topic. However, the contribution of Germany to the production of renewables in form of biogas is limited, although the European contribution is much bigger. The biogas industry in many European countries and beyond is growing very fast. However, Germany has more than ten years of experience with impacts of increased agricultural BGP in the agriculture.

## 4. Farmers' decision-making behavior – Developing the model

Approaches to explain entrepreneurs' decision behavior offer complementary normative (prescriptive) and descriptive decision theories. The first aims to understand the decision behavior on the basis of formalized rules and procedures under the assumption of rationally correct (optimal) decisions (Bell at al., 1988). On the other hand, the descriptive approach aims to reflect the realistic decision-making of humans by considering it in a broader context (ibid). Studies from 'behavioral decision research' queried the assumption that humans are rational and show that managerial decisions do not strictly follow the rational goal of economic profit maximization. They can also be influenced by other psychological elements such as intrinsic (e.g. satisfaction or risk-taking) or social factors (e.g. desired behavior) as extrinsic objective (Edwards, 1954; Simon, 1959 and Kahneman and Tversky, 1979). If the decision-making situation is more complicated and complex, the actual decision behavior differs greatly from expected formal normative behavior (Bell et al. 1988; Simon, 1959). An investment in renewables is in fact a multidimensional issue. Therefore the aim of this contribution is not an economic evaluation of the investment decision based on well calculable quantities such as (opportunity-) costs and government-guaranteed payments (subsidies), but rather an appraisal based on behavioral and other influential elements which should be taken into account in a realistic investigation.

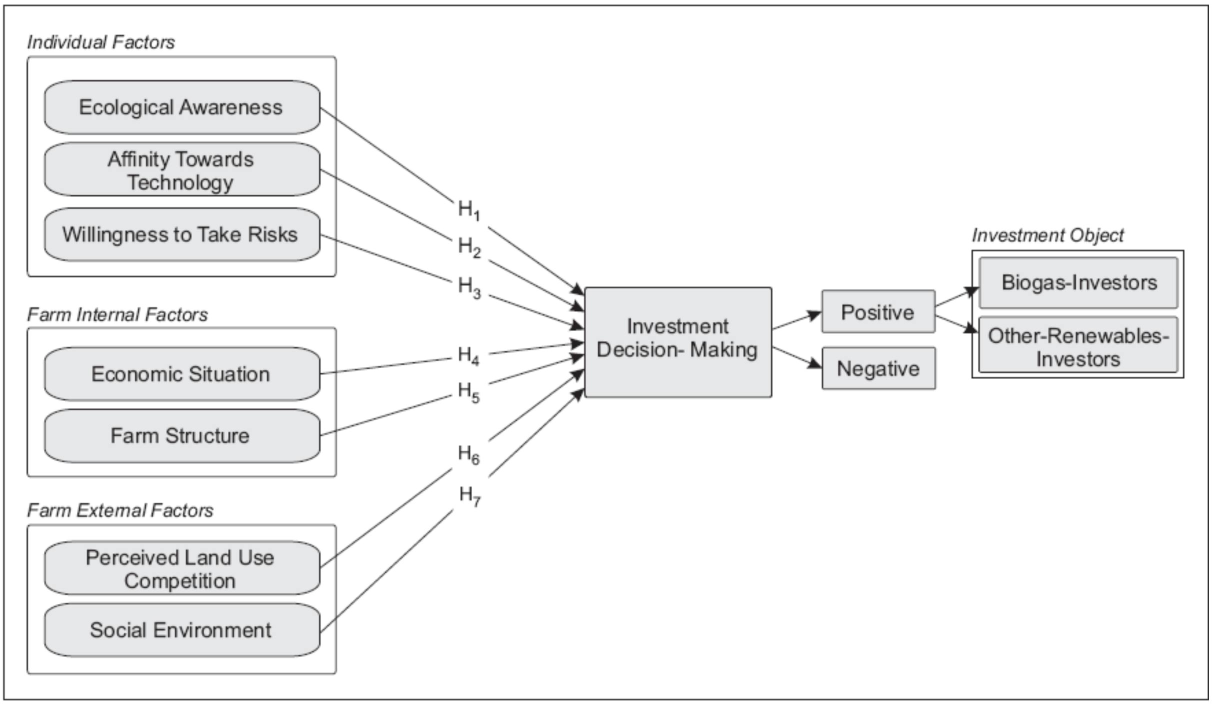
A number of studies have examined the general decision-making behavior on farms (see e.g. Kool, 1994 or Willock et al., 1999). They focus mostly on motivations, goals and attitudes of farmers. However, the decision behavior is seen as the result of a combination of motivational and external factors as well as farm structure (Burton, 2004). Within the external dimension Solano et al. (2003) focus on social network structures. The strong social impact on the farmer by other people in her or his work or family environment is characteristic of agricultural behavior and differs significantly from other sectors (ibid.).

Farms with their primary production are very dependent and close to nature compared to other sectors. Hence, farmers are facing a variety of complex decision situations, which allow only a limited formalization (Nuthall, 1999, 2010). *'As a farmer must deal with most aspects of biology, economics, the weather, organisations, people and so on, they face very complex decision situations with only a modicum of support in an immediate office sense.'* (Nuthall, 1999: 17)

Willock et al. (1999) have developed in their Edinburgh study of decision on farms an essential model to explain farmers' behavior. The authors found that personal factors such as personal character properties influence, through attitudes and objectives, indirectly farmers' behavior. Willock et al. (1999) and Burton (2004) pointed out that in particular decision situations, such as specific investments, the outcome behavior is influenced strongly by external, physical or situational effects in addition to intrinsic drivers.

Based on these theoretical assumptions and considering the LUC issue a basic model explaining farmers' individual decision behavior regarding investments in renewables was created (see Figure 1). There are three core elements: 'Individual', 'Farm internal' and 'Farm external' factors. For each construct, hypotheses ($H_1$ to $H_7$) were established. Additionally, the form of renewables is considered in the model because between the renewables technologies are differences in terms of impacts on agriculture. Due to the strong interactions between BGP and effects on agriculture, this technology is considered separately. For this purpose, biogas (BGP) and other forms of renewables sources (other renewables) as 'Investment Object' are integrated into the model.

Figure 1. Empirical model explaining farmers' decision behavior




## Individual factors

Trojecka (2007) found that farmers' ecological awareness influencing their own behavior. They desire for a $CO_2$-neutral, ecologically friendly renewables production could be a driver for bioenergy investments. Lynne and Rola (1988) refer to the sense of responsibility towards the environment, which has a strong influence on farmers due to its central importance in their mode of production. Therefore, we assume: *A high level of environmental awareness has a positive impact on the probability to invest in renewables ($H_1$).*

It is well known that farmers adopt new production techniques if they have a high technical interest (Austin et al. 1998). For the selection of an appropriate renewables technology, the construction and the operation of such facilities as well requires an extensive understanding and knowledge. Even the willingness to adopt such technology in an early stage, as a pioneer, has relevance in this context (ibid.). Therefore, we expect: *A high affinity for technology has a positive impact on the probability to invest in renewables ($H_2$).*

Sauer and Zilberman (2009) state in their studies that some decision-makers are not willing to take risks in order to advance their business and this results in a delay in the uptake of innovations. Therefore, we presume *A high willingness to take risk has a positive impact on the probability to invest in renewables ($H_3$).*

## Farm internal factors

The farm economic situation is also relevant for the decision-making. Farmers differ greatly in their perception of the economic success of their farm. Simon (1955) confirms in his Theory of Satisfaction Behavior that entrepreneurs are not only focused on increasing their returns, even they have good opportunities. Thus, the economic satisfaction is not driven exclusively by monetary reflections. van Rooij (2011) investigated and verified this theory and point out that satisfying behavior has a strong influence on business decisions. Therefore, we hypothesize: *A high level of satisfaction with the economic situation has a negative impact on the probability to invest in renewables ($H_4$).*

As with any form of reorientation of production methods the production capacity is limited by the structural conditions. Schramm (1977) proves that entrepreneurs among other factors pay a particular attention to the factor endowment of their business. Langert (2007) use the example of energy crops cultivation confirming the importance of structural conditions as a major factor in making farm production decisions. Therefore, we presume *A high quality of farmland ($H_{5a}$) has a … / A large amount of farmland ($H_{5b}$) has a … / High labor capacities ($H_{5c}$) have a positive impact on the probability to invest in renewables.*

**Farm external factors**

Entrepreneurs' behavior is strongly linked to the relationship with other managers in their branch (Fehr and Schmidt, 1999). Kahneman et al. (1986) constitute in this context the presence of fairness expectations in terms of economic behavior. We presume that intra-agricultural effects such as the increasing LUC and politically induced competitive distortions are perceived by many farmers and have a negative impact on their individual decision-making, since they are considered as unfair behavior: *Strongly perceived LUC have a negative impact on the probability to invest in BGP in particular ($H_6$).*

Farmers are key actors in the rural communication network and are in close contact with many non-agricultural groups of people (Retter et al., 2002): *The social environment has a strong impact on the decision-making process in general ($H_{7a}$).*

Fishbein and Ajzen (1975) describe in their Theory of Reasoned Action the importance of the social environment for behavior. Human behavior is affected by their perception of how others would view them if they performed the behavior, especially when the behavior is socially visible. The opinion of family, friends and local residents concerning a specific situation affects farmers' behavior considerably (Solano et al., 2003): *A negative opinion of the social environment concerning the object of investment (BGP) has a negative influence on the probability to invest in the BG ($H_{7b}$).*

## 5. Data and methods

Altogether we interviewed 160 farmers personally with a standardized questionnaire in Germany in September 2009. Hypotheses were operationalized in statements rated by respondents through a five point Likert scale. The survey region was focused on North-West Germany. North-West Germany has a large variety of production branches of farming and a large number of biogas plants have been constructed in these regions.

One anomalous response was detected and excluded from survey. Overall, 159 responses were available for the further analyses. The sample was divided into three types of farmers based on their investment decision (multiple answers): Total sample, 159 Respondents (100%); Non Investors, 37 (23.3%); Biogas-Investors, 58 (36.5%) and Other-RE-Investors, 64 (40.3%). The group of 'Other-RE-Investors' consists of farmers who are not producing biogas, but have chosen to produce other form of renewables. This is mostly photovoltaic technology, rarely wind power.

The socio-demographic and farm structural characteristics of the data set reflect the German average not exactly. The amount of farmland area per farm is on average 173 ha (average in Germany 48.5 ha), with a relatively high standard deviation of 238 ha. 149 farms were managed as a main occupation (full-time) and only ten part-time which differs from the national average. Five farmers produce organically. Around three workers are employed on each farm on average. In terms of the production portfolio on farms, about 9% of all farms are forage growers, 28% cash crop producers, 38% livestock producers, 23% are mixed farms and 2% belonging to other types of farms. The perceived average soil quality on farms is 44.0 points (from 0 to 100, were 100 equals the best quality). The respondents are on average 45 years old and well educated. Only five are female. Seven farms expected to sell the business in the near future. In 42 businesses the future is still unclear. The remaining farmers had made the takeover recently.

A multiple comparison between the three identified groups of farmers in terms of their perception of the effects caused by BGP in their region was carried out by multivariate analysis of variance. The level of significance was adjusted according to the Bonferroni correction. This post-hoc test identify between which subsamples the differences are statistically proved. For the further validation of the empirical model the data dimension was reduced by an explorative factor analysis. A multinomial logistical regression reveals the direction and strength of independent variables on the decision behavior.

## 6. Empirical results

First, farmers' perceived negative effects caused by the BGP previously described. The majority of the interviewed farmers are highly aware of BGP in their region. For 86% of all respondents, an average of 4 biogas plants are located within 10 kilometers of their farm.

Significant differences in farmers' perceived effects of BGP on the local agriculture were identified between the groups in Table 1. Non- and Other-RE-Investors see them especially confronted with increasing land rental rates and land scarcity. Thus, Non-Investors perceive an increasing level of competition with their biogas producing colleagues. Farmers, however, do not see BGP in the region posing the risk of increasing regional feed prices.

Table 1. Farmers' perceived dimensions of impacts concerning biogas production

| | **Total Sample** | | **Non-Investors (A)** | | **Biogas-Investors (B)** | | **Other-Renewables-Investors (C)** | | F-Statistics |
|---|---|---|---|---|---|---|---|---|---|
| | N=159 | | n=37 | | n=58 | | n=64 | | |
| | M[1] | SD[2] | M | SD | M | SD | M | SD | |
| *In my area…*[3] | | | | | | | | | |
| …biogas plants force up land lease rates. | 0.70 | 1.18 | 1.31 | 0.79 | -0.12 | 1.07 | 1.10 | 1.04 | 30.77 AB***; BC*** |
| …biogas plants lead to problems complying with nutrient limits. | -0.39 | 1.11 | -0.17 | 1.06 | -0.86 | 0,92 | -0.10 | 1.16 | 8.97 AB**; BC*** |
| *How do you assess the potential impacts caused by biogas plants located in your area on your farm as mentioned below?*[4] | | | | | | | | | |
| Land scarcity. | 0.27 | 1.33 | 0.84 | 1.34 | -0.17 | 1,18 | 0.36 | 1.35 | 6.23 AB**; BC** |
| Increasing of land lease rates. | 0.37 | 1.31 | 0.78 | 1.26 | -0.21 | 1.26 | 0.69 | 1.20 | 9.29 AB**; BC** |
| Increasing feedstuff rates. | -0.53 | 1.14 | -0.24 | 1.24 | -0.78 | 0.10 | -0.44 | 1.18 | 2,34 |
| Problems with the utilization of manure. | -1.01 | 1.10 | -0.67 | 1.24 | -1.41 | 0.73 | -0.80 | 1.22 | 6.22 AB**; BC* |
| Increasing competition between farmers. | 0.25 | 1.18 | 0.68 | 1.14 | -0.23 | 1.02 | 0.47 | 1.20 | 8.12 AB***; BC** |
| *The energy crop cultivation in my area will lead to…*[3] | | | | | | | | | |
| …an increased level of competition with livestock farmers. | 0.36 | 1.37 | 0.69 | 1.40 | -0.07 | 1.25 | 0.56 | 1.38 | 4.81 AB*; BC* |
| …an increased level of competition with cash crop farmers. | 0.54 | 1.18 | 0.67 | 1.15 | 0.14 | 1.22 | 0.81 | 1.08 | 5.48 AB+; BC** |
| …an increased level of competition with nature conservation. | -0.37 | 1.06 | -0.11 | 0.89 | -1.00 | 0.78 | 0.05 | 1.12 | 19.83 AB***; BC*** |
| *Biogas plants…*[3] | | | | | | | | | |
| …are bothering non biogas producers in my area. | 0.21 | 1.26 | 0.89 | 0.95 | -0.54 | 1.14 | 0.50 | 1.16 | 21.61 AB***, BC*** |
| …are crucially important for my area. | 0.06 | 1.06 | -0.29 | 1.10 | 0.58 | 0.89 | -0.22 | 1.02 | 12.50 AB***; BC*** |

[1] Mean | [2] Standard Deviation | [3] rated on a scale '-2 = fully disagree' to '2 = strongly agree' | [4] rated on a scale '-2 = very low' to '2 = very high' | p ≤ 0,001: very highly significant***; p ≤ 0.01: highly significant**; p ≤ 0.05: significant* | + non-significant trend | AB significance between the groups A and B | BC significance between the groups B and C

In a further item, all respondents were asked how they would view a biogas plant being built in close proximity to their farm. The very highly differentiated responses suggest that the different regional conditions and individual situations of farms play a greater role in the conflict perspective.

Comparing the structural and socio-demographic characteristics of the three groups no significant differences were observed except among the labor capacities. The Biogas-Investors have with a mean of 4.13 (full-time) employees more employees than the Other-RE-Investors, which operate with 2.37 employees. The significant difference (F-value: 3.88, $p < 0.05$) can be explained by the high demand for labor in the cultivation of energy crops as raw materials for the BGP.

To reduce the data dimension and for aggregation of variables, an exploratory factor analysis was carried out. Following the theoretical model (see Figure 1), all recorded and appropriate variables that explain the differentiated decision behaviors are included in the analysis. In the final factor analysis, 18 variables form five factors (see Table 2). With the exception of the fifth factor 'Affinity towards technology', all constructs have satisfactory indicator values concerning validity and reliability (Cronbach's alpha > 0.6; MSA > 0.6) (Field, 2009).

Table 2. Results of explorative factor analysis

| Factors or items | M[1] | SD[2] | R[3] |
|---|---|---|---|
| **Factor 1: Perceived land use competition (LUC)**[4] explains 23.8% of variance, Cronbach's α: 0.87 | | | |
| Biogas plants push up land lease prices in my area. | 0.68 | 1.18 | 0.81 |
| The cultivation of energy crops increased the competition with livestock production my area. | 0.36 | 1.37 | 0.80 |
| Biogas plants are bothering non biogas producing farmers. | 0.20 | 1.26 | 0.79 |
| There are already far too many biogas plants in my area. | -0.25 | 1.15 | 0.72 |
| Biogas plants cause problems with the compliance of nutrient input limits in my area. | -0.40 | 1.10 | 0.70 |
| The energy crops cultivation leads to an increased competition with the cash crop cultivation in my area. | 0.54 | 1.18 | 0.68 |
| The energy crops cultivation leads to an increased competition with the material usage of renewable resources in my area. | 0.04 | 1.07 | 0.67 |
| The energy crops cultivation leads to an increased competition with nature conservation. | -0.37 | 1.06 | 0.63 |
| **Factor 2: Economic situation**[5] explains 10.8% of variance, Cronbach's α: 0.68 | | | |
| Our farm income enables greater investments.[4] | 0.57 | 1.17 | 0.87 |
| I am satisfied with the current overall situation of my farm. | 0.67 | 1.03 | 0.77 |
| My farm will still exist in 20 years time. | 0.89 | 0.99 | 0.66 |
| **Factor 3: Social influence**[6] explains 9.7% of variance, Cronbach's α: 0.61 | | | |
| How important is the opinion of your employees for your investment decision. | -0.03 | 1.15 | 0.78 |
| How important is the opinion of your shareholders for your investment decision. | 0.61 | 1.49 | 0.75 |
| How important is the opinion of local residents for your investment decision. | -0.64 | 1.04 | 0.73 |
| **Factor 4: Ecological awareness**[7] explains 8.8% of variance, Cronbach's α: 0.67 | | | |
| I personally make sure, to produce sustainable respecting aspects of nature and environment. | 1.49 | 0.71 | 0.85 |
| As a farmer I have a special responsibility towards the environment. | 1.45 | 0.71 | 0.85 |
| **Factor 5: Affinity towards technology**[5] explains 7.4% of variance, Cronbach's α: 0.40 | | | |
| I am very interested in new technologies. | 0.81 | 0.78 | 0.75 |
| I am the first who is investing in new technologies. | -0.55 | 0.78 | 0.73 |
| Annotations: MSA = 0.713 \| $R^2$ = 60.56% \| N = 159 \| [1] Mean \| [2] Standard Deviation \| [3] Factor Loading \| [4] Scale from -2 'totally disagree' to +2 'totally agree' \| [5] Scale from -2 'does not apply at all' to +2 'completely applies' \| [6] Scale from -2 'not important at all' to +2 'very important'\| [7] recoded | | | |

The factor 'Perceived' reflects the negative socio-economic pressure between farmers in the course of increased BGP. The dimension 'Economic situation' is the economic self-assessment. In addition, the assessment of farms' viability is included in this factor. The construct 'Social influence' reflects the influence of entrepreneurs' social environment on decision-making. These are business people as well as external contacts from the area surroundings the farm, such as local residents. The family of the entrepreneur is not included in this factor. We aimed to have two dimensions in this construct: First, a general idea of the importance of people from farmers' social environments for him or her when making investment decisions ($H_{7a}$). For this we asked the farmers directly about the importance of other people for their decision-making. Second, we consider the phenomena of driving or inhibiting impacts on decision behavior ($H_{7b}$). However, only the first dimension is reflected by the factor, therefore further analysis focused only on hypothesis $H_{7a}$. The aggregation 'Environmental awareness' reflects farmers' attitudes towards the environment and ecological orientation of the entrepreneur. The factor 'Affinity towards technology' represents individual attitudes towards new technologies. The willingness of an early adoption of innovations is integrated in this factor.

The factor analysis does not represent all constructs of the explanatory model. Therefore, based on proper logical considerations individual items are included in addition to further analysis. The following variables represent the outstanding constructs:

- Willingness to take risk: 'The improvement of existing branches on the farm is less important to me than investing in unknown areas.' (This variable was recoded)
- Farm structure: soil quality rated in points, cultivated farm land area in ha and labour capacity in full time employees (family employees included)

The multinomial logistic regression reveals the direction and strength of independent variables on decision behavior. Farmers' actual taken investment decision (groups of farmers) is used as dependent variable in the logit model. The indentified factors and the additional items as covariates were used as explanatory variables. Despite the limited reliability of the factor 'Affinity towards technology', this was integrated in the model because of its theoretical relevance on behavior (Austin et al., 1998).

142 respondents from the total sample were included in the regression analysis, due to missing values in the socio-demographic and farm structure variables. The regression model fulfils the required quality criteria concerning reliability and validity (see Table 3). The overall explanatory power of the model with 53.0% of total variance (Nagelkerkes $R^2$) can be evaluated as good. 45.7% of Non-Investors, 66.1% of Other-RE-Investors, and even 79.2% of Biogas-Investors are correctly predicted. Overall, in the model 66.5% of the cases classified correctly and is with well above the proportional (34.7%) and maximal random probability (41.6%) (Field, 2009). Table 3 shows how the odds ratio of belonging to a certain group changes, if the value of the dependent variable increases by one unit.

Table 3. Influencing factors on farmers' decision behavior

| | | **Investment decision** | | | | **Investment object** | |
|---|---|---|---|---|---|---|---|
| | | **Biogas-Investors vs. Non-Investors[1]** | | **Other-RE-Investors vs. Non-Investors[1]** | | **Biogas-Investors vs. Other-RE-Investors[2]** | |
| | | **B** | **exp(B)** | **B** | **exp(B)** | **B** | **exp(B)** |
| Individual | **Ecological awareness** | 0.20 | 1.23 | 0.41 | 1.51 | -0.21 | 0.81 |
| | **Affinity towards technology** | 1.01** | 2.76 | $0.46^{+}$ | 1.58 | $0.56^{+}$ | 1.75 |
| | **Willingness to take risks** | 0.37 | 1.45 | 0.18 | 0.84 | 0.55* | 1.73 |
| Farm internal | **Economical situation** | 1.03*** | 2.81 | 0.93*** | 2.54 | 0.10 | 1.10 |
| | **Farm Structure: Soil quality** | -0.38* | 0.96 | -0.01 | 0.99 | -0.03* | 0.97 |
| | **Farm Structure: Cultivated farm land area** | -0.00 | 1.00 | 0.00 | 1.00 | -0.00 | 1.00 |
| | **Farm Structure: Labor capacity** | 0.19 | 1.21 | -0.07 | 0.94 | $0.25^{+}$ | 1.29 |
| Farm exter-nal | **Perceived land use competition** | -1.85*** | 0.16 | $-0.56^{+}$ | 0.58 | -1.30*** | 0.27 |
| | **Social influence** | 0.41 | 1.50 | -0.07 | 0.93 | $0.48^{+}$ | 1.61 |
| | **Absolute term** | 1.64 | | 1.11 | | 0.54 | |

Annotations: n=142 (Biogas-Investors=48; Other-Renewables(RE)-Investors =59; Non-Investors=35) | *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$ | $^{+}$ non-significant trend | [1;2] reference group | Chi-Square=88.67 ($p<0.001$) | Cox&Snell-$R^2$=0.46 | Nagelkerkes-$R^2$=0.53

When comparing the statistical significance of regression coefficients between the farmers who have invested in renewables (biogas and the other renewables) with those who have not invested show that three factors have an influence on the group affiliation. The satisfaction with the economic situation and a positive assessment of farm viability are strong predictors for the two groups of investors of renewables. Compared to the Non-Investors (reference group) the likelihood of investing in renewables (i.e. to be assigned in one of these two groups) increases 2.8 respectively 2.5 times if the economic satisfaction increases by one unit ($H_4$ rejected). The potential influence of other variables on which group a farmer belongs to, have to be considered differentially between the two groups of investors. The probability of an investment in BGP increases by 2.8 times if the farmer has a high technological interest ($H_2$ confirmed). The negative coefficient of soil quality, but especially of 'Perceived LUC' means a reduction of the probability to be in the group of biogas investors. An increasing soil quality means that the probability of being an investor decreases. This might be due to high opportunity costs of good farmland ($H_{5a}$ rejected). An increase in the perception of the negative impacts of BGP by one unit results in farmers being 6.3 times less likely to be willing to invest in BGP.

This repressive investment effect is caused by the focused political financial promotion of biogas which leads to higher competition between farmers (rising land rental rates) and shows the relevance of these side effects of diffusion of renewables on individual decision behavior ($H_6$ confirmed). Interestingly, this effect is only slightly significant for the other forms of renewables.

The impact of farmers' social environment on the decision-making is not significant ($H_{7a}$ confirmed). However, the opinion of people from the farmers' network (not tested in our model) may have an influence on the decision behavior (cf. $H_{7b}$).

The differences in decision-making between the forms of technology/investments, Biogas- and Other-RE-Investors, were considered in a second step of the logit regression where the Other-RE-Investors were chosen as the new reference group. In Table 3, this second step estimation is entitled 'Investment object'. The Biogas- and Other-RE-Investors are different from each other in terms of the factor 'Perceived LUC' on a significant level (-1.30***). Farmers, who perceive such negative effects, are less likely to invest in BGP, which is considered as a reason for these negative effects. These farmers are engaging in other forms of renewables, which are under less criticism.

Furthermore, an increasing level of soil quality (-0.03*) has a slight positive effect on the probability of investment in other renewables. Unlike, the factor 'Willingness to take risks': Farmers, who are less risk-averse, are 2.7 times more likely to belong to the group of biogas producers ($H_3$ confirmed).

A comparison of the three groups of farmers in terms of the factors 'Ecological awareness', 'Labor capacity' and 'Cultivated farm land area' found no significant differences ($H_1$, $H_{5b}$, $H_{5c}$ rejected).

## 7. Discussion

The findings of the multigroup comparison reveal a strong impact of biogas extension on agriculture. The farmers we asked were very concerned about the biogas expansion. BGP thus contributes to an increase in the already high level of competition between German farmers. Farmers perceived the effects of increasing expansion of BGP through a higher competitive pressure with other local farmers. The threat potential for food producing farms is obviously high, revealing very high conflict potential.

Furthermore, the results show that a large number of different factors influence farmers' decision behavior for investments in renewables. Thus, the findings by Willock et al. (1999) and Burton (2004) are confirmed.

Farmers' decision behavior is not only affected by intrinsic motives and the farm internal factor 'Economic situation', but rather primarily by perceived and use competition. This confirms the current controversial debate about the usefulness of BGP on farms (WBA, 2007). The considerable investment-inhibiting effect of LUC can be explained by several factors.

First, considering the increased demand for farmland for biomass production (energy crop cultivation) and limited land supply, the higher competition leads to rising costs for productive land. Thus, in many regions with intensive agriculture prices on the land lease market have increased (Bahrs and Held, 2007; Heissenhuber et al., 2008). The progressive LUC is problematic, because farms have a high proportion of leased farmland on average. Hence, they are very sensitive to changing land lease prices.

Second, energy production has a high added value compared to food production which results in a higher willingness to pay for land leases for biogas producing farmers with respect to their food-producing colleagues (Bahrs and Held, 2007). The agricultural energy producers establish themselves on the land market. Therefore the competitiveness of existing branches on farm (food production) is at risk. Food producers have a critical perception of the short and medium term effects, so that they decide not to invest in the BGP, leading to problems seen in the bioenergy market. Furthermore, the investment-inhibiting effect of LUC can be explained by social effects. The intra-agricultural resource conflict is problematic, because less competitive farms are not willing to sell their farms. For the common family owned farms the farm income is directly used to ensure farmers' family household income.

Furthermore, many farmers are very closely emotionally and traditionally connected with the agriculture (Roessingh and Schoonderwoerd, 2005). This results in a 'willingness to survive' of family owned farms which is compared to other sectors on a high level (Inhetveen and Schmitt, 2010). The farm business is continued even when their primary economic circumstances no longer permit. This irrational behavior, from an economical point of view, is also observed in other production braches on farms. For instance, the price decline in the German dairy production in recent years and the resulting lack of profitability of such farms has not resulted in extreme abandonment of dairy farming (BMELV, 2009). This could be explained by the 'willingness to survive' on farms, highlighting the urgency of competition between farmers. A reduction of pressure on the land lease market through more available farmland from farm sales therefore does not exist. In the case of increased competition, there is a higher potential for conflict in the long-term (Mautz et al., 2007). This has an explosive nature particularly if resource conflicts change into relationships conflicts, which are more complex (Feindt et al., 2004). Under these conditions, farmers choose other forms of renewables that have a lower conflict potential (e.g. photovoltaics).

In addition, many farms have close relationships with other local farms from which they mutually profit both from this constellation. An example for those positive network externalities is the joint purchase of machinery. If some of these farms are restructuring from food to energy production on farm, the new operating structure could result in a loss of cooperation partners in the network. Consequently, transition costs will increase.

## 8. Implications and conclusions

The findings contribute to the research of farmers' entrepreneurial behavior in general. In the context of renewables, we point out the high relevance of socio-economic patterns (level of competition) concerning BGP in agriculture. Our findings help to determine the future development of bioenergy production and the market potential more realistic. For energy and environmental policies, therefore, decision-making variables such as socio-economic patterns should be incorporated in the design of forecasting models.

The study confirms the occurrence of LUC in the context of expanded bioenergy production. The externalities are strongly linked to the funding scheme. In many European countries similarly funding mechanisms were adopted. In these countries, especially with strong agricultural characters such as France or Spain, LUC may occur after a time-delay. The findings should be considered for the optimization of the funding policy in order to indicate or prevent externalities.

However, the policy has established in its biomass allocation roadmap objectives for the further expansion of BGP (BMU and BMELV, 2009). Our findings imply that the further diffusion of BGP is overestimated and not realizable under present conditions. The policy-makers would be well advised to restructure the German REA so that competitive distortions are reduced among farmers. In this context a slight reduction of the compensation for energy from biogas may be able to decrease the economic profitability of BGP. An amendment is even necessary in terms of the structure of compensation rates. The present additional compensation for using biomass from farmland (energy crops) is forcing competition.

The policy has focused exclusively on the extrinsic factor of economic investment incentives, to motivate farmers to invest in the last decade. Our findings show that farmers have little scope for the creation of intrinsic motivations such as ecological awareness. This is in some respects problematic, because non-economic dimensions such as ecology become less important. The policy and the agricultural advisory services should therefore be required to provide better ecological guidance and not only to focus on economic incentives.

However, interpreting the findings some limitations should be taken into account. First, the study is limited representative because of the regional focus on North-West Germany and the limited sample size. In Germany, the diffusion of BGP has so far been rapid and wide-reaching. This is different in many other countries where the BGP is only in its infancy. Accordingly, the level of competition between farmers is different.

Furthermore, the findings of our explorative study imply possible approaches for further research. The lack of influence of the intrinsic factor 'Environmental Awareness' on the investment decision-making process is surprising in view of the climate change debate and should be validated in a large sample study. So far, the decision influencing factors have been considered separately from each other. However, there are indications that even among the factors themselves path dependency exists (e.g. between factors 'Social influence' and 'Perceived LUC'.

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