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From Agricultural Landscapes to the Regional Competitiveness - Bayesian Belief Network Approach.

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Abstract

The study focuses on the relations between landscape structure and composition, functions and benefits, and its contribution to the regional competitiveness understood as an ability to generate income, at the same time assuring employment and wellbeing of the society. The question is whether agricultural landscapes, through provision of ecosystem services could contribute to the development and competitiveness of the rural areas. The causal connections between landscape management, socio-economic benefits and mechanisms influencing the income level have been described and analyzed on the example of the case study region[1] – Chlapowski Landscape Park in Poland. The Bayesian Belief Network method was applied for the analysis of the abovementioned problem. It was found that all considered landscape elements (fields, forests, shelterbelts, and water reservoirs) have a positive influence on regional competitiveness. Agricultural land (fields and permanent grasslands) have the strongest, positive impact on the competitiveness of the region resulting from provisioning ecosystem services.

Keywords: Agricultural Landscape, Ecosystem Services, Regional Competitiveness, Bayesian Belief Network

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JEL codes: **Q240; Q150, Q570**

1. Introduction

The study focuses on development of the knowledge base on relations between the agricultural landscape structure and composition, functions and benefits, and their contribution to the regional competitiveness. Thus, the research question of the paper is whether agricultural landscapes, through provision of ecosystem services (TEEB 2010) can contribute to the development and competitiveness of the rural areas. There are many different definitions of the term "*competitiveness*" or "*regional competitiveness*", as well as different competitiveness indicators were used in various studies and papers (e.g. Krugmann, 1994, Porter 1992, EU 1999, Porter and Ketals, 2003). It became clear, that the idea of productivity and employment is a key, common link between all concepts of competitiveness, most of all in connection with the standard of living of the regional population (Claim 2012). The European Union's Sixth Periodic Report on the Regions specifies "*Regional Competitiveness*" as "*the ability of a region to generate, while being exposed to external competition, relatively high income and employment levels*..." (EU 1999, Claim 2012). Therefore in the study we understand the regional competitiveness as *the ability to generate income, at the same time assuring employment and wellbeing of the society***.**

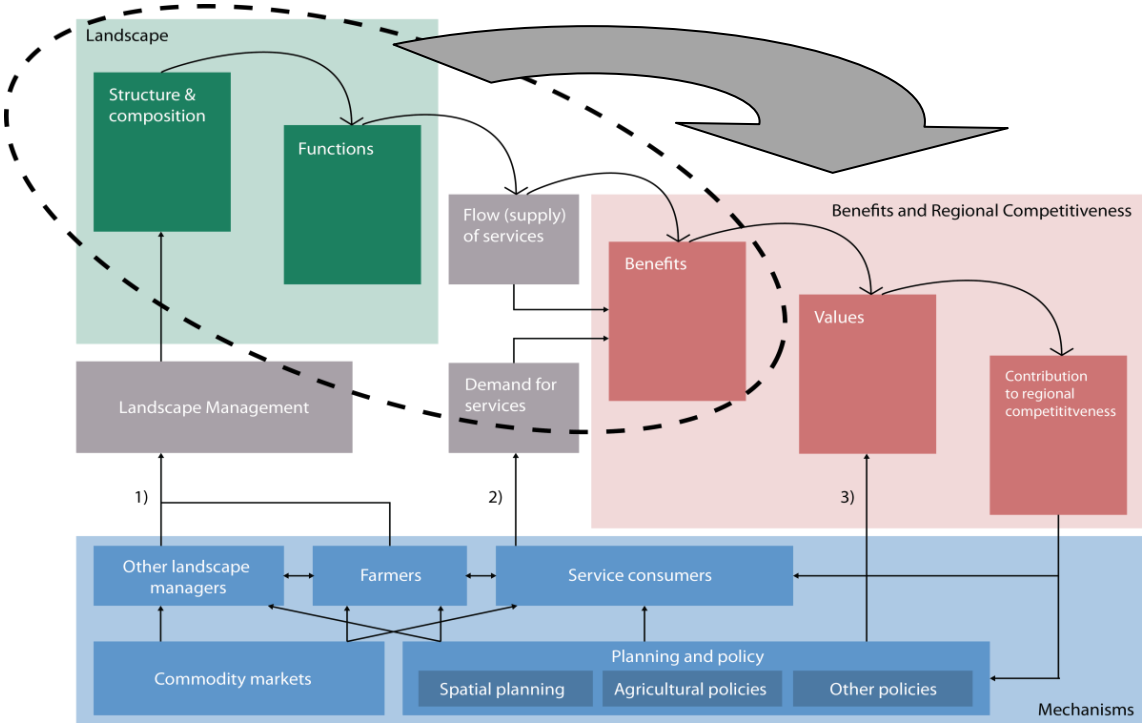
1.1. Landscapes and competitiveness

The landscape is a combined system, which goes beyond understanding it as a part of the physical space (such as "natural" or "cultural" landscapes). The system could be understood also in a socio-economic sense, representing its function as a precondition for supporting the regional economy and social well-being. (Targetti *et al.* 2014). The use of private and public good-type services from agricultural landscapes can create socioeconomic benefits, e.g. from the production and marketing of agricultural goods or from the direct use of recreation possibilities by both local population or tourists (Cooper *et al.*, 2009, Hein *et al.*, 2006). However it is uncertain how agricultural landscape and the landscape services could contribute to the development and competitiveness of rural regions. One of the concepts discussed is that agricultural landscapes hold the potential to provide private as well as public good-type (ecosystem) services which represent a resource not only for local inhabitants but also for different sectors of the rural economy, such as agriculture, forestry, tourism or the trade and services sector (van Zanten *et al*., 2014; Fieldsend, 2011, TEEB, 2010; De Groot *et al.*, 2010, Haines-Young and Potschin, 2010; Cooper *et al*., 2009). Depending on the valorization of the goods provided, landscapes can support the rural economy and the quality of life in rural areas and can become a factor of territorial development and competitiveness in terms of

agricultural income, population growth, employment creation, etc. (e.g. van Zanten *et al.* 2014; Cooper *et al.* 2009; Courtney *et al.* 2006; Courtney *et al*. 2013; Dissart and Vollet, 2011).

The causal connections between landscape management, local economy and mechanisms influencing and driving the system have been recently described within the CLAIM project[2] by van Zanten *et al.* (2014), who harmonize the widely adopted ecosystem services cascade (Haines-Young and Potschin, 2010). The analytical framework developed for the CLAIM project (Figure 2) distinguishes between service-demand and service-supply as the determinants of their value and specify different actors and pathways of mechanisms that affect the contribution of agricultural landscapes to the regional economy and human well-being (Targetti *et al.* 2014). The framework has been validated by a large group of stakeholders both, on the local level of the nine EU Case Study Areas (CSA) as well as on the European level, where representatives of stakeholders in the CSAs' countries as well as representatives from other EU countries and from EU-wide institutions have been involved.

Figure 1. CLAIM analytical framework as presented in Van Zanten *et al* 2014.



Source: Van Zanten at al 2014.

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1.2. Chlapowski Landscape Park

Our idea was to review the concept of the CLAIM diagram (figure 1) using an example of the rural area characterized by specific agricultural landscapes of the "Chlapowski Landscape Park" which was selected as the case study area. The Park located in the Koscian county (NUTS 3) in the Central-Western part of Poland, covers 172,2 km² and is characterized by typical agricultural lowland landscape, rich in small-structured landscape elements like field ponds, water catchments and shelterbelts (figure 2).

Figure 2: Typical landscape elements in Chlapowski Landscape Park. Source: own study

The shelterbelts, the wide, linear rows of trees, established in the 19th century by general Dezydery Chlapowski, shape and diversify the monotonous landscape of the area. They protect the fields against the wind erosion, reduce water deficit and support biodiversity as a natural habitat for different animals and birds (Kort, 1988). The local stakeholders emphasized that this characteristic landscape element allows to increase yields of agricultural production and to produce crops which would not be grown on relatively light soils, if there was no protection against wind erosion (like sugar beets or oil-rape).

Area of the park is also rich in historic buildings like manor houses in Racot, Kopaszewo, and churches. The green pathways created by windbreaks and local architecture encourage tourists to come for short term visits for biking or walking.

Benefits from the landscape for the regional competitiveness in the Chlapowski Landscape Park are clearly connected with agriculture supported by Shelterbelts are important for their regulating (protection) function (Johnson, Brandle 2003) and are clearly beneficial for the agricultural production, thus the regional competitiveness. An expected contribution of this landscape to the regional competitiveness is mainly attributed to the income from agricultural production and safeguarding employment in rural areas, but also, although to a lesser extent, employment in tourism and recreation activities.

In general, the competitiveness of the Koscian region, where the Park is located, can be assessed as medium. The regional economy of this region is dominated by agriculture-forestry activities (31% of working population engaged) and processing and manufacturing (25%). The agricultural production, due to a relatively good natural condition and a high agricultural culture in the area tends to have a strong competitive position in relation to other agricultural regions in Poland. Also well preserved natural environment and rich cultural sites create an opportunity for the development of tourism and related sectors such as trade and services. The degree of the economic activity of the population in the region is lower than in the Wielkopolskie (NUTS 2) district which the Koscian region is a part of (GVA = 83% of Wielkopolskie), and in the country (GVA = 82% of Poland). The wages in the region amount 78,8% of Polish wage level. This is, to a large extent, because of a lack of large industrial centres in the region and thus agricultural character of employment, which usually generates lower incomes then the other sectors. The population density and demographic structure are almost the same as the national average.

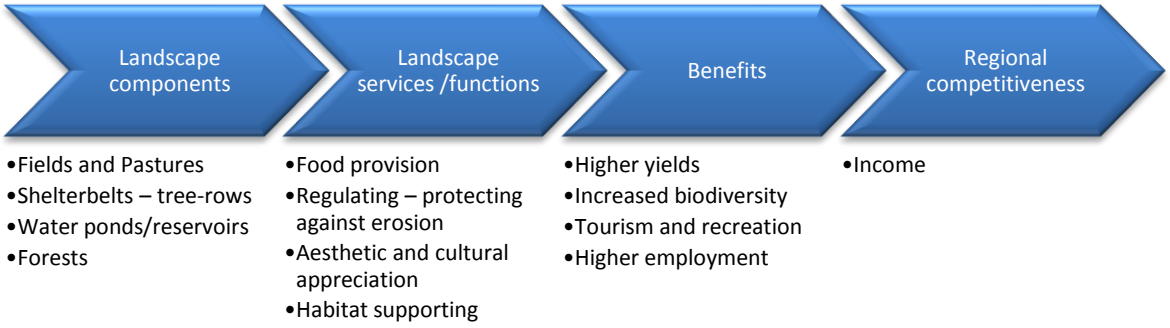
2. Method

Assessing influence of landscape on regional competitiveness is complicated due to complexity of the issue and dependence of competitiveness also on other factors like location, human capital and local investments, governance etc., which hide possible relation of landscape elements to regional competitiveness. It is rather about interactions of many intermediate factors. What is more, there is no faithful information about dependencies between variables, even for those intermediate factors. Usually the only available information are opinions of experts about positive or negative correlation between variables. The lack of experimental data practically prevents from the use of classical statistical methods. Therefore we decided to use Bayesian Belief Network (BBN) for determining influence of landscape elements on regional competitiveness. The BBN is a directed acyclic graph (DAG) with a set of conditionals probabilities (Korb, Nicholson 2004). BBNs have been used to valorize ecosystem services and natural resources management before (Marcot et al. 2001; McCann et al. 2006; Marcot et al. 2006; Haines-Young 2011; McCloskey et al. 2011; Landuyt et al. 2013), but have not been commonly used as a tool for economic valorization of landscapes and its impact on regional competitiveness. Here we try to check whether it is possible to use this method for the economic approach.

The BBN model was calibrated on the basis of 30 judgments of experts representing agricultural economists and landscape architecture specialists. The general model of connections between the tested variables is presented in figure 3. The BBN, basically, represents the correlation and causal relationships among variables. The variables were divided into 4 layers, with elements of each layer

affecting directly only elements of the next one. In the model we consider four, the most typical landscape elements in the case study area: fields and pastures (*FIELDS*), shelterbelts (*SHELTERBELTS*), forests (*FOREST*), field ponds and water reservoirs (*WATER*). For the analysis we used the Norsys Software Corp. program Netica.

Figure 3. Division of variables into layers



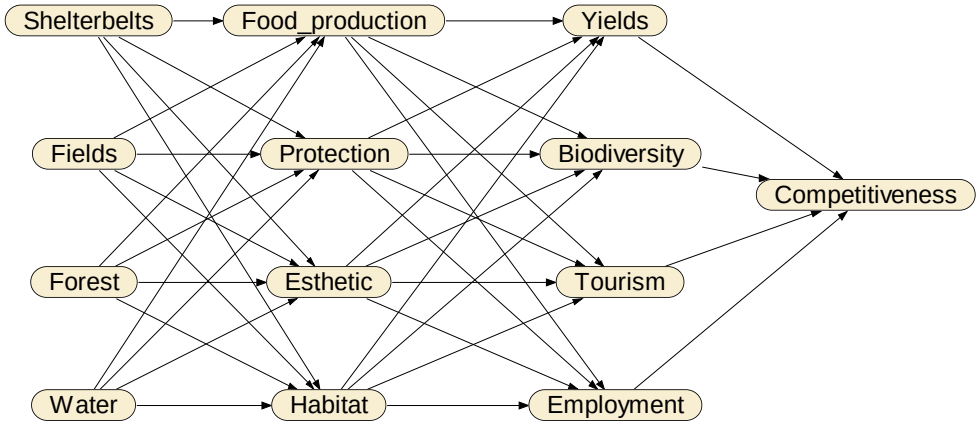
The main landscape services in the case study area are food provisioning, protection and regulating (mainly from wind-erosion), aesthetic-cultural and habitat supporting. *Provisioning* food is the main output of agriculture, and is largely influenced by regulating services provided by shelterbelts. Provision of wood is less important in this region and can be attributed to shelterbelts (4% of area of the park) and forests (11% share). Regarding *regulating services*, shelterbelts have a very important regulation function in this region, protecting the fields against wind and water erosion, and regulating the water and nutrient cycles. Existence of this landscape element allows to increase productivity of agricultural land and to introduce crops which otherwise could not be grown if there was no protection against wind. Agricultural landscape usually is less attractive to *cultural and recreation* use. However, the Chlapowski Landscape Park is famous in the country for its rare features and attractive green-paths along the roads and fields. The pathways created by windbreaks and local architecture encourage tourists to come for short term visits. Forestry management, water ponds and wind-breaks maintenance is influencing *habitat and supporting services*. It contributes to the existence of rare species (fauna and flora) living and breeding in the trees, and thus it contributes to rich biodiversity of the region.

The following socio-economic effects/benefits of the use of landscape services were analyzed in the BBN of the case study region: *Increase of productivity* (higher yields and larger variety of crops); *Maintenance and creation employment* (strong agricultural sector provides employment for local inhabitants; inflow of visitors provide possibility of development of the local tourist base); *Tourism and recreation* (specific landscape and cultural heritage attracts tourists); *Increased biodiversity* (diversified landscape trough its habitat supporting function contributes to rich biodiversity).

In general those abovementioned functions and services provided by landscape elements and benefits from its usage, contribute to higher *competitiveness of the region*, measured by income effects. The probability of achieving a certain income level (high, average, low) was measured by experts judgment. As in the case of all relations in the diagram, experts estimated the probability connection between the level of realization of certain benefit and the level of "competitiveness" understood as a potential to generate incomes and secure wellbeing of the regional communities.

The first approximation of the BBN describing influence of the landscape on regional competiveness is presented on the figure 4. The number of arcs between nodes caused relatively large probability tables with over 300 values which needed to be estimated by experts. In order to reduce that number the pilot survey was carried out. The initial survey showed that many causalities in the figure 4 carry relatively small weight (Table 1).

Figure 4. The first approximation of the BBN describing influence of the landscape on regional competiveness. Source: own study.



On the basis of this initial analysis, after excluding relations with a weak dependence, second approximation of conditional probabilities and the model was developed (figure 5). The two states for each variable from second and third layer were: "Low" and "High", while for landscape elements it answer to question whether the element is important part of landscape or not: "No", "Yes".

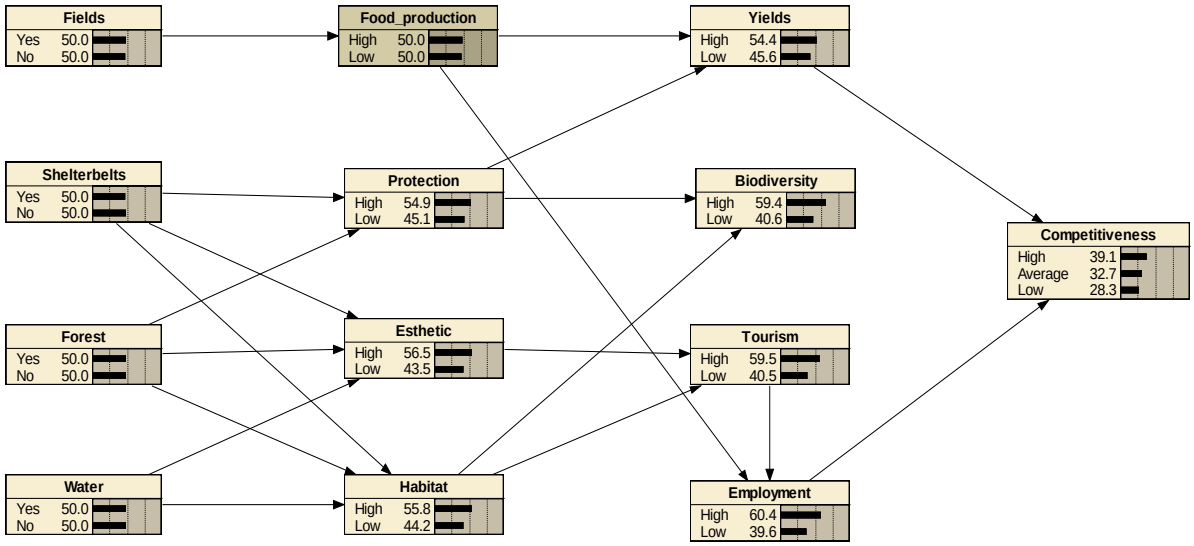
Table 1. Importance of each element for carrying out landscape functions

	Shelterbelts	Fields&Pastures	Forest	Water
Food_production	0.95	**8.1**	0.7	0.25
Protection	**5**	0.8	**3**	1.2
Aesthethic	**2.6**	1.4	**4.4**	**1.6**
Habitat supporting	**2.6**	0.8	**5.35**	**1.25**

Scale: 0 – 10 Source: initial survey

The calibrated Bayesian Belief Network for landscape impact on regional competitiveness is presented in the figure 5. The model shows relations in case of 50% chance of all elements being significant part of the landscape.

Figure 5. The calibrated BBN belief network for influence of the landscape on competitiveness



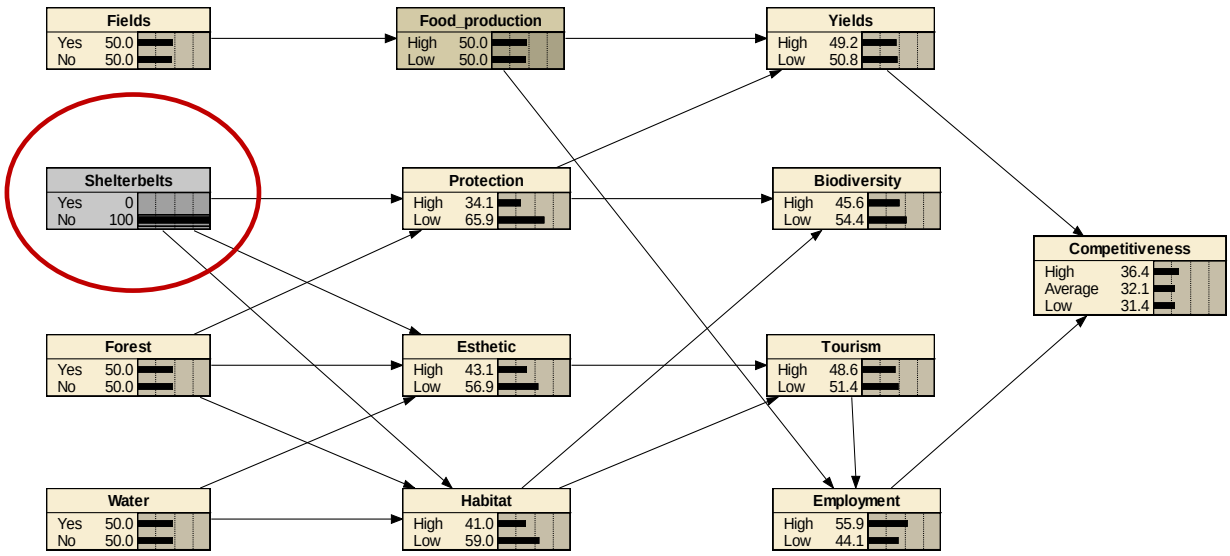
Source: own study.

3. Results

The changes in probabilities between the model with 0% and 100% of shelterbelts being significant part of landscape were analyzed (figure 6 and 7). It was observed that shelterbelts have a strongly positive impact on the realization of the protection (regulating) function by increasing by 41,6% (percent points) its probability to be at a high level. As it was supposed, these green pathways have a strong positive impact also on the aesthetic appreciation of the landscape, by increasing its valorization as high as by 26,7%. Existence of windbreaks create as well a good conditions for habitat for species. The probability of realization of this function rise by almost 30% together with implementing the shelterbelts into the landscape. Realization of abovementioned services by shelterbelts contributes to generation of certain socio-economic benefits. An increase of the chance

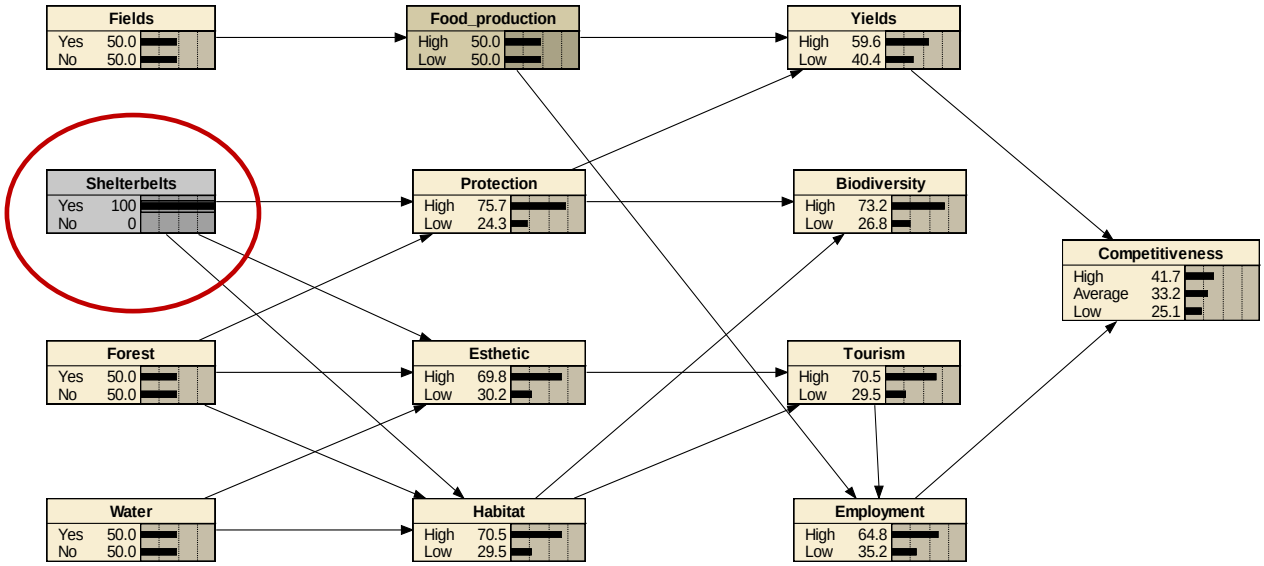
for high yields is estimated by the BBN model for 10%, probability of high biodiversity rise by 27,6% and higher tourist movement by 21%. This in turn has an impact on increase of the local employment by 8.9%. In case of regional competitiveness there is 5% increase of a chance of achieving high level of competitiveness and 6% decrease of low level chance due to implementation of the shelterbelts.

Figure 6. The BBN belief bars in case of 0% chance of shelterbelts being important part of landscape.



Source: own study.

Figure 7. The BBN belief bars in case of 100% chance of shelterbelts being important part of landscape.



Source: own study.

Similar calculation was carried out for all landscape elements (table 1). While all considered landscape elements display positive influence on regional competitiveness, the agricultural land shows the strongest impact by increasing chance of high competitiveness by about 20%. Shelterbelts and forest have very similar effects with increase about 5% and water gives almost negligible change of 1.5%.

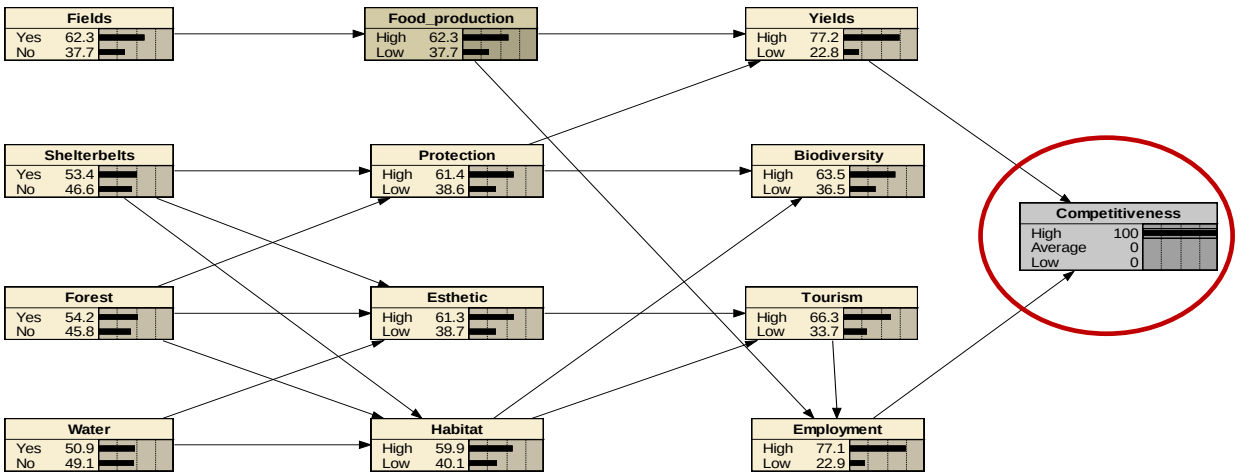
Table 2. The probabilities for high, medium or low level of regional competiveness for studied landscape elements

Landscape element	No			Yes		
	Competitiveness High	Competitiveness Medium	Competitiveness Low	Competitiveness High	Competitiveness Medium	Competitiveness Low
Fields	0.294	0.314	0.392	0.487	0.340	0.173
Shelterbelts	0.364	0.321	0.314	0.417	0.332	0.251
Forest	0.358	0.320	0.322	0.423	0.333	0.243
Water	0.384	0.325	0.291	0.398	0.329	0.274

Source: own calculations

It was also interesting to observe a reverse causality of the BBN model. On the figure 8 we checked what happens when we assume the high level of competitiveness at 100% probability. We compared the results with figure 5 - the calibrated BBN model. It can be observed that 100% chance of high level competitiveness (increase from 39,1% high to 100%) is assured by an increase of importance of fields and pastures in the landscape from 50 to 62%. The other landscape elements were far less significant. It is also worth mentioning that productivity increase (higher yields) has strongest effect on the competitiveness than the employment (creation of jobs). High competitiveness (100% chance) was obtained through increase of probability of high yields by 28% whereas higher employment by 16,7%.

Figure 8. The BBN belief bars in case of 100% chance of high competitiveness



Conclusions

Assessing influence of the landscape on regional competiveness is difficult due to a complexity of the problem and relations between several variables. The lack of experimental data practically prevents from the use of classical statistical methods. Based on expert judgment, the Bayesian Belief Network (BBN) approach was tested to determine the influence of landscape elements on regional competiveness. The method has occurred to be useful for the analysis of the problem, however, the proper determination of the relationship between the variables in the model, requires a large number of observations based on the assessments of different groups of experts.

Benefits from the landscape for the regional competitiveness in the Chlapowski Landscape Park are clearly connected with agriculture supported by shelterbelts and their regulating (protection) function. However it was found that all considered landscape elements (fields, forests, shelterbelts, and water reservoirs) have a positive influence on regional competitiveness and the potential of agricultural land. The agricultural fields and pastures have the strongest, positive impact on the competitiveness of the region showing the potential to increase the chance of high competitiveness by about 20%. Shelterbelts and forests have very similar effects with an increase about 5%. Shelterbelts, which are a unique and distinctive element of the landscape in the Chlapowski Landscape Park play an essential role in shaping natural conditions for farming in the Park area. It can be stated, that maintaining shelterbelts creates specific landscape features and increases competitiveness of the region, having an impact on productivity and profitability of agricultural sector.

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