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Assessing Impacts of Agricultural Landscapes on Regional Competitiveness with the Bayesian Belief Network Approach: A Case of the Wielkopolska Region in Poland

Abstract: The study focuses on the relations between the structure of the agricultural landscape and its contribution to regional competitiveness, which is understood as an ability to generate relatively high profits from economic activities, at the same time assuring employment and well-being of the society. 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 agricultural region, which is located within the area of Chłapowski Landscape Park in the Wielkopolska region of Poland. In order to characterize a unique landscape structure in Chłapowski Landscape Park with the use of GIS, soil maps and other materials, we prepared detailed maps of the selected region, and compared it to two agricultural areas of distinctly different landscape features, but located in the neighbourhood, adjacent to each other. On the basis of the prepared maps, the composition and structure of the landscape have been calculated. The complexity (diversity and concentration levels) of the landscape was expressed by two indicators – the Shannon Index (H) and Herfindahl-Hirschman Index (HHI). Then the Bayesian Belief Network method was applied to measure the impact/contribution of different elements of the landscape structure on regional competitiveness, and to estimate the strength of causal connections between landscape management, socio-economic benefits and mechanisms influencing regional competitiveness. Benefits from the landscape for regional competitiveness in Chłapowski Landscape Park are clearly connected with agriculture supported by shelterbelts and their regulating (protection) function. However, it was found that all the considered landscape elements (fields, forests, shelterbelts, and water reservoirs) have a positive influence on regional competitiveness, but with dif-

ferent strengths. Agricultural land (fields and permanent grasslands) has the strongest, positive impact on the competitiveness of the region due to its essential role in providing ecosystem services.

Key words: agricultural landscape, ecosystem services, regional competitiveness, Bayesian Belief Network, Chłapowski Landscape Park, shelterbelts

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

Introduction

In recent decades, profound changes have been observed in farmland and the landscape. They are caused by the intensification and concentration of agricultural production, stimulated mainly by technological progress, mechanization and policy mechanisms (van Vliet et al. 2015, Shaller et al. 2018). There is an increasing debate about how changing landscapes affect agricultural regions and to what extent this can affect their competitiveness (Zasada et al. 2017). In particular, the Ecosystem Services approach (Haines-Young, Potschin 2010, TEEB 2010) is used when talking about the impact of landscape on the delivery of private goods and services, which are important socio-economic assets for the rural economy (Huang et al. 2015, Zasada et al. 2017, Shaller et al. 2018, Viaggi et al. 2021).

The study focuses on the relations between the structure and composition of agricultural landscapes and regional competitiveness. The research goal and main question of the paper is to what extent agricultural landscapes can contribute to the development of rural areas, thus strengthening the competitive position of regions through the provision of ecosystem services, and what the mechanisms of this impact are.

The competitiveness of regions is not widely discussed in the scientific literature and for understandable reasons competition between companies captures most attention of scientists and practitioners. In the most general sense, regional competitiveness can be defined as "an ability to attract investments and labor providing conditions for generation of relatively high profits from economic activities and wellbeing of the region's society" (CLAIM 2012). Such a definition, however, indicates the effect of being a more competitive region and thus more attractive for potential investors and workers, but ignores the factors determining stronger or weaker competitiveness.

There are, however, several attempts to define and analyze regional competitiveness that focus on the quality and effective use of resources creating the basis for the economic activities of regions.

Borozan (2008) identifies two types of definitions of regional competitiveness:

- the one that explains and describes competitiveness of regions in terms of outcomes, such as productivity which is considered by Porter's (1992) real measurement for competitiveness;

- the second type that addresses factors responsible for achieving and enhancing regional competitiveness (Borozan 2008).

The idea of productivity (of labor and other production factors) 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). In a broader sense "outcomes" can be also interpreted as "the ability of a region to generate, while being exposed to external competition, relatively high income and employment levels…" as specified in the Sixth Periodic Report on the Social and Economic Situation and Development of the Regions of the European Union (European Commission 1999).

Thinking about regional competitiveness in terms of outcomes is strongly rooted in the microeconomic approach. However, as stated by Martin (2003) in his comprehensive study on the factors of regional competitiveness, typical of measuring competitiveness at the company level is that it implies "a reasonably clear and straightforward understanding of the notion of competitiveness, that is based on the capacity of firms to compete, to grow, and to be profitable" (Martin 2003). This is in line with the definition of a competitive industry proposed by Martin, which may be used to define a competitive company as well, which "is one that possesses the sustained ability to profitably gain and maintain market share in domestic and/or foreign markets" (Martin et al. 1991, p. 1457–1464). This is where a parallel might be made between "competitive industry" and "competitive region" considering that structure and quality of its specific assets determine the region's sustained ability to compete.

Regions, which may be in the simplest way identified as spatial units of different size within natural or administrative borders do not compete in the same way as companies that focus on rivalry for a market share and provision of goods that are attractive for consumers. Businesses may move to a different location, introduce innovative solutions that improve their competitive position and increase outcomes in a relatively short time. Regions are equipped with unique sets of capitals: natural, man-made and social which, however, are unmovable, fixed for indefinite perspective. They can be seen as "region specific assets hard to replicate or transfer to places elsewhere" (Boschma 2004, p. 1012).

Thus, an alternative approach towards defining regional competitiveness that is addressing factors allowing regions to become more competitive seems to be very appropriate. This is very much in line with Borozan's interpretation of regional competitiveness which "is not referred to the exploitation of resources, but it supposes the identification of growth potentials and constraints of an area, as well as the strengthening of its unique combination of resources (innovativeness and creativity, knowledge, technology, historical and cultural background, tolerance, social networks, trust, responsibility, and so on) in order to create sound conditions to live and to work. In other words, it refers to innovative and entrepreneurial conversion of these resources into intellectual capital, value added, economic growth and development" (Borozan 2008).

The factors that are decisive for a region's competitiveness may be classified as "controllable by firms and factors beyond the managers' control (non control-

lable)", as distinguished by Latruffe, who discusses competitiveness of the agricultural and agri-food sectors (Latruffe 2010, p. 6). Florida (2002) is pointing out that there are particularly valuable assets that contribute to attracting creative people: the presence of other creative people, cultural amenities, access to technology and technology advances, and the tolerance of the community to diversity and difference. Most of these factors are region-specific, and a wise regional policy can be very important and powerful in transforming a region lagging behind into a successful region, or in keeping a successful region into the line (Florida 2002, after Borozan 2008, p. 60).

Also Camagni (2002) emphasizes the importance of assets stating that regions do compete, but on the basis of absolute competitive advantages rather than comparative advantages. Achieving absolute competitive advantages depends on a region's superior technological, social, infrastructural and institutional assets that benefit companies operating in the region. Similarly, Kitson et al. (2004) argue that regional competitiveness focuses more on the drivers and dynamics of a region's (or city's) long-run prosperity than on the more restrictive notion of competing for markets shares and resources.

In this study[1] we consider that a region constitutes a complex of natural and socio-economic structures (factors) that create a basis for competitive advantage.

The agricultural landscape in a broad sense may be seen as an asset composed of natural and human-made capitals that are crucial for building the capacity of regions to be competitive (Zasada et al. 2017, Shaller et al. 2018). For the competitiveness of regions whose economy is predominantly dependent on agriculture, the quality of natural capital, which is the basic component of the agricultural landscape, is of particular importance.

In our study 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 agricultural region, which is located within the area of Chłapowski Landscape Park in the Wielkopolska region of Poland. The region was chosen because of its very diverse landscape, which is at the same time a typical rural lowland landscape with intensive agricultural production, but rich in small-structured landscape elements like field ponds, water catchments and shelterbelts, which protect fields against wind erosion. In order to characterize the unique landscape structure in Chłapowski Landscape Park we used GIS, soil maps and other materials to prepare detailed maps of the region, and compared it to two agricultural areas of distinctly different landscape features, but located in the neighbourhood, adjacent to each other.

On the basis of the prepared maps, the composition and structure of the landscape have been calculated. The complexity of the landscape was expressed by two indicators – Shannon Index (H, also known in the literature as Shannon-Weaver), one of the most commonly used (mainly in life-sciences) indexes of diversity, and Herfindahl-Hirschman Index (HHI), a commonly used economic

[1] The work has been granted in line with the collaborative project CLAIM, funded by the European Commission under the 7th Framework Programme (call identifier: FP7-KBBE.2011.1.4-04).

measure of concentration. To the best of our knowledge this is the first attempt in the literature to use these indicators to measure the diversity of landscape structure and the level of concentration of the landscape.

The second main contribution to the current state is that the Bayesian Belief Network (BBN) method was applied to measure the impact/contribution of different elements of the landscape structure on regional competitiveness, and to estimate the strength of causal connections between landscape management, socio-economic benefits and mechanisms influencing regional competitiveness. BBN has been used to valorize ecosystem services and natural resources management before (e.g. Marcot et al. 2001, 2006, McCann et al. 2006, Haines-Young 2011, McCloskey et al. 2011, Landuyt et al. 2013), but not as a tool for the economic valorization of landscapes and its impact on regional competitiveness.

Landscapes and regional competitiveness: The analytical framework

The landscape is a combined system, which goes beyond understanding it as part of the physical space (such as "natural" or "cultural" landscapes). The system has also a socio-economic dimension, representing its function as a precondition for supporting the regional economy and social well-being (Targetti et al. 2014, Zasada et al. 2017). The services of agricultural landscapes that generate private and public goods 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 (Hein et al. 2006, Cooper et al. 2009, Zasada et al. 2017, Shaller et al. 2018, Viaggi et al. 2021, Bethwell et al 2022). However, it is uncertain how agricultural landscapes and 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 (Cooper et al. 2009, De Groot et al. 2010, Haines-Young, Potschin 2010, TEEB 2010, Fieldsend 2011, van Zanten et al. 2014, Zasada et al. 2017). Depending on the valorization of the goods provided, landscapes can support rural economies 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. Courtney et al. 2006, Cooper et al. 2009, Dissart, Vollet 2011, Courtney et al. 2013, Zasada et al. 2017).

The causal connections between landscape management, a local economy and mechanisms influencing and driving the system have been described by van Zanten et al. (2014) and later analysed by Zasada et al. (2017), who harmonize the widely adopted ecosystem services cascade (of Haines-Young and Potschin 2010). The analytical framework (Fig. 1) distinguishes between service-demand and ser-

vice-supply as the determinants of their value and specifies 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, Zasada et al. 2017). The framework has been validated by a large group of stakeholders at the local level of nine case studies conducted within the CLAIM project, as well as at the European level, involving representatives from several EU countries and from EU-wide institutions.

This paper attempts to assess the agricultural landscape as an economic feature that determines regional competitiveness. For this purpose we use the Bayesian Belief Network approach to measure the strength of inter-dependencies in the cascade of relations of different elements of the landscape structure, landscape functions, benefits and mechanisms influencing regional competitiveness, as formulated in the CLAIM analytical framework (Fig. 1).

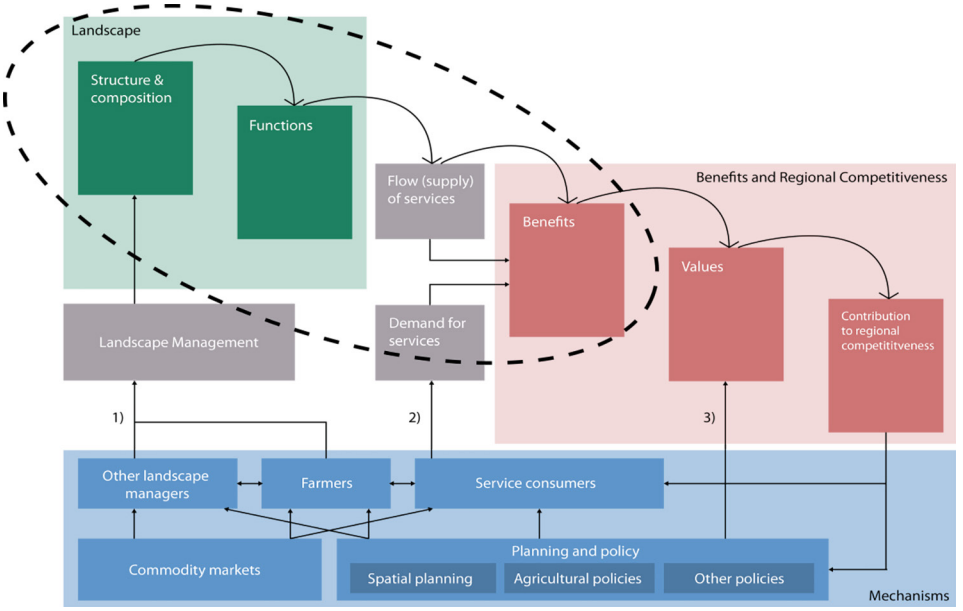

Fig. 1. CLAIM analytical framework as presented in van Zanten et al. (2014) and later by Zasada et al. (2017)
Source: van Zanten et al. (2014), Zasada et al. (2017).

Methodological approach

In order to characterize the unique landscape structure in Chłapowski Landscape Park (as the first step marked in a green box on our analytical framework – compare Fig. 1) with the use of GIS, soil maps and other materials, we prepared detailed maps of the selected region, and compared it to two agricultural areas of distinctly different landscape features, but located in the neighbourhood, adjacent to each other (Kobylniki and Czempiń). On the basis of the prepared

maps, the composition and structure of the landscape have been calculated. The complexity (diversity and concentration) of the landscape was expressed by two indicators – the Shannon Index (H) and Herfindahl-Hirschman Index (HHI).

Shannon Index (H) (also known in the literature as Shannon-Weaver) is one of the most commonly used (mainly in life-sciences) indexes of diversity (i.e. biodiversity). The Shannon diversity index (H) has the following formula:

$$H = \sum_{i=1}^{n} (p_i \times \ln p_i) \text{ (Shannon, 1948), where:}$$

pi – share of the element in the landscape structure

A greater H value implies greater landscape diversity.

The second indicator which we used was the Herfindahl–Hirschman Index (HHI), which in economics is a measure of industry concentration and an indicator of the strength of competition among them. We adjusted the index for measuring the complexity of the landscape, by replacing the shares in the market with the share of each landscape element in the landscape structure. The general formula for HHI is:

$$HHi = \sum_{n=1}^{n} s_i^2 \text{ , where:}$$

S – share of the element in the landscape structure, *i* – number of elements

The Herfindahl Index (*H*) ranges from 1/*N* to one, where *N* is the number of elements in the structure of the landscape.

The landscape structure of the chosen regions has been compared using H (landscape diversity) and HHI (landscape concentration) indicators. The fundamental analysis was made on the area divided into 1 km^2 (100 hectares) fields in each defined region. Analysis of the landscape structure was performed with the use of topographic maps at the scale of 1:25 000, aerial photographs and on the basis of field research.

The structure of the landscape was distinguished according to four thematic layers, containing the following information (GIS):

Layer 1: kilometer grid; hydrographic network, the network of roads, settlement units;

Layer 2: shelterbelts (including windbreaks and other woodlots in the vicinity of fields and internal roads that are not classified in any of the categories of public roads);

Layer 3: field-forest borders;

Layer 4: roadside plantings (tree-rows).

Assessing the influence of landscapes on regional competitiveness (as the second step of our analytical framework marked in a red box – compare Fig. 1) is complicated due to the complexity of the issue and dependence of competitiveness also on other factors like location, human capital, local investments, governance etc. Interactions of many intermediate factors make the analysis of relations between landscape elements and regional competitiveness difficult. What is more, there is no fully reliable evidence regarding dependencies between

variables, even for those intermediate factors. Usually the only available information is the opinion of experts about the positive or negative correlation between variables. The lack of experimental data makes it practically impossible to use classical statistical methods. Therefore, for determining the influence of landscape elements on regional competitiveness we decided to apply the Bayesian Belief Network (BBN), which is a directed acyclic graph (DAG) with a set of conditional probabilities (Korb, Nicholson 2004). The BBN was used in measuring of ecosystem services provision before (some examples are: Marcot et al. 2001, 2006, McCann et al. 2006, Haines-Young 2011, McCloskey et al. 2011, Landuyt et al. 2013, Burkhard, Maes 2017, Forio et al. 2018, Feurer et al. 2021), but not as a tool for economic valorization of landscapes and its impact on regional competitiveness. In our analysis we attempted to test the possibility of taking the BBN approach to measuring the importance of different elements of the landscape structure and their contribution to regional competitiveness.

The BBN model was calibrated on the basis of 30 judgments of experts, namely agricultural economists and landscape architecture specialists. All experts were researchers from universities and research institutions in Poland. In order to estimate causal connections between landscape elements, socio-economic benefits and mechanisms influencing regional competitiveness, experts were asked to fill in a specially designed questionnaire. In the survey experts were estimating a) the probability of implementation of particular landscape functions if the landscape contains the combinations of given elements, b) the probability of generating specific, measurable benefits by the landscape, depending on the degree of implementation of individual services, c) the probability of achieving a certain level of competitiveness if the following combinations of yield and employment levels were observed. The general model of connections between the tested variables is presented in Figure 2. The BBN, basically, represents the correlation and causal relationships among variables based on the theoretical framework (Fig. 1).

The variables were divided into four groups (as in Fig. 2), with elements of each group affecting directly only elements of the next one, neighbouring group. In the model four, the most typical landscape elements in the case study area were considered: fields and pastures (*FIELDS*), shelterbelts (*SHELTERBELTS*), forests (*FOREST*), field ponds and water reservoirs (*WATER*).

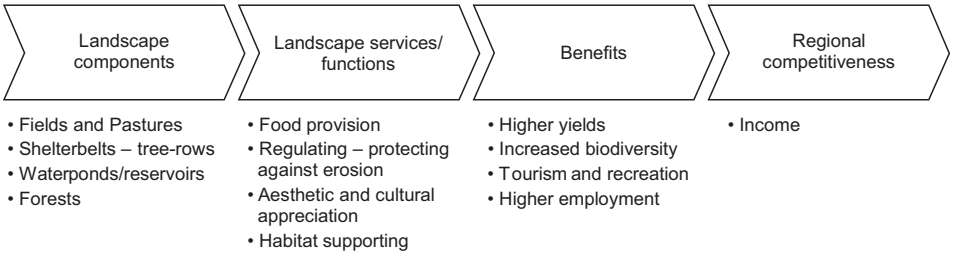

Fig. 2. Division of variables into four groups according to the theoretical framework
Source: own elaboration.

Statistical analysis was conducted with the use of the Netica program from Norsys Software Corp.

The main *landscape services* in the case study area are food provisioning, protection and regulation mechanisms applying to fields, aesthetic and cultural functions and habitat supporting. *Provisioning* food is the main output of agriculture, which in the region is largely influenced by regulating services provided by shelterbelts. The provision of wood is less important in this region and can be attributed to shelterbelts (4% of the park area, Table 2) and forests (11% share, Table 2). With regard to *regulating services*, shelterbelts have, a very important regulatory function in this region, protecting the fields against wind and water erosion, and regulating water and nutrient cycles. The existence of this landscape element allows increasing the productivity of agricultural land and introducing crops which otherwise could not be grown if there was no protection against wind. The agricultural landscape is usually less attractive for *cultural and recreational* use. However, Chłapowski Landscape Park is famous in the country for its rare features and attractive green-paths along the roads and fields. The pathways created by shelterbelts (also called windbreaks) and local architecture encourage tourists to come for short-term visits. Forestry management, water ponds and wind-breaks maintenance are influencing *habitat and supporting services*. It contributes to the existence of rare species (fauna and flora) enriching the 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 a greater variety of crops);
- *Maintenance and creation of employment* (strong agricultural sector provides employment for local inhabitants; inflow of visitors makes it possible to develop the local tourist base);
- *Tourism and recreation* (specific landscape and cultural heritage attract tourists);
- *Increased biodiversity* (diversified landscape through its habitat supporting function contributes to rich biodiversity).

In general, those 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 estimated on the basis of experts' judgment. As in the case of all relations in the diagram, the experts estimated the probability connection between the level of realization of certain benefits and the level of "competitiveness" understood as a potential to generate incomes and secure well-being of the regional communities.

The first approximation of the BBN describing the influence of the landscape on regional competitiveness is presented in Figure 3. The number of arcs (arrows) between nodes (as listed in Fig. 3) caused relatively large probability tables with over 300 values which needed to be estimated by experts. In order to reduce that number, a pilot survey with 10 experts was carried out (five representing agricultural economists and five representing landscape and natural sciences). The initial survey showed that many causalities in Figure 3 carry a relatively small weight (Table 1).

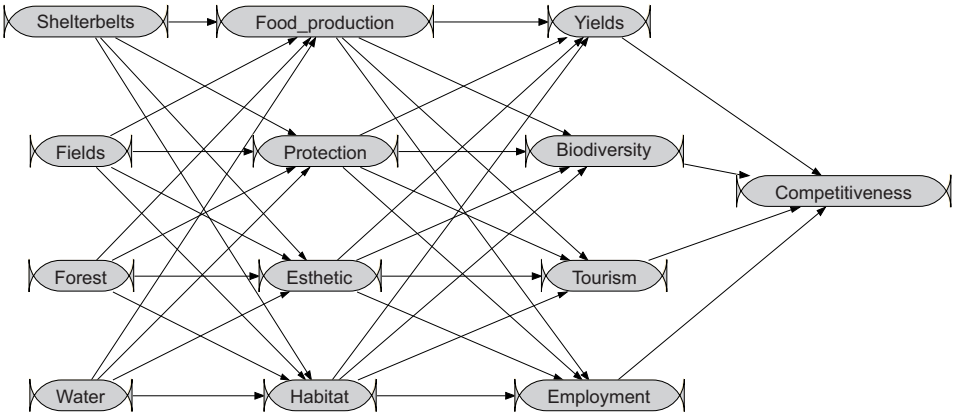

Fig. 3. The first approximation of the BBN describing influence of the landscape on regional competitiveness
Source: own study.

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, where 0 means not important and 10 means a very important function
Source: initial survey.

On the basis of this initial analysis, after excluding relations with a weak dependence, second approximation of conditional probabilities and the model was made (Fig. 4). The two states for each variable from the second and third layer were: "Low" and "High", while for landscape elements it answers the question whether the element is an important part of the landscape or not: "No", "Yes".

The finally calibrated Bayesian Belief Network for a landscape impact on regional competitiveness is presented in Figure 4. The model shows relations assuming 50% probability of all the elements (shelterbelts, fields, forests, water) being a significant part of the landscape. In the further part of the research, the BBN model simulations were made with changes in probabilities between 0% and 100% of each landscape element being a significant part of the landscape. The effects of these simulations are presented in the results section and indicate the strength of an impact of particular landscape element on the implementation of certain functions/services, benefits and finally on the level of regional competitiveness.

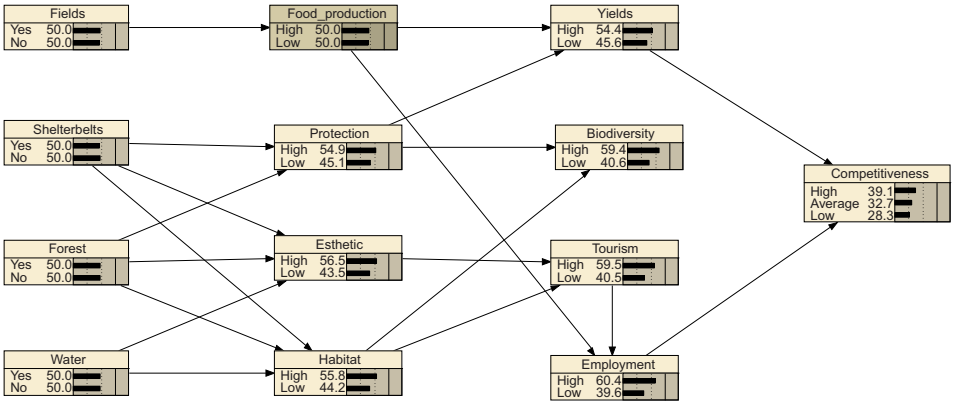

Fig. 4. The calibrated BBN for the influence of the landscape on competitiveness
Source: own study.

Results of the study

Measurement of the landscape structure, diversification and concentration, and the character of landscape functions

Chłapowski Landscape Park located in the Kościan county (NUTS 3) in the central-western part of Poland, covers 172.2 km^2 and is characterized by a typical agricultural lowland landscape, rich in small-structured landscape elements like field ponds, water catchments and shelterbelts (Fig. 5).

The shelterbelts, the wide, linear rows of trees, established in the 19th century by general Dezydery Chłapowski, are the most characteristic feature diversifying the monotonous landscape of the area. They form a natural asset that enhances the performance of the agricultural sector, protecting fields against wind erosion and reducing water deficit, as well as supporting biodiversity creating a natural habitat for different wild animals and birds (Kort 1988). The local stakeholders emphasize that this characteristic landscape element makes it possible to increase yields of agricultural production and to cultivate crops which would not be grown on relatively light soils (like sugar beets or canola), if there was no protection against wind erosion. The green pathways created by windbreaks and local architecture encourage tourists to come for short-term visits for biking or walking. The park area is also rich in historic buildings like manor houses and churches.

The following pictures (Fig. 6) present the structure of the landscape typical of Chłapowski Landscape Park (Turew) and for two communities adjacent to the Park – Kobylniki and Czempiń, measured as indicated in the methodological part.

The characteristics of landscapes in Chłapowski Park and two adjacent areas selected for comparisons are presented in detail in Table 2. The agricultural landscape in the park is mainly shaped by shelterbelts in-between the fields and rows

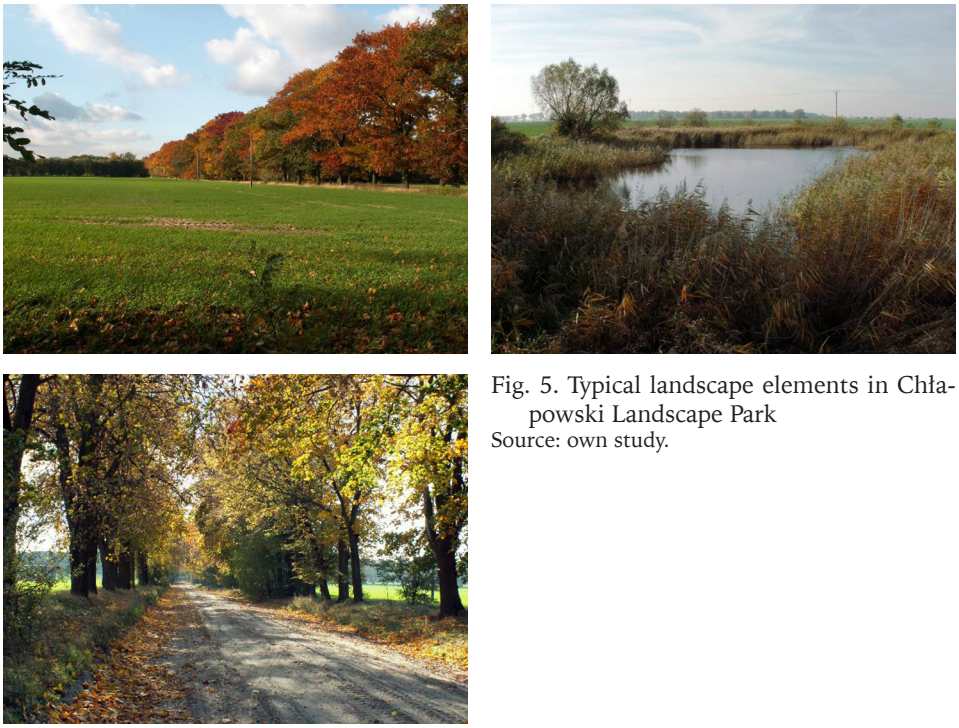

Fig. 5. Typical landscape elements in Chłapowski Landscape Park
Source: own study.

of trees (linear elements) along the roads. The concentration of this element in the case study region is almost two times greater than in the neighboring regions (53 meters/ha vs. 27 and 39 m/ha) which is clearly visible in Figure 6.

The landscape composition is more diversified in the Park than in the two other studied regions (Table 2). It can be expressed by *a higher* Shannon index (0.7 in the Park vs. 0.56 and 0.46 in the adjacent regions) and *a lower* Herfindhal Hirshman concentration index (0.68 in the Park vs. 0.81 and 0.79 in the adjacent

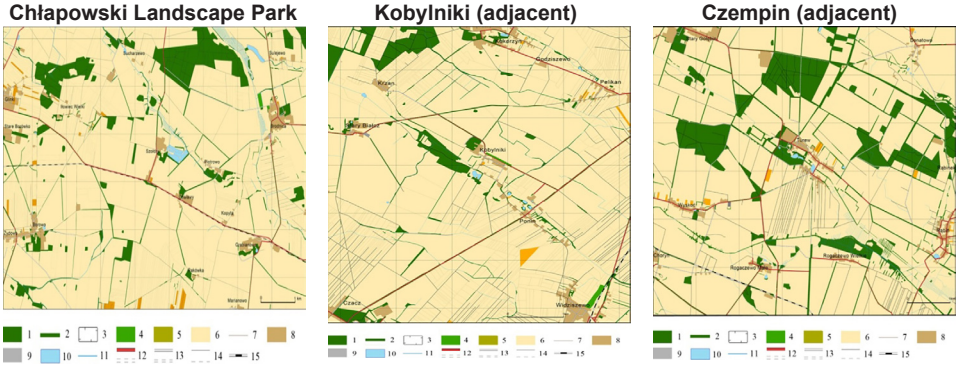

Fig. 6. Landscape structure and elements in Chłapowski Landscape Park and adjacent regions
Source: own study.

regions). The selected regions have a similar built-up area (about 2.6–2.8%), but differ in terms of the share of agricultural land, green-linear elements, forests and water reservoirs (see Table 2). There is also a double share of manor parks in the case of Chłapowski Park, compared to the neighboring regions.

Table 2. Structure of landscape elements in the case study region – Chłapowski Landscape Park and adjacent regions

Community (NUTS5)	Chłapowski Landscape Park (TUREW – within the park)	KOBYLNIKI (outside the park)	CZEMPIŃ (outside the park)
Field-tree/forest borders (km)	225 km (53 m/ha)	131 (39 m/ha)	140 (27 m/ha)
Shannon index H:			
Landscape concentration	0.70	0.56	0.46
Index (Herfindhal-Hirschman Index)	0.68	0.81	0.79
	Share of specific landscape elements in the total area of the selected region [%]		
Agricultural land	81.35	86.84	90.08
Forests and woodlands	10.88	7.26	3.58
Linear elements – trees	3.72	1.93	2.85
Lakes and ponds	0.14	0.33	0.01
Manor parks	0.91	0.37	0.53
Built-up areas	2.64	2.61	2.85
Other (orchards etc.)	0.35	0.65	0.33

Source: own calculations. HH index – the sum of the squares of the shares of distinguished elements in the landscape structure: the lower the index the greater the diversification of landscape elements. Shannon index – a greater H value implies greater landscape diversity.

Benefits for the regional competitiveness that result from the landscape features in Chłapowski Landscape Park are clearly connected with agricultural activities due to important *regulating and protecting functions* of shelterbelts (Johnson, Brandle 2003). The expected contribution of the landscape to the regional competitiveness in the Park is attributed mainly to the income from agricultural production and safeguarding employment in rural areas. However, it also strengthens competitiveness of the region, although probably to a lesser extent, through employment opportunities in tourism and recreation activities.

The economy of the region is dominated by agricultural- and forests-related activities (26.5% of the working population in 2020), followed by processing and manufacturing (29% in 2020) (Local Data Bank 2020). Agricultural production, due to fairly good natural conditions and a high agricultural culture in the area, tends to have a strong competitive position in relation to other agricultural regions in Poland. Also, a 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 average wages in the region amount to 85% of the country level. This is, to a large extent, because of a lack of large industrial centers in the region. Em-

ployment in agriculture and forestry sectors in Poland usually generates lower incomes than in other sectors of the Polish economy. The population density and demographic structure are almost the same as the national average.

Impact of the landscape structure on the regional competitiveness

The simulations of the BBN model indicate the impact of individual landscape elements on the implementation of specific functions/services, benefits and, finally, the level of competitiveness of regions, with the probability level of 0% and 100% that each landscape element is an important part of the landscape. The results for shelterbelts are presented in Figures 7 and 8, and for other landscape

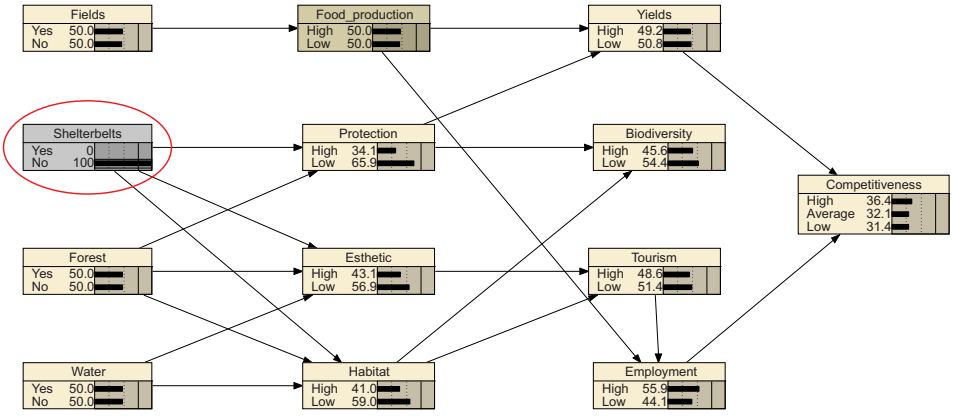

Fig. 7. The BBN belief bars in case of 0% of shelterbelts being an important part of the landscape
Source: own study.

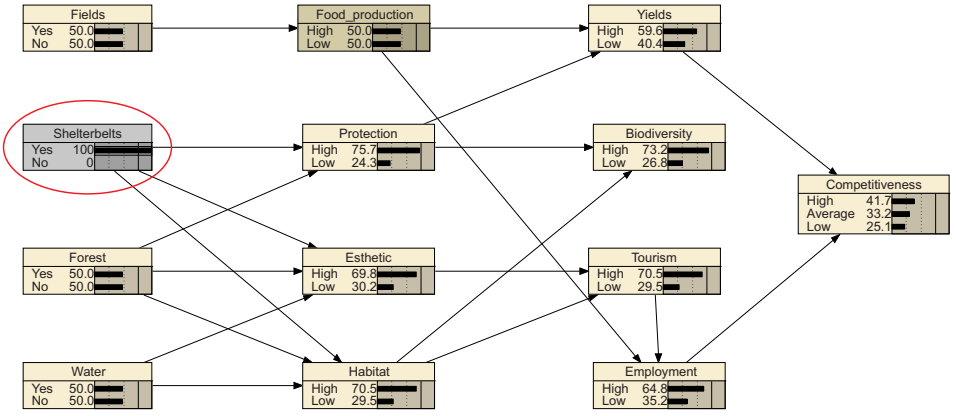

Fig. 8. The BBN belief bars in case of 100% of shelterbelts being an important part of the landscape
Source: own study.

Table 3. The probabilities for the high, medium or low levels of regional competitiveness for studied landscape elements

Landscape element	No (0%)			Yes (100%)		
	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.

elements in Table 3. It was observed that shelterbelts have a strongly positive impact on the realization of the protection (regulating) function by increasing by 41.6 p.p. (percent points, calculated as difference between result in Fig. 7 and Fig. 8) its probability to be at a high level. As 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 p.p. The existence of windbreaks creates as well good conditions for habitat for species. The probability of realization of this function rises by almost 30 p.p. together with implementing the shelterbelts into the landscape. Realization of the abovementioned services by shelterbelts contributes to the generation of certain socio-economic benefits. An increase of the chance for high yields is estimated by the BBN model for 10 p.p., the probability of high biodiversity rises by 27.6 p.p. and higher tourist movement by 21 p.p. This in turn has an impact on an increase in local employment by 8.9 p.p. In the case of regional competitiveness, there is a 5 p.p. increase in the chance of achieving a high level of competitiveness and a 6 p.p. decrease of low level chance due to the implementation of the shelterbelts.

A similar calculation was carried out for all landscape elements (Table 3). Due to brevity reasons, we present here only a direct impact of a particular element on the region's level of competitiveness. While all the considered landscape elements display a positive influence on regional competitiveness, the agricultural land being an important element of the landscape shows the strongest impact by increasing the chance of high competitiveness by about 20 percent points, and decreasing the chance of low competitiveness by about 21.9 percent points. Shelterbelts and forest have very similar effects with an increase of about 5 p.p. and water gives an almost negligible change of 1.5 p.p.

It was also interesting to observe a reverse causality of the BBN model. In Figure 9 we show what happens when we assume a high level of competitiveness at 100% probability. We compared the results with Figure 4 – the calibrated BBN model. It can be observed that 100% chance of high level competitiveness (an increase from 39.1% high to 100%) is assured by an increase of the 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 a productivity increase (higher yields) has a stronger effect on competitiveness than employment

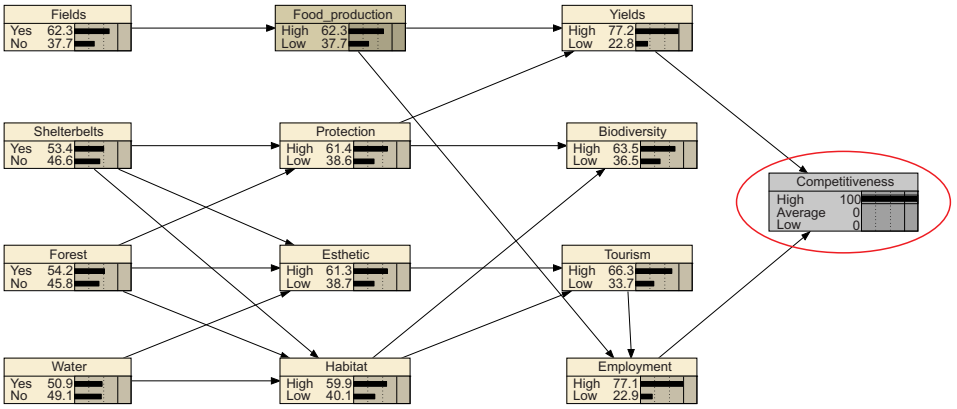

Fig. 9. The BBN belief bars in case of 100% chance of high competitiveness

(creation of jobs). High competitiveness (100% chance) was obtained through increasing the probability of high yields by 28 p.p. whereas higher employment by 16.7 p.p.

Conclusions

The main research question of the paper was to what extent agricultural landscapes can contribute to the development of rural areas, thus strengthening the competitive position of regions through the provision of ecosystem services, and what the mechanisms of this impact are. In the study the causal connections between landscape management, socio-economic benefits and mechanisms influencing the income level have been described and quantified on the example of Chłapowski Landscape Park in the Wielkopolska region of Poland. It turned out that the landscape composition of Chłapowski Landscape Park is more diversified than in the two other adjacent regions. It was expressed by a higher Shannon index and lower Herfindhal Hirshman concentration index. Although these indicators are not commonly used in the literature to measure landscape diversity and concentration, they have proven useful in assessing the landscape.

The influence of the landscape on regional competitiveness is difficult to assess due to the complexity of the problem and the relations between several variables. The lack of experimental data makes it practically impossible to use classical statistical methods. To achieve the overall objective of this study, the Bayesian Belief Network approach was tested to measure the influence of landscape elements on regional competitiveness. The method has proved 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. This might be a limitation of this study, and results should be further validated on a larger dataset.

It was concluded that the functions and services provided by landscape elements and benefits from its usage contribute to higher competitiveness of the region, measured by income effects. Benefits from the landscape for the regional competitiveness in Chłapowski Landscape Park are clearly connected with agriculture supported by shelterbelts and their regulating (protection) function. It has been found that all four, considered landscape elements (fields, forests, shelterbelts, and water reservoirs) have a positive influence on regional competitiveness but with a diverse estimated strength. 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 percentage points. Shelterbelts and forests have very similar effects with the potential to increase the chance of high competitiveness by 5 pp. Shelterbelts, which are a unique and distinctive element of the landscape in Chłapowski 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 the competitiveness of the region, having an impact on the productivity and profitability of the agricultural sector. It should be emphasized that the regional policy should include maintenance and conservation of this unique landscape element. It has been also found that productivity increase (higher yields) has stronger effect on the competitiveness than employment (job creation).

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Ocena wpływu krajobrazów wiejskich na konkurencyjność regionów metodą Bayesian Belief Network – przypadek Wielkopolski w Polsce

Zarys treści: W opracowaniu przedstawiono wyniki badań dotyczące pomiaru wpływu krajobrazu wiejskiego, jego elementów i struktury na konkurencyjność regionu rozumianą jako zdolność do generowania relatywnie wysokich dochodów z działalności gospodarczej, przy jednoczesnym zapewnieniu zatrudnienia i dobrobytu społeczeństwa. Powiązania przyczynowe pomiędzy kształtowaniem krajobrazu, korzyściami społeczno-ekonomicznymi i mechanizmami wpływającymi na poziom dochodów zostały opisane i zmierzone na przykładzie regionu rolniczego, który znajduje się na terenie Parku Krajobrazowego im. Gen. Dezyderego Chłapowskiego w Wielkopolsce. W celu scharakteryzowania unikatowej struktury krajobrazu parku, za pomocą GIS, map glebowych i innych materiałów przygotowano szczegółowe mapy wybranego regionu i porównano je z dwoma obszarami rolniczymi o wyraźnie odmiennych cechach krajobrazowych, ale położonymi w sąsiedztwie. Na podstawie przygotowanych map dokonano inwentaryzacji krajobrazu i jego struktury. Stopień koncentracji i zróżnicowania elementów krajobrazu został zmierzony dwoma wskaźnikami – indeksem Shannona (H) i indeksem Herfindahla-Hirschmana (HHI). Następnie w celu określenia potencjalnego wpływu krajobrazu na konkurencyjność regionu opracowano koncepcję oceny zależności metodą Bayesian Belief Network (BBN). Opracowanie struktury BBN pozwoliło na ustalenie siły zależności pomiędzy

poszczególnymi elementami krajobrazu, funkcjami pełnionymi przez krajobraz, korzyściami a konkurencyjnością regionu. Wyniki wskazują, że korzyści z krajobrazu dla konkurencyjności regionu w Parku Krajobrazowym im. Gen. Dezyderego Chłapowskiego są wyraźnie związane z rolnictwem chronionym przez pasy zadrzewień. Występowanie zadrzewień liniowych jest ponad dwukrotnie większe na terenie Parku niż w regionach sąsiednich. Krajobraz Parku waloryzowany jest z perspektywy dwóch najważniejszych pełnionych funkcji – produkcyjnej oraz regulacyjnej. Funkcja produkcyjna związana jest z rolniczym charakterem krajobrazu i produkcją żywności. Funkcja ochronno-regulacyjna wynika z występowania pasów zadrzewień śródpolnych, które w znaczący sposób redukują erozję wietrzną, na którą narażone są uprawy w tym regionie Polski. Stwierdzono też, że wszystkie rozważane elementy krajobrazu (pola uprawne, lasy, zadrzewienia śródpolne i przydrożne, zbiorniki wodne) mają pozytywny wpływ na zdolność do generowania dochodów w regionie, zwiększając szanse na osiągnięcie wysokiej konkurencyjności, ale z różną siłą oddziaływania.

Słowa kluczowe: krajobraz rolniczy, usługi ekosystemowe, konkurencyjność regionów, Bayesian Belief Network, Park Chłapowskiego, pasy zadrzewień

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