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# Sustainability Assessment of Agribusiness Clusters: A Case Study Based on Regional Sustainability Assessment Methodology

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## Abstract

*Socioeconomic and environmental sustainability is becoming critical for the evaluation of regional development. Regional planning and policy development depend on accurate sustainability assessment for the estimation of genesis and evolution of agribusiness clusters. The lack of a universal methodology creates challenges for the analysis of regional issues and the role of separate industries in the sustainability of regional development. This research suggests and reviews the application of Regional Sustainability Assessment Methodology (RSAM) by using a case study approach with a special attention to agribusiness clusters. The empirical analyses reveal the importance of resource cycling in the regions, their dependency on external resources and self-sufficiency as indicators of regional sustainability (social, economic and environmental resource use efficiency) in a dynamic perspective, applicable to diverse regions and separate aspects of sustainability. The study areas include three sub-national level regions in Germany: two forming an agribusiness cluster, specialized in livestock-meat production (Vechta Landkreis and Cloppenburg Landkreis) and one control region (Hochsauerlandkreis). The application of RSAM revealed varying rates of resource use efficiency, self-sufficiency and dependency on external resources for both static and dynamic perspectives. The assessment indicated the potential of RSAM application for the static and dynamic assessment of regions with agribusiness clusters. At the same time, static analysis of separate aspects of sustainability (economic, social and environmental) was not informative. RSAM application to the separate types of resource analysis allowed identification of sustainability hotspots (unbal-*

*anced development, “weak sustainability” and increased dependency on separate resources).*

## Key Words

*regional sustainability assessment; agribusiness cluster; case study approach; input-output analysis; life cycle analysis*

## 1 Introduction

Modern rural agribusiness clusters are the drivers and the response to the globalization changes of food trade. VAN WITTELOOSTUIJN highlighted this paradox as one of the most important propositions for future research, indicating that: “globalisation will trigger regionalisation, and regionalisation will boost globalisation” (VAN WITTELOOSTUIJN, 2009). Despite the extensive literature about industrial development analysis in Germany (STERNBERG and LITZENBERGER, 2004; ROCHA and STERNBERG, 2005; BRENNER, 2006; ALECKE and UNTIEDT, 2008; TITZE, BRACHERT and KUBIS, 2011; BRACHERT et al., 2011; KAHL and HUNDT, 2015; WROBEL, 2015) the identification and classification of agribusiness clusters is a challenging task (HOFFMANN, HIRSCH and SIMONS, 2015). It is connected with high data aggregation at the national level of analysis, when overall industrial production is taken into account without a proper detail level. Most of the areas of food production in such case could not be accounted as regional industrial clusters (TITZE et al., 2011). There are quite a few examples of using scientific methods to identify clusters linked to the food industry (STEINER et al., 2007; WANDEL, 2010; DIEZ-VIAL, 2011; GELLYNCK et al., 2011). They illustrate

the hurdles of agribusiness clusters identification and characterization as different methodological approaches result in sometimes quite opposite results. Such a great variety is caused by the differences in regional clusters definitions and assessment techniques.

Mentioned studies demonstrate a wide range of approaches towards the identification and assessment of rural agribusiness clusters. It is logical that the analysis of their development is a challenging task, especially in terms of their role in the network of global interconnected value chains, driving forces and evolution of agribusiness clusters, sustainable consequences of agribusiness clusters globalization. Industrial clusters development has a direct impact on the regional development, both in positive and negative perspective, depending on the state of cluster life cycle (BRENNER and GILDNER, 2006; MENZEL and FORNAHL, 2007; MENZEL and FORNAHL, 2010; BROEKEL et al., 2015). The sustainability assessment of rural agribusiness clusters from regional perspective is needed. It would indicate the endogenous and exogenous interconnection properties of the systems, relevant “hotspots” and identify the evolutionary dynamic paths of their development.

Despite multiple hurdles of agribusiness cluster identification for the regional scale, some authors (HOFFMANN et al., 2015) were able not only to identify clusters but also point towards their specialization (e.g. Cloppenburg and Vechta Landkreises for meat processing). They were able to perform analysis of the clusters with high level of disaggregation (up to the county level). Following the publications (MARTIN and SUNLEY, 2003; MARTIN and SUNLEY, 2007; HOFFMANN et al., 2015), our study concentrated on the comparative assessment of development sustainability of the identified agribusiness clusters.

The selection of agribusiness clusters, as a point of interest was dictated by their controversial nature. They are triggering the economic development of regions from one side and are responsible for more than 50% of all greenhouse gas emissions and more than 70% of water footprint globally (PACHAURI et al., 2014; SCHMIDT and MERCAI, 2014; HOEKSTRA et al., 2012; PFISTER and BAYER, 2014). The highest share of the environmental impact of food is associated with meat production (SCHMIDT and MERCAI, 2014; STEINFELD et al., 2006). It sets a lot of questions about the sustainability of development of the regions, which form agribusiness clusters relying on meat production. Regions of Vechta and Cloppenburg are known as an agribusiness cluster of intensive live-

stock production and meat processing (TAMÁSY, 2013; HOFFMANN et al., 2015; SMETANA et al., 2016). That is why these counties were selected as the main study area.

The aim of this paper is to empirically indicate sustainability issues of sub-national regions development influenced by cluster formation by using RSAM as an assessment tool. Following the previous research (SMETANA et al., 2015; SMETANA et al., 2016), the paper concentrates on the dynamic application of RSAM. For the dynamic sustainability assessment the study includes socioeconomic activities of the regions, which form agribusiness clusters. The analysis will focus on two similar rural regions, which compose the Oldenburger Münsterland and one rural-urban region, which will serve as a control area (Hochsauerlandkreis). All three regions of the same level (NUTS3) are located in the west of Northern Germany. The Oldenburger Münsterland region (Vechta Landkreis and Cloppenburg Landkreis) has a common historical development, economic structure and dynamics. The economic development of the region is based on intensive agricultural production, mainly livestock farming, and related food processing industry. The economic success of the Oldenburger Münsterland is connected with the placement of many globally operating agricultural and food businesses, which clearly indicate the region as an agribusiness cluster (HOFFMANN et al., 2015). At the same time a high number of livestock and their concentration in the region cause over-supply of manure, air pollution, groundwater deterioration and related health issues (TAMÁSY, 2013). The third region (Hochsauerlandkreis), used for comparison, is characterized with economic development which relies on manufacturing and service industries. It is not known as an agribusiness cluster. Moreover, large areas (almost 40,000 ha) are preserved as natural reserves mainly due to middle mountain landscape. The economic structure of the region is based, in a big degree, on the service sector, development of the metal industry, electrical engineering, engineering and plastics industry. The region is also holding a central residual landfill site for waste treatment.

Therefore, this paper commences with some conceptual considerations and methodological background of sustainability assessment with application of RSAM for the identification of regional development paths. This is followed by the results of the regional sustainability comparison in terms of resource use efficiency and resource transferability. Using the

three rural and semi-urban sub-national regions as a case study, static and dynamic properties of agribusiness clusters are analyzed and presented. The generalized regional analysis is followed by the identification of the critical aspects in regional development, affecting the sustainability. Finally, the paper concludes with a brief discussion of the results and application possibilities of RSAM.

## 2 Conceptual Considerations

Currently sustainability is a guiding approach for the development of humanity (ROBERT et al., 2013; CAMPBELL and GARMESTANI, 2012; O'RIORDAN and VOISEY, 1998). Even though, it might have certain conflicts of interpretation and understanding (VOINOV, 2008; GATTO, 1995), its application is proven to provide a sufficient guideline for regional planning. The idea of sustainability is in equilibrium of multiple dimensions included in three main pillars (social, economic and environmental). Such multi-criteria balance, which should also preserve resources in non-degraded state for future generations, demands for multi-criteria assessment techniques (MUNDA and SAISANA, 2011). The multidimensional social development triggered the advancement of corresponding sustainability assessment techniques. They covered a wide number of social (GUINÉE et al., 2011; ZAMAGNI, 2012; COOKE et al., 2005; FLORIDA et al., 2008; ABEL et al., 2010), economic (WECKMAN et al., 2008; BOSKER, 2009) and environmental aspects (BOSKER, 2009; RODRÍGUEZ and ARIAS, 2008; PHILLIPS, 2011). However, most of the assessment methods do not provide an answer to the integrated estimation of “a sustaining degree” for different regions (products, technologies etc.) with weighted interlinked value estimation for various assessment categories. Neither can they assess the developmental properties of industrial clusters. Moreover, advanced integrated or multi-criteria approaches, developed in the last decade (KURKA, 2013; CABELLO et al., 2014; AGOSTINHO and ORTEGA, 2012; SINGH et al., 2012; VAN PASSEL and MEUL, 2012; KOURTIT et al., 2014; TENERELLI and CARVER, 2012), revealed sustainability of an object either with a number of indices (not interlinked with each other) or concentrated only on a few indicators, important for the development. Therefore, at a given time, published and available to the public review methodologies do not provide an integrated sustainability assessment of multiple aspects of regional development.

Among the variety of sustainability assessment indices, life-cycle and input-output methods have a great potential for sustainability assessment of a regional development. Input-Output Analysis (IOA), well-known in economic studies, was successfully combined with environmental aspects (including life cycle assessment) and applied to the assessment of production economies at national level (LEONTIEF, 1951; HENDRICKSON et al., 1998; DANIELS et al., 2011). IOA techniques were also applied for the regional industrial cluster identification (TITZE et al., 2011). Providing its potential combination possibilities with Social Accounting Matrices (ALLAN et al., 2010; MORILLA et al., 2007; LEHMANN et al., 2013) it might become an integrated technique for sustainability assessment at national or regional levels. It has not been completed due to the hurdles of a single accounting unit selection, overlapping of social and economic aspects and regional variations.

Regional Sustainability Assessment Methodology (RSAM) is an original methodology developed to assess relative regional sustainability, based on adapted and combined methods of input-output table analysis, life cycle assessment and resource cycling indices (SMETANA et al., 2015; SMETANA et al., 2016). It is aimed to provide an assessment of relative sustainability levels for regions and indicate the “hotspot” aspects of regional development (SMETANA et al., 2016). RSAM, however, should identify the dynamic paths and opportunities for the development of the regions, based on the main economic activities, which have not been previously tested with real regional data. As Vechta and Cloppenburg counties are characterized as regions, which origin the agribusiness cluster of livestock-meat production (HOFFMANN et al., 2015; BRACHERT et al., 2011; TITZE et al., 2011) their dynamic analysis was selected as an appropriate testing ground for RSAM. We argue that amount, quality and changes of the natural (environmental), social and economic resources and their availability determine regional (local) cluster development paths. Such approach is well-supported in the literature (DEVINE-WRIGHT, FLEMING and CHADWICK, 2001; ADGER, 2003; JORDAN et al., 2010; BIRCH et al., 2010; BEN LETAIFA and RABEAU, 2013; DELGADO et al., 2016).

Despite multiple indicators of sustainability aiming at simplification of sustainability measurements (SINGH et al., 2012; SICHE et al., 2008; BÖHRINGER and JOCHEM, 2007; MAYER, 2008), RSAM is placed as a holistic assessment system, capable of multiple

issues analysis and further adaptation. That is why it is based on a combination of Input-Output Analysis and efficiency estimations of resource flows, which account for the true cost of activities. It differentiates RSAM from common evaluations of sustainability, which are based on operational and professional judgement rather than on quantitative approaches (SHAKER, 2015; PHILLIPS, 2015). The applicability of RSAM for the identification of development paths of agribusiness clusters is an empirical task to solve further in the article.

### 3 Methods

Input-Output (IO) tables' analysis is a well-known methodology used for the indication of purchasing interdependencies between sectors of the economy (LEONTIEF, 1951; MILLER and BLAIR, 2009). It was improved with further developed IO techniques, which included environmental impacts (HENDRICKSON et al., 1998; MATTHEWS and SMALL, 2000) and social accounting (MORILLA et al., 2007; ALLAN et al., 2010). IO tables' analysis consists of linear balance models, which account for multiple connections of system elements. IO tables' analysis was a basis for RSAM data compilation, selected due to comparison abilities inside sectors and with other matrix systems and indices. The relation of IO tables based models and Life Cycle Assessment (HERTWICH, 2005) indicated the potential of RSAM for a combination of social, environmental and economic data in a single assessment system. The basis of RSAM on IO tables' analysis allowed data transparency and multiple combination and recombination abilities. They assured the flexibility of RSAM and its independence from specific data.

Traditional IO analysis perceives sectors of economy as producers and consumers at the same time. It, therefore, accounts for the transfer of resources from one industry (a producer) to all the others in the forms of a value or a price. The accounting of such transfers is usually presented in a form of matrix, which is then applicable for the matrix analysis. Moreover, some authors introduced the application of IO analysis to the matrices formed with physical units (mass, energy, number) (MILLER and BLAIR, 2009). Therefore, IO matrices are the representation of a certain amount of resources stored and the transfers of the resources between sectors. Balanced and non-balanced models of IO matrices are a viable presentation of the complex system character of regional systems and their economies.

RSAM followed a simple algorithm for the assessment of resource use in the regions. It required data collection for the comparable regions, input-output tables' construction, estimation of resources cycling in the regions, comparison and analysis of results (SMETANA et al., 2016). Further, the data were compiled into the corresponding initial resource matrices, which were the basis for more complex IO matrices construction. The data for the assessment was collected from official statistical sources (LWK, 2015; NLWKN, 2015; RDG, 2015). The data sources contain publicly available information on sub-national regions (NUTS2 and NUTS3 levels), classified according to the Nomenclature of Units for Territorial Statistics. The agricultural association of Lower Saxony (LWK, 2015) contains updated information (including prices) on biotic resources. Lower Saxony data bank for water data of State Enterprise for Water Management, Coastal and Nature Conservation (NLWKN, 2015) is a reliable source of information for water supply and wastewater management. The biggest amount of data was mined from The Regional Database Germany (RDG, 2015).

There are a few benefits of using the data from the indicated sources. First of all, they represent the official sources of data collected directly from the regional statistics offices which accumulate the annual data on a constant basis. It assures the consistency and comparability of the data. Second, the datasets represent a wide variety of economic, environmental and social indicators, which can be used to identify the interactions between different components of the regional system. While economic data represent the interactions between production and consumption components, environmental data are presented with amounts of natural resources (biotic, mineral, water, energy, land resources and wastes generated and treated). The social component of sustainability in RSAM model is including information on the characterization of different components of the society (working population, direct consumers, service suppliers, social beneficiaries and regulators). This way the RSAM model tried to cover the whole population, which performs different functions from social benefits suppliers and consumers to the regulators, which act as transformers of the social goods distribution.

The analysis required initial resource IO matrices construction and their further transformation into single unit IO tables (based on the actual price index). The prices of the resources were acquired from multiple sources, which include regional statistical offices (Landesbetrieb für Statistik und Kommunikations-



technologie Niedersachsen), regional minister's offices (Niedersächsisches Ministerium für Wirtschaft, Arbeit und Verkehr) and other available sources. The integrated monetized matrix represents the estimation of separate resource development at given time frame (usually annual). Then the same calculation procedure was used to estimate the efficiency of resource use for the whole region. The detailed methodology of static RSAM application is presented in published papers (SMETANA et al., 2015; SMETANA et al., 2016).

Methodologically, except IO table analysis RSAM included flows cycling analyses (FINN, 1976; ALLESINA and ULANOWICZ, 2004), which assess resource transfer data within an outlined area. The efficiency of resource use in the regions was indicated as a relation of the resources amount cycled in the system to the amount of resources, leaving the system, according to the cycling estimations based on adapted Han (HCI), Finn (FCI) and Comprehensive cycling indices (CCI) (FINN, 1976; ALLESINA and ULANOWICZ, 2004). Cycling indices represent the complexity of the network in the system. The higher amount of alternative routes for resource transfer would result in higher cycling indices. The self-sufficiency index (sum of minors of included matrices) demonstrated the strength of a region to satisfy the needs for a specific resource with own resources. Further analysis included the interpretation of the results and repetition of the application procedure for the time series (dynamic assessment) and separate production impact assessment. The last two stages could

indicate the development of clusters based on specific industries. It was performed as a case study on two selected economically similar "rural districts", which formed a single agribusiness cluster, and one "rural-urban district" of level NUTS3 (Nomenclature of Units for Territorial Statistics) for comparison. Selected regions, compared in this case study, were situated in the west part of Northern Germany (Figure 1).

RSAM application for the regional characterization allows assessment of separate productions available in the region. It was performed with the use of multipliers for IO tables. Once the RSAM is applied for the regional analysis, then the identification

**Figure 1. The location of case study regions on the map of Germany**



Source: authors

of specific production share for the regional sustainability is possible. This article estimates the relative importance of biotic resources (as an indicator of the agri-food based regional development) and their potential impact on the development of regions. Production properties as a driver of the economy were also separately evaluated for the efficiency of resource use. Dynamic trends were analyzed as a series of RSAM applied to the regions at different annual time frames. Trend analysis of time series was used to estimate possible paths for regional development.

## 4 Empirical Results

### 4.1 Static Comparison

Static sustainability comparison of regional development of the three regions was performed for 2010 as the most detailed statistic data were well presented for the year from a single source for all the studied regions (it decreased the influence of data inconsistency). Regional comparison with RSAM showed that regions with similar economic and social sectors have similar indicator results (Table 1). Rural-urban region (H) is characterized by higher rates of resources cycling in the system and lower dependency on the external flows. The rate of self-sufficiency of Region (H) was higher than in the other two regions.

Presented analysis of the studied regions reflected the overall regional assessment and the differences between regions caused by the variations in organization and economic activities. However, it did not provide information on separate pillars of sustainability or drivers for agribusiness cluster development. That is why we performed an analysis of RSAM applicability for the assessment of social, environmental and economic aspects (Table 2). The results indicated higher rates of economic resources cycling (FCI and

CCI) in Region (V) and Region (H). Region (C) was different due to the higher FCI and CCI in social aspects, whereas economic aspects had lower values. Environmental resources had the lowest cycling indices and self-sufficiency scores for all the regions. The analysis of separate aspects of sustainability and even separate production sectors was more informative with sectoral IO tables' analysis of RSAM presented further (Table 3).

**Table 1. Integrated regional system comparison results (2010)**

Regions	HCI	FCI	CCI	I,O/Total	Self-sufficiency
(V)	0.15	0.93	1.06	0.39	23.56
(C)	0.14	0.99	1.13	0.4	17.72
(H)	0.27	1.14	1.31	0.35	28.93

Note: HCI – adapted Han cycling index; FCI – Finn cycling index; CCI – Comprehensive cycling index; I,O/Total – relation of inputs or outputs to total flows; (V) – Vechta Landkreis; (C) – Cloppenburg Landkreis; (H) – Hochsauerlandkreis  
Source: authors

**Table 2. Integrated regional system comparison results for separate aspects of sustainability (2010)**

Regions	Aspects	HCI	FCI	CCI	I,O/Total	Self-sufficiency
(V)	Soc	0.74	3.94	4.50	0.15	22.29
	Eco	8.73	7.29	8.32	0.05	19.45
	Env	0.09	1.20	1.37	0.38	7.05
(C)	Soc	1.33	7.21	8.23	0.07	47.52
	Eco	28.07	1.38	1.57	0.02	58.90
	Env	0.10	1.20	1.37	0.38	7.12
(H)	Soc	0.70	3.31	3.78	0.18	19.24
	Eco	7.17	6.21	7.10	0.06	16.32
	Env	0.10	1.20	1.38	0.38	7.43

Note: HCI – adapted Han cycling index; FCI – Finn cycling index; CCI – Comprehensive cycling index; I,O/Total – relation of inputs or outputs to total flows; (V) – Vechta Landkreis; (C) – Cloppenburg Landkreis; (H) – Hochsauerlandkreis; Soc – social; Eco – economic; Env – environmental  
Source: authors

**Table 3. Producer resources comparison of the regions in 2010**

Regions	HCI	FCI	CCI	I/O	I/Total	O/Total	Self-sufficiency
Absolute (monetized) values based comparison							
(V)	1.37	3.21	3.66	0.21	0.12	0.57	647
(C)	1.18	3.67	4.19	0.24	0.14	0.59	279
(H)	0.78	2.96	3.38	0.32	0.18	0.54	99

Note: (V) – Vechta ; (C) – Cloppenburg ; (H) – Hochsauerlandkreis; HCI – adapted Han cycling index; FCI – Finn cycling index; CCI – Comprehensive cycling index; I/O – relation of inputs to outputs; I/Total – relation of inputs to total flows; O/Total – relation of outputs to total flows  
Source: authors

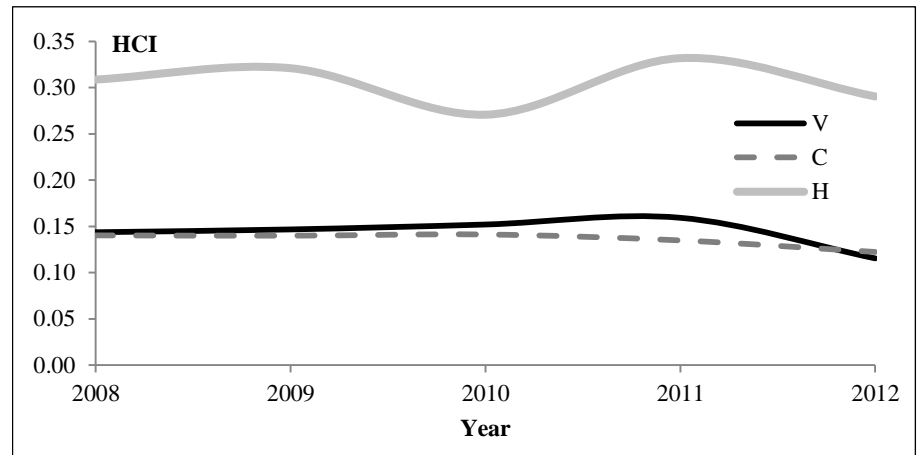
## 4.2 Dynamic Trends Comparison

The comparison of resource cycling rates was based on five-year period, which represented the ability of RSAM to reflect the short-term changes and indicate tendencies for further regional development. The identified trends demonstrated insignificant annual changes in regional development for the economically and socially similar regions (V and C) (Figure 2). They had similar stable results throughout the five year period with variations in the range of 0.2-9% for adapted Han Cycling Index (HCI) with the only exception of a 27.5% drop in 2012 for Region (V). Region (H) had overall higher indices of HCI (Figure 2). It also had a higher level of the index annual fluctuations (4-23%) which indicated higher regional dependence on annual changes of resource structure.

Trend analysis of adapted HCI results indicated that the amount of inner resources cycling in regions will be decreased in all three regions. Region (H) inner resources cycling will drop 4% by within the next two years comparing to the value of 2008, while the same measure will drop by 12.5% and 15% for Region (C) and Region (V) accordingly.

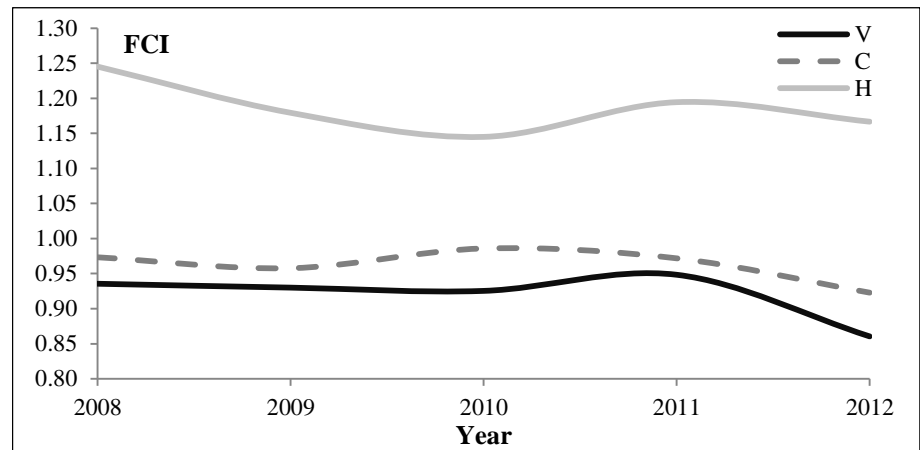
The analysis of the data with Finn Cycling Index (FCI) revealed similar results (Figure 3). Region (H) had a higher index of inner resources cycling ( $FCI = 1.2-1.5$ ) and higher annual fluctuations (2.3-24.6%). The other regions had lower resource cy-

**Figure 2. Results of adapted Han cycling index (HCI) applied to the regions**



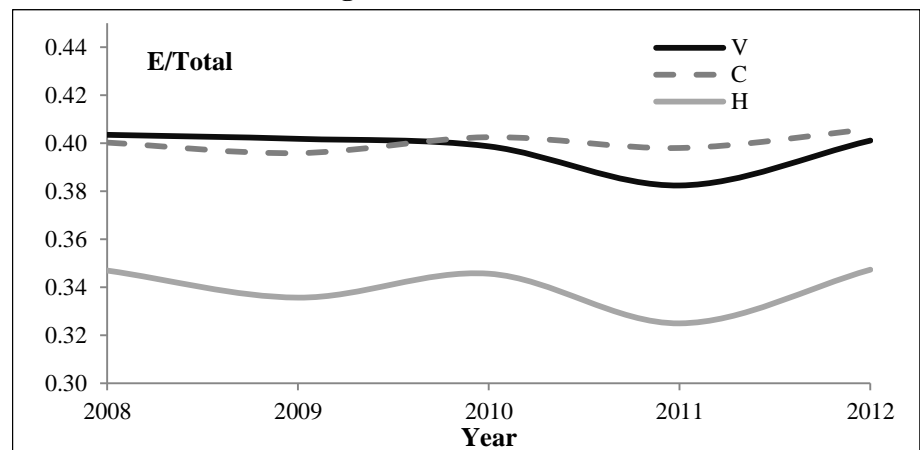
Note: V – Vechta; C – Cloppenburg; H – Hochsauerlandkreis; HCI – Han cycling index  
Source: authors

**Figure 3. Results of adapted Finn cycling index (FCI) applied to the regions**



Note: V – Vechta; C – Cloppenburg; H – Hochsauerlandkreis; FCI – Finn cycling index  
Source: authors

**Figure 4. Results of external flows relation to the total amount of flows in the region**



Note: V – Vechta; C – Cloppenburg; H – Hochsauerlandkreis; E/Total – relation of external flows to the total flow amount  
Source: authors



cling indices: ~0.9 for Region (V) and ~0.95 for Region (C). Annual changes of the cycling indices achieved 0.5-9.3% for Region (V) and 1.4-5.0% for Region (C).

Trend analysis of FCI application results revealed similar results of decreasing dependency on resources cycling in the regions. All three regions forecasted to have the FCI decreased within the range of 5.4-8%.

The dependence on external flows was indicated as a relation of external flows to the total amount of resource flows in a region. The higher representation of external resources was highlighted for Region (V) and Region (C). Their dependency on external resources was around 40% (Figure 4). Region (H) had a lower overall dependency on external resources (0.25-0.35%). Annual fluctuation of results was 0.4-0.8% for Region (V) and 1.1-2% Region (C). The dependence on external resources in Region (H) fluctuated in a higher degree at 3.3-31.2%.

Trend analysis of dependence relations on external resources indicated minor possible changes in the future for the regions. Region (H) is unlikely to change the overall score as it was predicted to lower the dependency on 1.5% within the next two years comparing to the value in 2008. Region (V) should lower the dependency on 3.9%, while Region (C) should probably increase the use of external resources at 2%.

#### 4.1 Sustainability Assessment of Driving Forces of Regional Development

The sustainability analysis of separate aspects of regional development was performed with the use of the same methods of RSAM (see Methods). In order to reflect on the drivers of agribusiness cluster development this paper presents the analyses of overall producer interactions (Table 3) and biotic resources (Table 4). The lowest rates of producer resources cycling were outlined for Region (H). Producers in Region (V) and Region (C) had higher cycling indices of resources and therefore higher self-sufficiency. At the same time, the dependency of producers on external resource flows was similar between the three regions. High dependency on the external resource flows could

**Table 4. Biotic resources comparison of the study regions in 2010**

Regions	HCI	FCI	CCI	I/O	I/Total	O/Total	Self-sufficiency
<b>Absolute values comparison</b>							
(V)	4.47	3.52	4.02	0.37	0.17	0.46	719
(C)	5.85	5.56	6.35	0.25	0.12	0.48	62741
(H)	8.08	36.10	41.23	0.05	0.02	0.42	352280
<b>Monetized values comparison</b>							
(V)	5.86	1.30	1.48	0.60	0.30	0.50	871
(C)	6.48	2.02	2.31	0.42	0.24	0.57	20412
(H)	20.05	10.95	12.50	0.16	0.07	0.46	366345

Note: (V) – Vechta; (C) – Cloppenburg; (H) – Hochsauerlandkreis; HCI – Han cycling index; FCI – Finn cycling index; CCI – Comprehensive cycling index; I/O – relation of inputs to outputs; I/Total – relation of inputs to total flows; O/Total – relation of outputs to total flows

Source: authors

result in negative changes in case of scarcity of external resources. Self-sufficiency of production activities was much higher in regions, which form the agribusiness cluster (V and C).

Similarly, separate aspects of regional development could be analyzed with RSAM for any important issue of sustainable development. In this article aggregated IO tables included assessment of lands, energy, water, biotic resources, minerals, producers, consumers, service suppliers, correctors (regulators), social beneficiaries and wastes. But it should be considered that the analysis on separate issues does not reflect their relative contribution towards the overall level of regional sustainability, but rather indicates the comparative value.

Another example, illustrating the application of RSAM for the drivers of agribusiness characterization is presented for biotic resource flows in 2010 (Table 4). On contrary to producer IO matrix it was possible to perform an analysis of absolute values and weighted monetized indicators for biotic resources.

IO table analysis for biotic resources (absolute values) identified the lowest levels of resource cycling for Region (V). Region (V) was also characterized with the highest levels of input flows. Monetized weighted IO matrix analysis indicated similar results for Region (V). Region (H) had the highest cycling rates of biotic resources in the region and the lowest dependency on external flows (both for absolute and monetized weighted values).

## 5 Discussion

Sustainability assessment at regional level has its specifics. We defined regional sustainability as the ability of a regional system (outlined with administrative,

cultural, social, economic or other criteria) to sustain current socioeconomic and environmental conditions with possibilities for future development or current state preservation (SMETANA et al., 2015). Such regional definition as well refers to industrial cluster definitions (CRUZ and TEIXEIRA, 2010; BRENNER, 2004; BRENNER, 2006). Regional (sub-national) scale of analysis allows local data aggregation and integration, but keeps the possibilities for the detailed analysis of the key influencing factors of regional development. Identification of links between diverse elements, which influence the sustainability of regional development (LEIN, 2014; GRAYMORE et al., 2010; GRAYMORE et al., 2008) is a useful characteristic for the analysis of endogenous and exogenous drivers of cluster development. For example, the agribusiness cluster (the Oldenburger Münsterland) was dependent on external biotic resource flows. Together with higher than in the control region (Hochsauerlandkreis) inner cycling rates of economic production resources it indicated the active role of food production chains in the cluster region. Despite relatively high inner cycling rates of resources in the agribusiness cluster no considerable dynamic changes were observed, which pointed to the mature stage of cluster development. At the same time, the dependency of the region on the external resources is “preserving” deep shocking effects in the future. Therefore, a system vision of regional factors influencing the development of a region could identify the factors and solutions to the problems of sustainable development for regions.

We argue that the level of resources cycling in the system (region or cluster) and regional dependency on external resource flows indicated the sustainability of the system performance. In this case, the comparison of the flow rates with other systems allowed indication of problem areas, while a few-year comparison allowed evolutionary trend analysis in a dynamic perspective.

The application of RSAM for the static comparison of the regions revealed the possibilities of relative efficiency estimation of resources cycling in the system (region, cluster). RSAM application was indicative to distinguish the regions, which were characterized with different socioeconomic and environmental structure, which corresponds well to the previous study (SMETANA et al., 2016). At the same time, the differentiation between similar regions (V) and (C) was not indicative.

RSAM analysis of separate pillars of sustainability revealed differences in economic and social fac-

tors, whereas the efficiency of resource use in environmental sector was similarly low for all the regions. RSAM analysis of separate issues of sustainability allowed determination of differences and similarities between regions, thus, allowing for the selection of regional aspects aimed for further deeper analysis and hotspot identification. At the same time, at a given level of data aggregation and analysis, it was not possible to provide a substantial basis for sustainable hotspots allocation of the regions in 2010.

In order to exclude the potential impact of the annual changes on the resource use (and potential mistakes of sustainability levels indication) we performed a dynamic regional assessment for the five-year period. Further dynamics of a regional system were evaluated with trend analysis for the series of time periods. The analysis was reflective and confirmed the conclusions on the overall higher sustainability rates of Region (H), which was reflected in higher rates of resources cycling and lower dependency on external resources over the five-year period. It was also characterized with the prediction of decreased dependency on external resources.

Development and application of RSAM is foreseen to provide information about the current state of sustainability of regional development, to identify the “problem” fields and to indicate more sustainable alternatives for the development of a region. As compared regions had a high level of dependency on the use of biotic resources due to the cluster formation (Regions V and C are known as regions of intensive agricultural production), it was necessary to analyze the relative performance of biotic resources (environmental pillar) and production industries (economic pillar). The analysis indicated that despite relatively efficient use of economic resources in Region (H), the efficiency of resource use by producers was lower than in the other two regions, while dependency on external resources was higher and self-sufficiency was therefore, lower. Biotic resources were used with the highest efficiency in Region (H), which was explained with the lower economic dependency on the biotic resources (compared to the other regions). As Region (H) had a comparatively low share of external resource flows in the economy, the self-sufficiency measure was very high. The application of RSAM for the analysis of only biotic resources should not be performed separately from general regional assessment, as it would emphasize the value of biotic resources and neglect the role of other components of regional development. RSAM application for biotic

resource efficiency assessment also revealed minor differentiation between Region (V) and Region (C), which indicated the potential sensitivity of RSAM application.

The use of RSAM, presented in this article, indicated its abilities for sustainability analysis of diverse regions and their dynamics. It is also applicable for the analysis of separate sustainability aspects of regional development with a high level of details according to the type of resources. RSAM provides the results in the same relative form, which can be compared and analyzed. Such a diverse apparatus for data analysis makes the RSAM a tool, which can provide a support for the identification of agribusiness cluster development in rural areas. Therefore, a further testing and application of RSAM is foreseen for diverse regions in various countries, potentially forming industrial clusters. It was indicated that RSAM is applicable for the analysis of specific sustainability components and their internal and external performance according to the integrated RSAM model. It can be used for the “hotspot analysis” of sustainability issues in relation to inter and intra-dynamics. The answer to such issues could be interesting for the actors involved in regional research and planning (e.g. government and scholars). Moreover, the interest in the research from community demonstrated the relevance of the research application for public acknowledgement with regional sustainability problems.

## 6 Conclusions

The study presented Regional Sustainability Assessment Methodology (RSAM) application to the analysis of static regional sustainability conditions and dynamic trends of regional development. A case study approach of RSAM use for regions of agribusiness cluster analysis in comparison to a control region was performed.

Similarities of socioeconomic development of regions were reflected in comparable indices of RSAM. Thus, Vechta and Cloppenburg regions (V and C) had comparable endogenous resource cycling rates, dependencies on external resources and self-sufficiency rates. The control region – Hochsauerlandkreis (H) had different results. Such results could potentially indicate the applicability of RSAM for the identification of industrial clusters through the comparison of similarities between neighboring regions. However, in order to claim the significance of such conclusions, further

testing of the methodology with more diverse industrial clusters and regions should be performed.

Agribusiness cluster formation in rural areas requires the increased magnitude of external resource flows as the development of an industrial center depends on the external demand and supply. Similar to the other studies (WILK and FENSTERSEIFER, 2003; FENSTERSEIFER, 2007) it was highlighted in the case of RSAM application for Regions (V) and (C). On the other hand, regions which depend on inner resources for the development (H) do not form industrial clusters. The conclusion should be further investigated with a wider range of industrial clusters in order to confirm the applicability of RSAM for cluster identification.

The characterization of agribusiness clusters was performed with RSAM for the resources reflecting producer and biotic sectors of the economy. Producer activities analysis with RSAM revealed almost a double rate of economic resources cycling in agribusiness cluster, comparing to the control Region (H). The high level of resources cycling in cluster regions triggered also higher rates of self-sufficiency. At the same time high dependency on the external resource flows holds a risk of resources use efficiency leveling to the rates of the control region, which might add another point to the conclusions of other authors about the self-destructing forces in clusters (BROEKEL et al., 2015; MENZEL and FORNAHL, 2010).

Application of RSAM for biotic resource analysis reflected regions of the agribusiness cluster as dependent on the external resource flows and having low cycling rates of inner resources compared to the control region (H). RSAM analysis also revealed the relative position of the regions in terms of biotic resources use efficiency and self-sufficiency. Despite producer and biotic resource characterization, the results of separate sustainability pillars with RSAM analysis did not indicate the specific drivers of agribusiness cluster formation at the regional scale. Neither were they illustrative for the hotspot characterization.

Dynamic analysis based on the results of RSAM application for the five-year period, indicated the stable nature of the results to characterize the differences of sustainability condition of regional development. Forecasting trend analysis allowed indication of the potential changes of regional sustainability. The overall resource efficiency use (as an indicator of sustainability) was reflective on the annual changes for all the indices, but demonstrated the overall stable position between different socioeconomic regions.

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