LAND USE CHANGES AND BIOENERGY IN LATVIA

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Abstract. The paper presents results of studies devoted to the changes of land use caused by implementation of bioenergy policy in Latvia. The period of 2007-2012 was chosen and chiefly data on declared utilised agricultural area on municipal and region level from the Rural Support Service were used for assessment of land use changes. In Latvia, utilised agricultural areas (UAA), which is mainly used for bioenergy feedstocks production - rape and maize for silage - are located in the territories/regions (Zemgale and Kurzeme) with the highest proportion of agricultural lands and the highest soil fertility. The growing trends in these regions are statistically significant. The biogas plants are also located in these territories. Meanwhile, slight but decreasing tendency of the share of unused UAA in all regions, except Latgale, was observed. Moreover, the share in Latgale, the most undeveloped region, increases and reached 18% in 2012. The observed changes in land use in Latvia show some contradictions to bioenergy policy which is oriented to: returning the unused agricultural land in the production of feedstock; improving the quality of the environment, particularly, biodiversity and the landscape; and encouraging rural development.

Key words: agricultural land, bioenergy policy, region, Latvia.

JEL code: Q15, Q20, Q53, R14

Introduction

Bioenergy as one of the renewable energy resources is currently at the global focal point, both due to its effect on environment and the necessity to replace rapidly decreasing fossil energy sources with renewable and more environment-friendly source. The possible benefits from the environmental point of view, including the lower greenhouse gas (GHG) emissions when replacing the fossil fuel with biomass, is among the main driving forces for wider usage of bioenergy. However, in the European Union (EU), production of agricultural biomass, whether used for food, feed, material, or energy, has to meet a series of statutory environmental rules regarding the quality of water, soils, and air. The EU Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (The European Parliament..., 2009), provides a legislative framework for the Community. Regarding the expand of bioenergy, particularly biofuels, use in the EU, the Directive aims to ensure the use of sustainable biomass only, which generate a clear and net GHG saving without negative impact on biodiversity and land use.

Therefore, Latvia has also developed the national renewable energy policy and the support programme based on the EU principles. Support measures for bioenergy production encourage increasing cultivation of energy plants for biomass feedstock: 1) rapeseed production for biodiesel production; and 2) maize for silage as feedstock in the biogas production. The programme of development of production
and use of biogas 2007-2013 (Ministru kabinets, 2007) says one of the goals of bioenergy production development is encouraging rural development processes, creating new jobs, and improving the quality of the environment and the landscape.

Along with the benefits of bioenergy generation, the different negative influence caused by some types of bioenergy is also stressed (Wilhelm et al., 2007; Searchinger et al., 2008; Tyner, 2010; Perimenis et al., 2011; Finco, 2012). The majority of such objections are related with the biomass production from the agricultural lands and field crops. It is recommended that before entering into or accepting bioenergy projects, states should make a full calculation of the social, economic, and environmental costs compared with the benefits – and to the ways in which the benefits will be shared (Eide, 2009:33). It is becoming increasingly evident that land is a finite or restricted resource due to conflicting demands for agricultural land for the production of food, animal feed, fibre and biomass for energy (Dauber et al., 2012).

Taking into account the above mentioned, the hypothesis of study was determined - the bioenergy development in Latvia causes changes in land use. The aim of study is to investigate the present situation and processes regarding land use changes initiated by bioenergy development in Latvia. The tasks of study are: to clarify the impact of bioenergy on countryside and landscape, particularly, on land use changes; to investigate land use changes in Latvia regarding the main bioenergy crops as feedstocks: rape for rape seed (biodiesel production) and maize for silage (biogas production); and possible impact on permanent and temporary pastures and meadows (landscape) as well as unused or surplus land. The research is concentrated on the impact of bioenergy, which is closely connected with agricultural sector.

The principal materials used for the studies are as follows: different sources of literature, e.g. scholars’ articles, research papers and the reports of institutions, inter alia, governmental; and data from database of the Latvian Rural Support Service (RSS). For investigation the land changes the data of declared areas of utilised agricultural land area (hereinafter - UAA) were used in the period of 2007-2012. The suitable qualitative and quantitative research methods have been used for various solutions in the process of study: monographic; analysis and synthesis; logical and abstractive constructional; spatial analysis of field blocks, using GIS24; correlation and regression etc.

Due to limited space, only the most important results of research are set out in the paper.

Research results and discussion

Land use and bioenergy

The bioenergy means any form of energy derived from biomass - living organisms or their metabolic products (Bioenergy, 2013). On the EU level (The European Parliament and the Council of the European Union, 2009: 27), ‘biomass’ is defined as ‘...the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture as well as the biodegradable fraction of industrial and municipal waste.”

The growing demand for bioenergy crops can create further competition for land and water between the existing agricultural activities and the use of agricultural land for nature conservation, which could result in additional negative environmental pressures from cultivating bioenergy crops (EEA, 2006). Many scholars (e.g. Pingali et al., 2008; Flora, 2010; Kirschenmann, 2010; Krasuska et al., 2010; Piroli et al., 2012) and experts (FAO, 2013) argue that food production has a priority, only surplus land could be used

24 geographic information system - GIS
for non-food crops. Moreover, Krasuska with co-authors (2010) forecast the amount of surplus land in the EU-27 Member States (excluding Cyprus and Malta) that could be available for non-food crops after satisfying food and feed demands. In Latvia, the percentage of surplus land was 7-9% in the period of 2003-2007 but projections show that surplus land could be 14-17% in 2020 and 22-27% in 2030 (Ibid.).

The proposed potential non-food cultures for Poland, the Baltic States (Estonia, Latvia, and Lithuania) and the Nordic countries (Finland, Sweden) are: willow, poplar, reed canary grass, rapeseed, flax (Ibid.), which could be cultivated on surplus land, mainly fallow. Surplus land could be seen as the all-embracing umbrella term for areas potentially available for bioenergy cultivation. Indicating that there is no clear definition for this term, Dauber with co-authors (2012) distinguish two different origins of surplus land: 1) land currently not in use for the production of food, animal feed, fibre, or other renewable resources due to poor soil fertility or abiotic stress, and 2) land currently no longer needed for food and feed production, because of intensification and rationalisation of production. Moreover, Nuwer (2012) stressed that Dauber et al. (2012) encountered a plethora of terminology of surplus land that seemingly all referred to different versions of the same thing, including marginal land, reclaimed land, and degraded land.

Some scholars (Divan and Kreikebaum, 2009) argue that expansion of farming for biofuel production causes unacceptable loss of biodiversity for a much less significant decrease in fossil fuel consumption. The loss of biodiversity also makes heavy dependence on biofuels very risky by reducing ability to deal with blights affecting the few important biofuel crops (Ibid.). Perimenis et al. (2011) and Finco (2012) note that land use changes and intensification of cultivation following the increased demand for biofuels may cause new GHG emissions and affect the biodiversity, the soil quality, and the natural resources. To handle these problems, attention is focused on the development of next generations – second and third generation of biofuels (e.g. lignocellulosic ethanol, Bio-SNG, synthetic biofuels) that will use a wider range of feedstock including lignocellulosic material, waste and residues, and will not compete with food production (Perimenis et al., 2011) or stimulate production of algae origin biodiesel (Ziolkowska, 2014). Moreover, Howard et al. (2009) affirm that the first generation biofuels are inefficient both in terms of economy and the environment.

Regarding biomass or feedstock development, scholars (e.g. Berndes et al., 2012; Kusch and Evoh, 2013) conclude that the need for bioenergy can reinforce through efficient and sustainable waste management strategies.

**Land use changes in Latvia**

The structure of agricultural land and its spatial distribution is essential for both: 1) development of agricultural sector related with basic resource; 2) environment and nature protection, which is an essential part of the Common Agricultural Policy. For estimation, the UAA was divided into main agricultural crops: arable land (different crops); perennial grass sown into arable land or temporary grassland (hereinafter - TG); permanent pastures and meadows (hereinafter – PPM); and fallow and unused and unmanaged (hereinafter - unused) UAA.

The results show that TG constituted 17% from area of field blocks in 2012; other arable land – 40%, while PPM – 22%. No information is available about 20% of area, since it has not been declared for support payment. However, previous studies and results (LVAEI, 2013b) suggested that this undeclared area mainly consists of extensively managed PPM or fellow, and unmanaged grasslands. Overall, more than half of the UAA is being managed intensively but more than one third of the UAA is being managed extensively or not managed at all. Positive trend is observed in case of fellow share in the UAA, where...
decreasing of fallow area in all regions is observed (Table 1). Moreover, the coefficient of correlation (r) is significant in all municipalities.

### Table 1

The changes of share (%) of fallow area from the UAA in Latvia’s regions and significance of trends, 2007-2012

<table>
<thead>
<tr>
<th>Regions</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Correl. coef. of trend</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurzeme</td>
<td>0.8</td>
<td>0.6</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
<td>r = 0.85</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Latgale</td>
<td>0.9</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
<td>r = 0.95</td>
<td>α&lt;0.01</td>
</tr>
<tr>
<td>Pieriga</td>
<td>0.8</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.3</td>
<td>r = 0.82</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Vidzeme</td>
<td>1.0</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
<td>r = 0.91</td>
<td>α&lt;0.01</td>
</tr>
<tr>
<td>Zemgale</td>
<td>0.5</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>r = 0.92</td>
<td>α&lt;0.01</td>
</tr>
</tbody>
</table>

Source: authors’ calculations based on the unpublished data from Latvian Rural Support Service

The results of spatial analysis show that the share of cereals and technical crops has increased in some municipalities most of all – more than 8%. The changes of share of rape area from the UAA in Latvia’s regions are increasing in all regions (Table 2). Statistically, this trend is significant in all regions, except Zemgale, where the share was very high (10.2%) in 2007 and tops other regions. In 2012 the highest share is seen in Zemgale (10.6%) and Kurzeme (7.1%) but the lowest - in Latgale (2.7%) and Vidzeme (3.5%).

### Table 2

The changes of share (%) of rape area from the UAA in Latvia’s regions and significance of trends, 2007-2012

<table>
<thead>
<tr>
<th>Regions</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Correl. coef. of trend</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurzeme</td>
<td>3.9</td>
<td>3.1</td>
<td>4.4</td>
<td>6.2</td>
<td>6.7</td>
<td>7.1</td>
<td>r = 0.93</td>
<td>α&lt;0.01</td>
</tr>
<tr>
<td>Latgale</td>
<td>1.6</td>
<td>0.9</td>
<td>1.0</td>
<td>1.6</td>
<td>2.5</td>
<td>2.7</td>
<td>r = 0.77</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Pieriga</td>
<td>4.1</td>
<td>3.3</td>
<td>4.2</td>
<td>5.4</td>
<td>5.6</td>
<td>5.4</td>
<td>r = 0.85</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Vidzeme</td>
<td>2.9</td>
<td>2.5</td>
<td>2.9</td>
<td>3.3</td>
<td>3.9</td>
<td>3.5</td>
<td>r = 0.82</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Zemgale</td>
<td>10.2</td>
<td>7.0</td>
<td>9.4</td>
<td>10.1</td>
<td>10.9</td>
<td>10.6</td>
<td>r = 0.56</td>
<td>α&lt;0.05</td>
</tr>
</tbody>
</table>

Source: authors’ calculations based on the unpublished data from Latvian Rural Support Service

The changes of share of maize for silage area of total UAA in Latvia’s regions show (Table 3) that the highest significant increase and share has been observed in Zemgale (1.8%) and Pieriga (1.8%).

### Table 3

The changes of share (%) of maize for silage area from the UAA in Latvia’s regions and significance of trends, 2007-2012

<table>
<thead>
<tr>
<th>Regions</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>Correl. coef. of trend</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurzeme</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.8</td>
<td>r = 0.80</td>
<td>α&gt;0.05</td>
</tr>
<tr>
<td>Latgale</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>r = 0.75</td>
<td>α&gt;0.05</td>
</tr>
<tr>
<td>Pieriga</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.9</td>
<td>1.8</td>
<td>r = 0.85</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Vidzeme</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.5</td>
<td>r = 0.69</td>
<td>α&lt;0.05</td>
</tr>
<tr>
<td>Zemgale</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>1.3</td>
<td>1.8</td>
<td>r = 0.88</td>
<td>α&lt;0.05</td>
</tr>
</tbody>
</table>

Source: authors’ calculations based on the unpublished data from Latvian Rural Support Service

However, an increasing trend was observed in Kurzeme, Vidzeme and Latgale, and it is not statistically significant. Besides, the highest share (0.5%) of maize was in Zemgale compared with other regions, in the evaluation’s starting point – in 2007 (Table 3).
The relationship of share of maize area in 2012 and the number of biogas plants in 2012 on municipalities’ level was performed for better assessment of increasing maize areas coherence with biogas plants (installations) development (Figure 1). The results of correlation and regression analysis of: 1) share (percentage) of maize for silage area in the total UAA area in municipalities; and 2) biogas plants number in same municipalities show that the correlation is significant (correlation coefficient – $r = 0.87, \alpha < 0.01$). Even though the data (e.g. type and volume) of feedstock used in biogas plants are not available, the results of spatial analysis as seen in Figure 1 show that in general the growing tendency of maize areas more or less corresponds with the location of biogas plants. It must be noted that biogas plants are mostly located in the central region Zemgale, where fertility of soil is the highest and share of arable land is also the highest (Melece, 2013). Moreover, there has been a long-term food and feed crops in this region. Because of this, the region is often referred to as “Latvia’s granary”. At present, biogas plants are located in those territories of Latvia with the highest proportion of agricultural lands and the highest soil fertility (Ibid.), which fails to stimulate using the unused UAA or surplus land for bioenergy generation. This fact contradicts bioenergy policy, oriented to returning the unused UAA or surplus land in the production of feedstock and improving the quality of the environment, particularly, biodiversity and the landscape.

Besides, the analysis of land area changes under wheat, rape, other crops and total area of UAA, was carried out for clarifying bioenergy policy impact on returning unused UAA in production of energy crops. The results (Table 4) demonstrate that raising of areas of rape and wheat probably has occurred due to reducing cultivation of other agricultural crops, including grasslands. The reduction could decrease biodiversity, because more diverse land cover, inter alia, diversification in crop type, creates a greater number of habitats for species from different taxa (EEA, 2006).
The changes of area (ha) of wheat, rape, other crop and total UAA in Latvia, 2007–2012

<table>
<thead>
<tr>
<th>Crop</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>224168</td>
<td>218405</td>
<td>271734</td>
<td>300258</td>
<td>309931</td>
<td>351268</td>
</tr>
<tr>
<td>Rape</td>
<td>98525</td>
<td>70343</td>
<td>89998</td>
<td>108457</td>
<td>121071</td>
<td>117164</td>
</tr>
<tr>
<td>Other crops</td>
<td>1282662</td>
<td>1045857</td>
<td>1128615</td>
<td>1164455</td>
<td>1186203</td>
<td>1158582</td>
</tr>
<tr>
<td>Total</td>
<td>1605355</td>
<td>1334605</td>
<td>1490348</td>
<td>1573170</td>
<td>1617205</td>
<td>1627014</td>
</tr>
</tbody>
</table>

Source: authors’ calculations based on the unpublished data from Latvian Rural Support Service

Spatial analysis of the UAA changes in the period of 2007-2012 show the biggest decrease of TG share (82.5 thousand ha), while other arable land has increased by 65 thousand ha; and PPM – 44 thousand ha. The share of TG in the period of 2007-2012 has increased only in five municipalities and by less than 5% (Figure 2); no changes were registered in six municipalities, while in other municipalities the share has decreased, especially, in municipalities located in Pieriga region.

Spatial analysis of the UAA changes in the period of 2007-2012 show the biggest decrease of TG share (82.5 thousand ha), while other arable land has increased by 65 thousand ha; and PPM – 44 thousand ha. The share of TG in the period of 2007-2012 has increased only in five municipalities and by less than 5% (Figure 2); no changes were registered in six municipalities, while in other municipalities the share has decreased, especially, in municipalities located in Pieriga region.

However, the share decreased by more than 10% (Figure 2) in other regions’ municipalities (e.g. Ligatne, Vecpiebalga, Amata, Baldone, Priekuli, and Jaunpiebalga). Considering the fact that the main method of PPM managing is grass cutting, performed once year and often the grass is left on field, the biodiversity of grassland also decreases (LVAEI, 2013a). Although, TG has considered better from the land management view, the environmental benefits of long-term grassland are: protection of soil from erosion, improvement in soil structure, reduction in use of plant protection chemicals, and some benefits also for biodiversity (Herzon, 2009). The importance of traditional agriculture landscapes has been widely recognised in Europe and the world (Navarro and Pereira, 2012). In Latvia, the changes of landscapes structure are caused by the changes of UAA, which are connected with processes of marginalisation and polarisation (Nikodemus et al., 2010). The main causes of landscape changes are: unused UAA and...
overgrowing processes or secondary succession, which is common in the mosaic landscapes (Ibid.). However, the results of study suggest some positive changes observed in the past years, where increasing trends of managed PPM are noted. Some negative impact is related with increasing intensification of the UAA management, which in the recent years has increasingly reduced the morphological quality and biodiversity of landscape, lowering the total value of landscape and ecology.

Comparing the data\(^{25}\) of unused UAA and its tendencies by different Latvia’s regions, one can see in Table 4 that negligible but decreasing tendency of the share of unused UAA was registered in all regions, except Latgale (most undeveloped region). Moreover, the share of unused UAA in Latgale increases and reaches 18% in 2012.

Table 5

<table>
<thead>
<tr>
<th>Regions</th>
<th>Unused UAA, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td>Kurzeme</td>
<td>14</td>
</tr>
<tr>
<td>Latgale</td>
<td>17</td>
</tr>
<tr>
<td>Pieriga</td>
<td>18</td>
</tr>
<tr>
<td>Vidzeme</td>
<td>14</td>
</tr>
<tr>
<td>Zemgale</td>
<td>10</td>
</tr>
<tr>
<td><strong>Average in the country</strong></td>
<td><strong>14</strong></td>
</tr>
</tbody>
</table>

*Source: authors’ construction based on the unpublished data from Latvian Rural Support Service*

The results of spatial analysis show that the changes in the structure of the UAA concern relatively small areas, where TG areas have been replaced by areas of the cereals and the technical crops. Besides, the unmanaged grasslands are declared as PPM. Therefore, only the small areas of unused UAA are returned in the agricultural production.

**Conclusions, proposals, recommendations**

1. Due to conflicting demands for land in rural areas for the production of food, animal feed, fibre and biomass for bioenergy, the land is becoming increasingly vital and restricted resource. Moreover, scholars, experts and some officials agree that agricultural land, which could be used for bioenergy plants, must no longer be used for food and feed production due to poor soil fertility or abiotic stress. Besides, more attention could be devoted to non food and feed biomass, and the second and third generation of bioenergy.

2. In Latvia, areas of the utilised agricultural land, mainly used for bioenergy feedstocks production - rape and maize for silage - are located in the territories/regions with the highest proportion of agricultural lands and the highest soil fertility. In the period of 2007-2012, the growing trends of land usage for rape and maize production are statistically significant in the most fertile regions (Zemgale and Kurzeme) with higher share of managed agricultural land. Besides, the increase of rape and wheat areas probably has occurred due to reducing of cultivation of other agricultural crops, including grasslands.

3. At present, biogas plants are mainly located in the territories of Latvia with the highest proportion of utilised agricultural areas and the highest soil fertility. This fact contradicts bioenergy policy, oriented to returning the unused UAA or surplus land in the production of feedstock and improving the quality of the environment, particularly, biodiversity and the landscape.

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\(^{25}\) The data are available only from 2010, when RSS started collect these data
4. There are some positive changes observed in the past years - increasing trends of managed permanent pastures and meadows. At the same time, some negative impact is recognised, connected with: decreasing trend of temporary grasslands; increasing intensification of agricultural land management, which has increasingly reduced the quality and biodiversity of grasslands and landscape in the recent years, lowering the total value of landscape and ecology.

5. Even though statistically significant decrease of fellow area in all regions is observed, only small areas of unused utilised agricultural land have been returned to the agricultural production in the past years. A slight but decreasing tendency of the share of unused UAA was registered in all regions, except Latgale. Moreover, the share in Latgale, most undeveloped region, increases and reached 18% in 2012.

6. In general, the observed land use changes in Latvia show some contradictions to bioenergy policy which is oriented to returning the unused agricultural land in the production of feedstock; improving the quality of the environment, particularly, biodiversity and the landscape; and encouraging rural development.

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