# PROJECTING INVESTMENTS AND FIXED ASSETS IN AGRICULTURE IN LATVIA

**Aleksejs Nipers[1], Irina Pilvere[1], Agnese Krievina[2], Valda Bratka[2]**
[1]Latvia University of Life Sciences and Technologies, Latvia;
[2]Institute of Agricultural Resources and Economics, Latvia
aleksejs.nipers@llu.lv, irina.pilvere@llu.lv, agnese.krievina@arei.lv, valda.bratka@arei.lv

**Abstract.** To generate projections for agricultural production in Latvia until 2050, the Latvian Agricultural Sector Analysis Model (LASAM) was developed at the Latvia University of Life Sciences and Technologies in 2016. At that stage, the model generated projections for the so-called "activity data", which were used for projecting GHG (greenhouse gases) emissions from agriculture. Nevertheless, the model lacked socio-economic information, including the information on the necessary investment in agriculture and the aggregate value of fixed assets, which could be used for policy analysis and planning, especially within the context of debates about the new European Union (EU) Common Agricultural Policy (CAP) and the Rural Development Plan of Latvia 2021-2027. Within this research, LASAM was extended by a module for the value of fixed assets as at the end of a year and the amount of gross investment required to ensure the achievement of the projected area under crops, the projected number of livestock and the projected total agricultural output in Latvia until 2050. The aim of the research is to produce a projection of aggregate gross investment and of the aggregate value of fixed assets necessary for agriculture in the period until 2050 in Latvia. The research projected gross investments and the value of fixed assets. The authors have concluded that the aggregate gross investment in agriculture in Latvia is expected to increase to EUR 708 mln. in 2030, reaching an aggregate of EUR 1040 mln. in 2050, which are increases of 53 % and 128 %, respectively, compared with 2016, thereby also determining an increase in the aggregate value of fixed assets at the end of the year.

**Keywords:** agriculture, simulation, investment, fixed assets.

## Introduction

Agriculture is a specific industry that depends on natural conditions, limited natural resources and human activity, as it is difficult to project market effects and volatility in the global market as well as various global developments, for example, climate change that can considerably affect this industry. For these reasons, making projections for agriculture by employing various models is widespread. The projections are used by farmers themselves as well as policy makers, agriculture-related businesses, financiers of agriculture and other agricultural stakeholders. In the world, the models employed to project agricultural processes differ in the purpose they were developed for. For example, the UK employs such models for optimising land usage and achieving higher grassland productivity [1], elsewhere in Europe the models are used to quantify the impact of parameter value uncertainty on prediction uncertainty for modelling spring wheat [2], while elsewhere in the world – to examine the extent to which crop performance can be predicted from information on current and recent past management practices [3].

The European Commission is also involved in producing various agricultural projections to make crop yield forecasts and crop production estimates, which are necessary at the EU and Member State level to provide the EU's CAP decision makers with timely information for rapid decision-making during the growing season. Estimates of crop production are also useful in relation to trade, development policies and humanitarian assistance linked to food security [4-7].

But for food to become cheaper and more plentiful, agriculture must become more productive, more efficient and more sustainable. This calls for enormous investment volumes. Investing in agriculture and food systems can produce multiplier effects for complementary sectors, such as service or manufacturing industries, thus further contributing to food security and nutrition, and overall economic development [8]. The OECD stated that private investment is essential, if agriculture is to fulfil its vital function of contributing to economic development, poverty reduction and food security. Agricultural production needs to increase by at least 60 % over the next 40 years to meet the rising demand for food resulting from the world population growth, higher income levels and lifestyle changes. Given the limited scope for net area expansion, agricultural growth will rely mainly on new increases in productivity, supported in particular by private investment in physical, human and knowledge capital. Agricultural investment can help contain upward pressure on food prices in a context of rising land and water scarcity, thereby enhancing global food security [9]. Providing farms with tractors and agricultural machines in time is important for performing agricultural work [10]. However, it is not enough because farmland, farm buildings and structures, equipment and farm animals are also necessary. Therefore, *the overall aim of the research* is to produce a projection of aggregate gross investment and of the aggregate value of fixed assets necessary for agriculture in the period until 2050 in Latvia.

## Materials and methods

To generate projections for the Latvian agricultural sector, the LASAM model was developed in 2016. The model covers the following key agricultural industries: cereals (wheat, barley, rye, oats, triticale), oil crops (rapeseed), legumes, potato, vegetables, dairy and beef cattle, sheep, goats, horses, pigs, poultry and laying hens [11-14]. The model initially was developed as an econometric, recursive, dynamic, multi-period scenario model. Those projections were primary focused on "activity data" (agricultural areas, numbers of animals) and used to estimate agricultural production in Latvia and agricultural GHG emissions. Within this research project, the LASAM model was extended by a module for the value of fixed assets and investment [14]. One of the model indicators shown in this paper is the value of fixed assets as at the end of a year and the amount of gross investment required to ensure the achievement of the projected area under crops and the projected number of livestock and therefore the projected total agricultural output. The calculation and projection of investments and of the value of fixed assets until 2050 largely relies on the Farm Accountancy Data Network (FADN) data [15]. The model is written in R language, using RStudio software.

To simulate the ***value of fixed assets*** and the amount of the necessary investment in agriculture, the first step involved the use of causal associations identified in a data set comprised of FADN farm data for 2014, 2015 and 2016. Of the total of 1000 farms in the FADN system, the research employed the data for a set of 905 farms, excluding the farms having a zero value for the kinds of fixed assets analysed as well as selecting the farms that participated in the FADN system for all the three years analysed, as the research used average three-year data (i.e. the averages for the period 2014-2016). The causal associations were analysed using a multifactor regression equation. In the analysis, the dependent variable was the value of fixed assets as at the end of the year, which represented the values of permanent crops, land improvement, farm buildings and structures, machinery and equipment, other fixed assets and breeding livestock. The factors of the equation (independent variables) represented the areas under various crops and the average numbers of livestock on the farms.

The following crop and livestock categories were selected: 1) GOP (grains, oil crops and legumes); 2) permanent crops; 3) vegetables, strawberry, flowers and potato; 4) dairy cows; 5) other grazing livestock – suckling cows and horses –, which were assigned a coefficient of 1, as well as sheep and goats, which were assigned a coefficient of 0.5; 6) pigs (coefficient 1) and poultry (coefficient 0.01). The summing within the factor 5) and 6) was based on the own assumption regarding the differences in the occupied space by livestock.

In the first step, the value of fixed assets for the Latvian agricultural sector was projected by the following equation:

$$P' = a + \beta_1 \cdot Q_{GOP} + \beta_2 \cdot Q_{per} + \beta_3 \cdot Q_{vegfp} + \beta_4 \cdot Q_{cowmi} + \beta_5 \cdot Q_{graz} + \beta_6 \cdot Q_{graniv} \tag{1}$$

where $P'$ – value of fixed assets (thsd EUR);
$Q_{GOP}$ – area (ha) under grains, oil crops and legumes;
$Q_{per}$ – area (ha) under permanent crops;
$Q_{vegfp}$ – area (ha) under vegetables, strawberry, flowers and potato;
$Q_{cowmi}$ – number of dairy cows;
$Q_{graz}$ – number of other grazing livestock;
$Q_{graniv}$ – number of pigs and poultry.

The necessary coefficients for the projection were obtained from the linear regression analysis (OLS) applied to farm level data. The intercept $a$ of the regression equation equalled -42.83, the coefficient $\beta_1$ for the GEP area was 1.00, the coefficient $\beta_2$ for permanent crops was 5.98, the coefficient $\beta_3$ for vegetables, strawberry and flowers was 3.38, the coefficient $\beta_4$ for dairy cows (number) was 4.12, the coefficient $\beta_5$ for other grazing livestock was 1.56, the coefficient $\beta_6$ for pigs and poultry was 0.38, and $p = 0.000$ (Table 1).

Table 1

**Regression equation parameters for the average value of fixed assets in Latvian farms, without considering structural changes (average for the period 2014-2016) [14; 15]**

| Parameters of the regression equation | | | | |
|---|---|---|---|---|
| **Coefficients** | **Estimate** | **Std. Error** | ***t* value** | ***Pr* ( > \|t\|)** |
| Intercept | -42.83 | 16.22 | -2.640 | 0.00843 ** |
| $Q_{GOP}$ | 1.00 | 0.05 | 19.864 | < 2e-16 *** |
| $Q_{per}$ | 5.98 | 3.03 | 1.971 | 0.04905 * |
| $Q_{vegfp}$ | 3.38 | 1.18 | 2.853 | 0.00443 ** |
| $Q_{cowmi}$ | 4.12 | 0.21 | 19.856 | < 2e-16 *** |
| $Q_{graz}$ | 1.56 | 0.63 | 2.487 | 0.01305 * |
| $Q_{graniv}$ | 0.38 | 0.01 | 48.631 | < 2e-16 *** |
| Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | | |
| Residual standard error: 404.3 on 898 degrees of freedom<br>Multiple R-squared: 0.7961, Adjusted R-squared: 0.7947<br>F-statistic: 584.2 on 6 and 898 DF, p-value: < 2.2e-16 | | | | |

The agricultural sector-level projections of the crop area and the number of livestock produced by the LASAM model [14] were used in the presented equation for calculating the future values of fixed assets for the Latvian agricultural sector (without considering structural changes and therefore excluding farm consolidation component).

In view of the existing differences between generalised agricultural sector level data obtained from the FADN farms and overall agricultural area and livestock statistical data, the projections of the total crop area and the number of livestock were corrected by a ratio of generalised FADN data to area and livestock statistical data for 2016 and the following years for each category of crops and livestock (for the future, it is assumed that the FADN coverage will expand).

The second step involved taking into consideration agricultural structural changes too that, among others, included an increase in capital intensity on farms. It was assumed that the value of fixed assets obtained from the FADN farms generalised to the agricultural sector level represented the amount of fixed assets for the agriculture of Latvia; accordingly, projections were made for this value, which was also the dependent variable of the regression equation, the causal associations of which were used for further projection.

One of the factors of the regression equation was the value of fixed assets (which excludes farm consolidation component) calculated in the first step, while the second factor – the average UAA per farm. In Latvia, the average farm size in 2014 was 24.4 ha UAA, in 2015 – 26 ha and in 2016 – 27.6 ha, which was a 2.2-fold increase compared with 2005 and indicates the consolidation of farms. The total value of fixed assets for the Latvian agricultural sector (considering also structural change) was projected by the following equation:

$$P = b + \beta_7 \cdot P' + \beta_8 \cdot S_A \tag{2}$$

where $P$ – total value of fixed assets, considering structural change (thsd EUR);
$P'$ – value of fixed assets (thsd EUR);
$S_A$ – average area (ha) per farm.

The necessary coefficients were derived from the linear regression analysis (OLS), where intercept (b) of the regression equation equalled -9.971e + 05, the first coefficient ($\beta_7$) equalled 8.302e-01, the second coefficient ($\beta_8$) equalled 3.273e + 04 and p = 0.000 (Table 2).

To calculate the future values of fixed assets for the Latvian agricultural sector, the equation (2) took into account the previously calculated values of fixed assets (which excludes farm consolidation component) and a projection of the average UAA per farm (made based on the trend equation).

Table 2

**Regression equation parameters for the value of fixed assets in Latvia, taking into account the structural change in agriculture with regard to UAA use (2005-2016) [14; 15]**

| Parameters of the regression equation | | | | |
|---|---|---|---|---|
| **Coefficients** | **Estimate** | **Std. Error** | ***t* value** | ***Pr* ( > \|*t*\|)** |
| Intercept | -9.971e + 05 | 4.800e + 05 | -2.077 | 0.0676 . |
| *P'* | 8.302e-01 | 3.873e-01 | 2.144 | 0.0606 . |
| $S_A$ | 3.273e + 04 | 1.310e + 04 | 2.499 | 0.0339 * |
| Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | | |
| Residual standard error: 101500 on 9 degrees of freedom<br>Multiple R-squared: 0.9001, Adjusted R-squared: 0.8779<br>F-statistic: 40.55 on 2 and 9 DF, p-value: 3.146e-05 | | | | |

***Gross investment***. Production expansion is associated with the need to purchase fixed assets or make investments. At the same time, the use of fixed assets in the production process involves their depreciation, which could be offset by making investments and, consequently, increasing the book value of fixed assets. The following equation is employed to determine the need for investment:

$$I_t = \frac{\left(P_t - 2P_{t-1} + P_{t-2} + I_{t-1} - \frac{1}{n} I_{t-n}\right)}{1 - 1/n}, \tag{3}$$

where $I_t$ – necessary investment in the t-th year;
$P_t$ – book value of fixed assets in the t-th year;
$n$ – period of complete depreciation of fixed assets in years.

It was assumed that the value of gross investment for the FADN farms generalised to the agricultural sector level represented the amount of the gross investment needed for the agriculture of Latvia; accordingly, projections were made for this value.

To determine the amount of the necessary investment in the Latvian agricultural sector, the equation (3) took into account the values of fixed assets for the previous years (generalised FADN data) and the previous projection of the value of fixed assets, which represented a function of output (based on the area and the number of livestock) and farm consolidation, as well as the value of gross investment made in the previous years (generalised FADN data) and the future values of gross investment, which were dynamically calculated in each of the previous steps. The depreciation period was assumed to be seven years.

## Results and discussion

Agriculture is a capital-intensive industry. A percentage breakdown of fixed assets by key type of farms in Latvia in 2016 reveals differences, which are summarised in Table 3. In terms of value, the most important items of fixed assets are farm buildings and structures as well as machinery and equipment. In 2016, the buildings and structures of dairy farms accounted for 42 % of the aggregate value of fixed assets of the farms, while those of pig and poultry farms as well as vegetable farms comprised almost 70 %; the share for field crop farms was 27 %. In 2016, the machinery and equipment of vegetable farms represented the highest percentage of fixed assets of the farms at 64 %, while the percentage for dairy farms was 33 %.

To replenish their fixed assets, farms in Latvia usually use their own resources, which are earned from their main economic activity, loans as well as various support payments – direct payments and the financial assistance provided by the Rural Development Programme. Of the total value of gross investment, investment subsidies comprised on average 12 %; in the period 2014-2016, the average rate for dairy farms was the highest at 17 %, while that for field crop farms was 12 %.

As agricultural output and farm consolidation progressed in Latvia in the period 2005-2016, the aggregate value of fixed assets increased from EUR 687.9 mln. to EUR 1546.6 mln. or 2.25-fold. Compared with the previous year, a very considerable increase in the aggregate value of fixed assets was observed in 2011, 2013, 2006 and 2008 – by 18.6 %, 18.5 %, 17.6 % and 15.3 %, respectively; it indicated the active implementation of the EU-funded investment projects in the mentioned years. In

2010 and 2015, however, the value of fixed assets, compared with the previous year, decreased, which could be explained by the economic crisis in the former case and the beginning of a new EU programming period and the unavailability of investment subsidies in the latter case.

Table 3

**Percentage breakdown of fixed assets and financial support (as a percentage of total gross investment) for various types of farms in 2016 [15]**

| Type of farms/ investment | Field crops | Vegetables | Permanent crops | Dairy | Grazing livestock | Pigs and poultry |
|---|---|---|---|---|---|---|
| ***Percentage breakdown of fixed assets*** | | | | | | |
| Permanent crops | 0.2 % | 0.0 % | 55.1 % | 0.1 % | 0.0 % | 0.0 % |
| Land improvement | 0.9 % | 0.0 % | 0.2 % | 0.1 % | 0.3 % | 0.0 % |
| Farm buildings and structures | 26.8 % | 68.8 % | 19.4 % | 41.5 % | 25.6 % | 69.9 % |
| Machinery and equipment | 63.7 % | 27.0 % | 21.2 % | 33.1 % | 37.5 % | 19.1 % |
| Other fixed assets | 7.5 % | 4.1 % | 4.1 % | 3.4 % | 3.6 % | 2.9 % |
| Breeding livestock | 0.9 % | 0.0 % | 0.0 % | 21.9 % | 33.0 % | 8.1 % |
| Total | 100 % | 100 % | 100 % | 100 % | 100 % | 100 % |
| ***Financial support as a percentage of total gross investment*** (*average in* 2014-2016) | | | | | | |
| Investment subsidies in the reporting year | 11 % | 13 % | 8 % | 18 % | 18 % | 9 % |
| Investment subsidies | 12 % | 16 % | 5 % | 17 % | 10 % | 3 % |

In the future, based on the projections of the area under crops and the number of livestock, the aggregate value of fixed assets in the agriculture of Latvia is projected to increase, reaching EUR 2274 mln. in 2030 and EUR 3097 mln. in 2050, which are increases by 46 % and 100 %, respectively (Fig. 1).

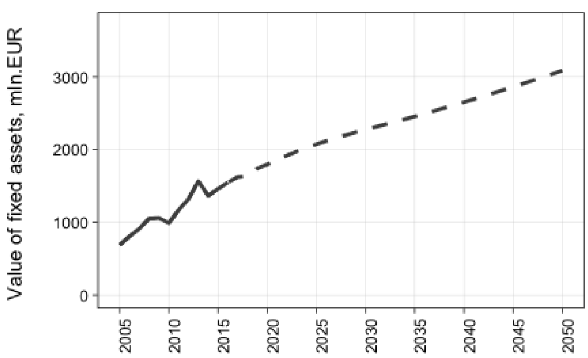


Fig. 1. **Aggregate value of agricultural fixed assets in period 2005-2016 and projection of it in Latvia for period 2017-2050, mln. EUR [14; 15]**

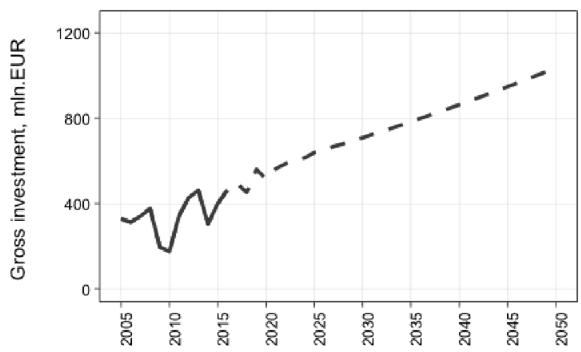


Fig. 2. **Aggregate gross investment in agriculture in 2005-2016 and projection of it in Latvia for period 2017-2050, mln. EUR [14; 15]**

In view of the aggregate value of fixed assets (determined as a function of agricultural output and farm consolidation), and fixed asset depreciation, the research estimated the need for the potential aggregate amount of investment in the agriculture of Latvia. In the period 2005-2016, the annual aggregate amount of gross investment in the agriculture of Latvia ranged from EUR 176 mln. in 2010 to EUR 463 mln. in 2016 and EUR 462 mln. in 2013, which determined the aggregate value of fixed assets at the end of the year (Fig.1). The highest annual rate of increase in the aggregate amount of gross investment was reported in 2015 at 31 %, whereas the lowest rate was reported in 2009, when it was only 52 % of the 2008 level, which was due to the global financial crisis. In the period 2005-2016, the annual aggregate amount of gross investment increased by 41 % (from EUR 329 mln. to EUR 463 mln.). According to the projections, the annual aggregate amount of gross investment needed for the agriculture of Latvia is expected to equal EUR 708 mln. in 2030, increasing to EUR 1040 mln. by 2050, which represent 53 % and 128 % increases, compared with 2016. This means that the aggregate amount of investment has to increase at a slightly higher rate in order to reach the necessary aggregate value of fixed assets at the end of the year.

## Conclusions

Successful agricultural development requires investments and a certain amount of fixed assets in order to perform technological operations within the best period from the agricultural and technological perspective and at high quality, which is a basis for achieving the projected crop yields and agricultural output levels. In the period 2005-2016, an annual aggregate amount of gross investment in the agriculture of Latvia was, on average, EUR 344 mln., totalling EUR 4.1 bln. over the entire period. In the result, the aggregate value of agricultural fixed assets rose to EUR 1.5 bln. in 2016. The annual aggregate amount of the gross investment needed for the agriculture of Latvia is projected to increase to EUR 708 mln. in 2030 and EUR 1040 mln. in 2050, which represent 53 % and 128 % increases, compared with 2016. In the result, the aggregate value of agricultural fixed assets in Latvia is projected to increase to EUR 2.3 bln. in 2030 and EUR 3.1 bln. in 2050.

## Acknowledgements

The research was promoted with the support of the project of the Ministry of Agriculture of the Republic of Latvia “Forecasting of Agricultural Development and the Designing of Scenarios for Policies until 2050”, agreement No. 18-100-INV18-5-000001.

## References

[1] Qi A., Murray P.J., Richtera G.M. Modelling productivity and resource use efficiency for grassland ecosystems in the UK. European Journal of Agronomy, vol. 89, September 2017, pp. 148-158. Available at: https://doi.org/10.1016/j.eja.2017.05.002.

[2] Alderman Ph.D., Stanfill Br. Quantifying model-structure- and parameter-driven uncertainties in spring wheat phenology prediction with Bayesian analysis. Available at: https://doi.org/10.1016/j.eja.2016.09.016.

[3] Nkurunziza L., Chongtham I.R., Watson Cr.A., Marstorp H., Öborn I., Bergkvist G., Bengtsson J. Understanding effects of multiple farm management practices on barley performance. European Journal of Agronomy, vol. 90, 2017, pp. 43-52. Available at: https://doi.org/10.1016/j.eja.2017.07.003.

[4] Whitcraft A., Jarvis I., Rembold F., Baruth B. Summary of the GEOGLAM Workshop on Data and Systems Requirements for Operational Agricultural Monitoring. Publications Office of the European Union, Luxembourg, 2018. Available at: doi:10.2760/31351.

[5] Fritz St., See L., Carlos J., Bayas L., Waldner Fr., Jacques D., Becker-Reshef I., Whitcraft A., Baruth B., Bonifacio R., Crutchfield J., Rembold F., Rojas O., Schucknecht A., Van der Velde M., Verdin J., Wu B., Yan N., You L., McCallum I. A comparison of global agricultural monitoring systems and current gaps. Agricultural Systems, vol. 168, January 2019, pp. 258-272. Available at: https://doi.org/10.1016/j.agsy.2018.05.010.

[6] Ceglar A., Van der Wijngaart R., De Wit A., Lecerf R., Boogaard H., Seguini L., Van den Berg M., Toreti A., Zampieri M., Fumagalli D., Baruth B. Improving WOFOST model to simulate winter wheat phenology in Europe: Evaluation and effects on yield. Agricultural Systems, vol. 168, January 2019, pp. 168-180. https://doi.org/10.1016/j.agsy.2018.05.002.

[7] Toreti A., Maiorano A., De Sanctis G., Webber H., Ruane A.C., Fumagalli D., Ceglar A., Niemeyer S., Zampieri M. Using reanalysis in crop monitoring and forecasting systems. Agricultural Systems, vol. 168, January 2019, pp. 144-153. https://doi.org/10.1016/j.agsy.2018.07.001.

[8] Committee on World Food Security. Principles for Responsible Investment in Agriculture and Food Systems. October 15th, 2014, 32 p.

[9] OECD. Policy Framework for Investment in Agriculture. March 2013, 40 p.

[10] Cicea C., Subić J., Turlea C. Specific Economic Efficiency Indicators of Investments in Agriculture. Journal Central European Agriculture, vol. 11 (2010), No. 3, pp. 255-264.

[11] Nipers A., Pilvere I., Zeverte-Rivza S., Krievina A. Use of Econometric Model for Developing an Outlook for Livestock Sector in Latvia In: 16th International Scientific Conference “Engineering

for Rural Development": Proceedings, May 24-26, 2017, vol. 16, Jelgava, Latvia, pp. 874-883. [online] [20.12.2018] Available at: DOI: 10.22616/ERDev2017.16.N176.

[12] Nipers A., Pilvere I., Zeverte-Rivza S. Projections for the Latvian Dairy and Beef Sector. In: 16th International Scientific Conference "Engineering for Rural Development": Proceedings, May 24-26, 2017, vol. 16, Jelgava, Latvia, pp. 546-554. [online] [18.12.2018] Available at: DOI: 10.22616/ERDev2017.

[13] Nipers A., Pilvere I., Zeverte-Rivza S., Upite I., Krievina A. Projections for the Latvian Cereal Sector. In: 17th International Multidisciplinary Scientific GeoConference SGEM 2017, Vienna GREEN Conference Proceedings, 27-29 November, 2017, vol. 17, issue 63, pp. 309-318; [online] [22.12.2018]. Available at: DOI: 10.5593/sgem2017H/63/S25.040.

[14] Zinātniskā pētījuma Lauksaimniecības attīstības prognozēšana un politikas scenāriju izstrāde līdz 2050. gadam projekta atskaite (Report on the Project Forecasting of Agricultural Development and the Designing of Scenarios for Policies until 2050). Jelgava: Latvia University of Agriculture, December 2018, 149 p. (in Latvian).

[15] SUDAT datu bāze (FADN database). Unpublished resource. (In Latvian).