ANALYSIS OF REMOTE SENSING DATA FOR DETERMINATION OF SPATIAL CHANGES IN ORCHARDS

Mg.sc.ing. Vita Celmina [1]
Dr.oec. Vivita Pukite [2]
[1, 2] Latvia University of Life Sciences and Technologies, Latvia

ABSTRACT

Aim of the paper is to explore the application possibilities of remote sensing data for determination of spatial changes in orchards from 1995 to 2019.

In Latvia, many fruit-growing companies have been established around the turn of the century and today have established a solid production base. Although many farms achieve good yields, the average level of productivity in orchards is insufficient. Often the yields are different in the same garden in different places. Remote sensing technology provides tree crown size data. Evaluating garden data would identify sectors with lower increments. When you see specific sectors on the map, they will be surveyed by gardeners looking for factors that have influenced tree growth (soil nutrient content, moisture content, abundant fruit yield, etc.). As a result, average productivity may increase by at least 10%, but in the longer term (5-6 years) by 20-30%

Using Latvian Geospatial Information Agency's available orthophoto and digital surface model (DSM) data, were examined three land units - orchards, where the spatial changes could be observed. The spatial changes can be observed over a longer period of time, therefore there were compared several orthophoto maps, each taken in different period of time. This study is an initial analysis of the data to determine the spatial changes. Future research will further investigate orchards with aerial laser scanning to determine accurate tree crown volumes and develop digital surface models.

Keywords: *ortophoto, spatial changes, orchards, calculation of revenue*

INTRODUCTION

In Latvia, many fruit-growing companies have been established around the turn of the century and today have established a solid production base. Although many farms achieve good yields, the average level of productivity in orchards is insufficient. Often the yields are different in the same garden in different places. One reason is the heterogeneity of soil and terrain within a single field. Increased yields are more effective if appropriate measures are taken in well-targeted garden sectors where productivity is below average. It is difficult to objectively identify these sectors in an orchard - this can be done by listing the yields for each tree individually, but it is very laborious and needs to be done in a very short time. The vegetative growth of trees is a good indicator of the state of health of trees, of their growing conditions in general, and also shows the potential for productivity. The vegetative height can be assessed visually, but such an assessment is subjective. The

garden's visual judgment is further complicated by the fact that the trees are taller than humans and can only be compared in rows. Remote sensing technology provides tree crown size data. Repeated measurements would show an increase in shoots over some time. Evaluating garden data would identify sectors with lower increments. When you see specific sectors on the map, they will be surveyed by gardeners looking for factors that have influenced tree growth (soil nutrient content, moisture content, abundant fruit yield, etc.). An additional purpose is to obtain data on tree crown thickness and total crown volume. This data will be used to evaluate the effectiveness of tree-making work, to adjust harvest protection dose calculations. As a result, average productivity may increase by at least 10%, but in the longer term (5-6 years) by 20-30%

It is not possible to obtain precise data on what part of the area of the gardens is considered to be under-productivity sectors. According to the statistics, the total apple production in Latvia is 8 000-10 000 t, if the yield is increased by 5%, it amounts to 400-500 t or 160 000-200 000 EUR per year. [1]; [4]

This study is an initial analysis of the data to determine the current situation. Future research will further investigate orchards with aerial laser scanning method to determine accurate tree crown volumes and develop digital surface models.

Aim of the paper is to explore the application possibilities of remote sensing data for determination of spatial changes in orchards from 1995 to 2019. To achieve the aim, the following tasks were set:

- gather remote sensing data;
- process the obtained data;
- use the obtained results for determination of spatial changes;
- calculate the revenue of orchards

MATERIALS AND METHODS

In result of previous studies [2]; [5] were developed scheme - use of remote sensing data.

Use of remote sensing data could be divided in 4 stages:

1. Remote sensing data gathering. If it is necessary to obtain data about the object from the distance, you may use the available satellite images or orthophoto maps. Carrying out remote sensing by aerial photography were used the Latvian Geospatial Information Agency orthophoto, scale of 1:10 000, which are freely available at the website of Latvian Geospatial Information Agency. In Latvia orthophoto maps are prepared in Latvia Coordinate System LKS-92 TM in accordance with the TKS-93 division of map sheets (scale 1:10 000 map sheet complies with the 5x5 kilometers in nature). For the entire territory of Latvia the orthophoto maps are completed in TIFF format, scale 1:10 000 [3].

2. Processing of obtained orthophoto and satellite images. Orthophoto can be processed in computer programs: Microstation, SAGA, GRASS, Quantum GIS, Open JUMP, ILVIS Open and Photomod. In this research orthophoto were processed in Microstation software.

3. Data accumulation and storage. For this research data are accumulated on Latvia University of Life Sciences and Technologies GIS competences center server. It is possible to include this information in Territorial Development Planning Information System.

4. Use of data. After data processing, are obtained thematic maps or data of interest for a particular area. These data may be used by the real estate - orchard owners.

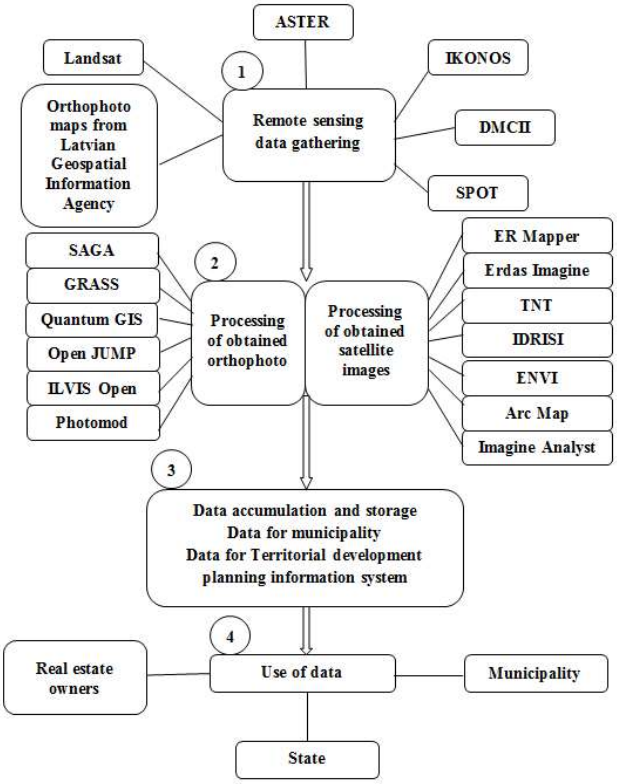

Fig.1. Use of remote sensing data.

RESULTS AND DISCUSSION

Using Latvian Geospatial Information Agency's available orthophoto and LIDAR data, were examined land units – orchards. Spatial changes in these land units can be observed over a longer period of time. Therefore, there were compared several orthophoto maps and digital surface model (DSM), each taken in different period of time. In orthophoto maps the best could see the spatial changes.

The first of the objects located in Broceni municipality, Blidene municipality rural territory (56°38′ N (B); 22°43′ E (L)). In Figure 2 can be seen orthophoto from the location. In first two orthophotos which were taken in period from 1994 to 2005 visible area is used for agriculture purposes as arable land. Situation start to change

in third a orthophoto, which were taken on June 7, 2007, where is visible that in part of this area the fruit garden – apple trees are planted. In the next three orthophoto shows almost the same situation. In last orthophoto, taken in June 3, 2019, can be seen that orchard - apple tree garden is expanding.

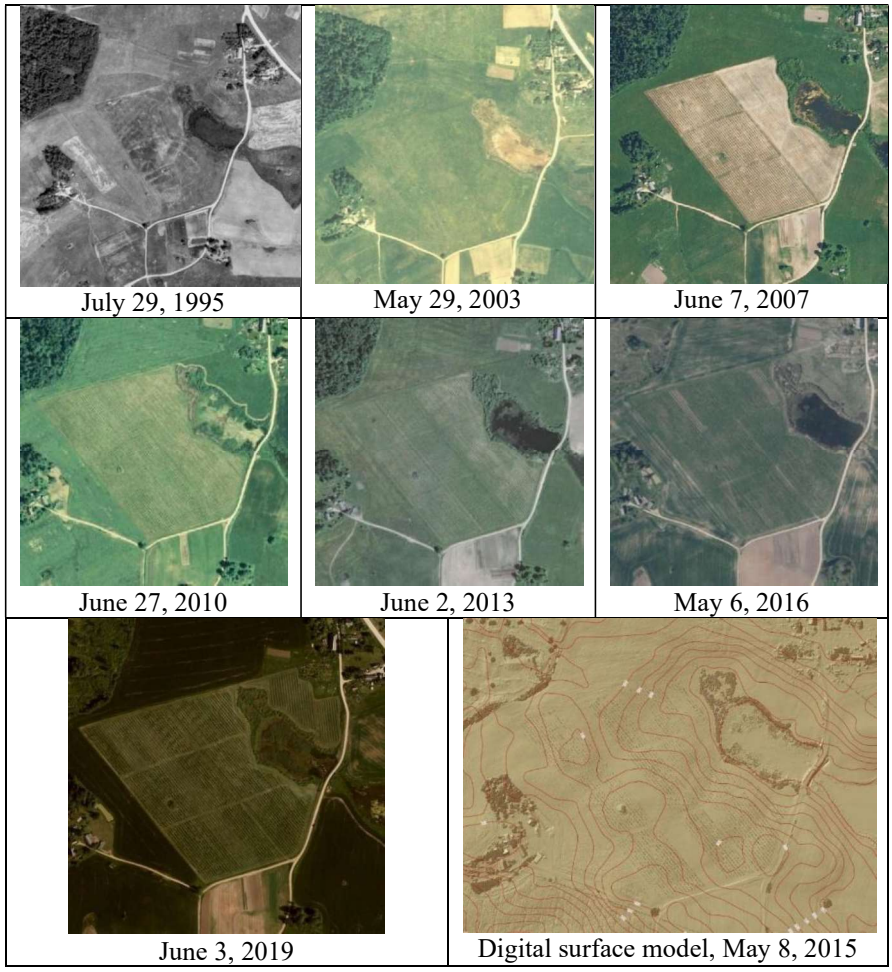

Fig.2. Orthophotos and digital sutface model from orchard in Blidene municipality rural territory.

Analyzing the orthophoto data, it can be seen that the apple orchard started to form around 2007, the initial area was about 5 ha. Already from 2010 the orthophoto shows that the orchard has been expanded by 2,8 ha, the total occupied by 7,8 ha and in 2019 orthophoto shows that the orchard has been expanded by another 0,7 ha, bringing the total area to 8,5 ha.

Orthophoto shows that in some apple garden areas are the places where within the boundaries of the garden, there are sectors with smaller increases in harvesting levels.

When you look at specific sectors on the map, they will be surveyed by gardeners looking for factors that affect tree growth (nutrient content, moisture content, rich fruit yield, etc.). Improving tree growth parameters can also predict productivity growth. As a result, average productivity may increase by at least 10%, but in the longer term (5-6 years) by 20-30%

Improving productivity can be expected to increase revenue. Using the Latvian Rural Advisory and Training Center's Calculation of the Gross Agricultural Coverage [4], the revenue from the field was calculated.

Table 1 The calculation of revenue of orchard in Blidene municipality rural territory

	Field area, ha	Productivity t/ha	Price EUR/t	Sum, EUR	10 % predicted increase	25 % predicted increase
Apples	8,5	10	400	34 000	37 400	42 500
Apples for juice	8,5	4	100	3 400	3 740	4 250
Sum:				37 400	41 140	46 750

The table shows that the revenue from the orchard is currently EUR 37 400, but if the increase is 10 %, the revenue would be EUR 41 140, but in longer - term (after 5 to 6 years) increase could be 25 %, that is EUR 46 750.

The second object is located in Jelgava municipality, Vilce municipality rural territory (56°26′ N (B); 23°29′ E (L)). In Figure 3 can be seen orthophotos from the location.

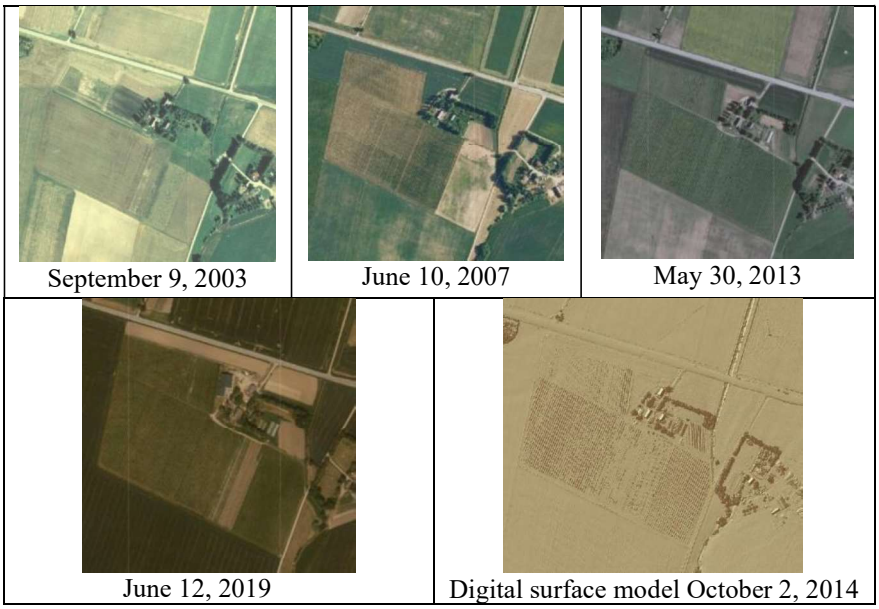

Fig.3. Orthophotos from apple tree garden in Vilce municipality rural territory.

Analysis of the orthophoto data shows that the area was arable land in 2000. Around 2007 apple trees were planted on an area of 9,5 ha. Orthophoto shows that by 2013, the apple tree garden was expanded by another 2,1 ha, bringing the total area to 11.6 ha. By the year 2019, the situation is changed a little bit. It can be seen in orthophoto that there are some places where the orchard area is increased and at the moment the total area of the orchard is 10,7 ha. As can be seen from the orthophoto from 2019, some areas of the orchard show areas with lower harvesting levels within the garden borders. Also for this orchard, the harvest from the orchard was calculated (Table 2).

Table 2 The calculation of revenue of orchard in Vilce municipality rural territory

	Field area, ha	Productivity t/ha	Price EUR/t	Sum, EUR	10 % predicted increase	25 % predicted increase
Apples	10,7	10	400	42 800	47 080	53 500
Apples for juice	10,7	4	100	4 280	4 708	5 350
Sum:				47 080	51 788	58 850

The table shows that the revenue from the orchard is currently EUR 47 080, but if the increase is 10 %, the revenue would be EUR 51 788, but in longer - term (after 5 to 6 years) increase could be 25 %, it would be EUR 58 850.

The third object is located in Tukums municipality, Pure municipality rural territory (57°2′ N (B); 22°52′ E (L)). In Figure 4 can be seen orthophotos from the location.

June 29, 1994

June 4, 2007

May 11, 2016

June 4, 2019 | Digital surface model, May 28, 2016

Fig.4. Orthophotos from orchard in Pure municipality rural territory.

Analysis of the orthophoto data shows that this area was arable land in 1994. Around 2007 apple trees were planted on 3,3 ha. Orthophoto shows that by 2016 the apple orchard was expanded by another 2,1 ha, bringing the total area to 5,4 ha.

And as seen in the orthophoto of 2019, the apple orchard was further expanded, bringing the total area to 8 ha. Gross Coverage Calculates that the respective harvest per hectare is obtained for the orchard, from 4 to 20 years. The table below shows the profit that will be made when the newly planted apple trees reach their production period – at least 4 years.

Table 3. The calculation of revenue of orchard in Pure municipality rural territory

	Field area, ha	Productivity t/ha	Price EUR/t	Sum, EUR	10 % predicted increase	25% predicted increase
Apples	8	10	400	32 000	35 200	40 000
Apples for juice	8	4	100	3 200	3 520	4 000
Sum:				35 200	38 720	44 000

The table shows that the revenue from the orchard is EUR 35 200, but if the increase is 10 %, the revenue would be EUR 38 720, but in longer - term (after 5 to 6 years) increase could be 25 %, it would be EUR 44 000.

CONCLUSION

The spatial changes can be observed over a longer period of time, therefore for this research were compared orthophoto maps and digital surface model (DSM), each taken in different period of time (from 1995 to 2019).

Analysing orthophotos of orchards in Blidene municipality rural territory, Vilce municipality rural territory and Pure municipality rural territory, they show that in some apple garden areas are the places were within the boundaries of the garden, there are sectors with smaller increases in harvesting levels. When you look at specific sectors on the map, they will be surveyed by gardeners looking for factors

that affect tree growth (nutrient content, moisture content, rich fruit yield, etc.). Improving tree growth parameters can also predict productivity growth. As a result, average productivity may increase by at least 10%, but in the longer term (5-6 years) by 20-30%.

Calculating the revenue of orchards, actual data were taken from Latvian Rural Advisory and Training Centre. For the purpose of research were taken the Calculation of the Gross Agricultural Coverage and also calculated revenue if the productivity would increase by 10% and in longer time average by 25%.

REFERENCES

[1] Latvian State Institute of Fruit-Growing Lauksaimniecības zemes izmantošanas efektivitātes un iespēju novērtējums (Agricultural land use efficiency and feasibility studies). (in Latvian) (2012) Available: http://www.lvm.lv/images/lvm/Atskaite_zemesefekt_LVM_2012_1.pdf

[2] Baumane V., Cintina V., Lapina A. Application of remote sensing data in determination of land degradation. Применение данных дистанционного зондирования для определния деградации земель. Сучасні досягнення геодезичної науки та виробництва: Збірник наукових праць Західного геодезичного товариства УТГК. Львів, 2016. Вип. 1(31), с. 115-121 ISSN 1819-1339.

[3] Latvijas Ģeotelpiskās informācijas aģentūras mājas lapa (Latvian Geospatial Information Agency). Available: http://map.lgia.gov.lv/index.php?lang=0&cPath=4&txt_id=88

[4] Latvian Rural Advisory and Training Centre, Calculation of the Gross Agricultural Coverage http://new.llkc.lv/lv/nozares/ekonomika/bruto-segumi

[5] Cintina V., Pukite V. (2018) Analysis of orthophoto maps and cadastre data for determination of spatial changes in Latvia. 18th International multidisciplinary scientific GeoConference SGEM 2018 : conference proceedings, Albena, Bulgaria, 2 - 8 July, 2018 / Bulgarian Academy of Sciences. Sofia, 2018. Vol. 18 : Informatics, geoinformatics and remote sensing; Issue 2.2 : Geoinformatics Geodesy and mine surveying, p.599-606. DOI: 10.5593/sgem2018/2.2/S09.075