POSSIBILITIES OF APPLICATION OF ORTHOPHOTO MAPS IN DETERMINATION OF LAND DEGRADATION

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Abstract
Aim of the paper is to explore the possibilities of application of orthophoto maps in determination of land degradation. One of the forms of remote sensing is aerial photography. Orthophoto maps are made from aerial photography with specialized software orthophoto maps were analysed in perspective for several years – from 2005 to 2011.The results are based on the expert. With each year possibilities of application of orthophoto maps are expanding. During the research, data of survey and SWOT analysis of determination of land degradation by orthophoto maps. The study results prove that based on orthophoto maps mainly, it can be detected the following land degradation processes – agricultural land overgrowing with bushes and abandonment of built-up areas.
Key words: remote sensing, orthophoto, land degradation.

Introduction

In recent years, increasing attention is being paid to sustainable land use issues. Not only in the world, but also in Latvia the land degradation processes – water and wind erosion, coastal erosion, bogging of ameliorate areas, agricultural land overgrown with bushes and landscape depletion is taking place.

In Latvia, according to the State Land Service data, 19.2% of agricultural land, including ameliorate lands, currently is not used, and they are gradually overgrown with weeds and bushes; therefore, the process of land degradation has already begun.

The solution of land degradation detection and reduction is to take a set of several important activities in order to successfully combat land degradation, which is already starting to develop or have already developed. It is very important to identify the type of land degradation and provide the appropriate solution for a particular type of degradation. Since each type of land degradation manifests its own specificities, it is important to choose the most appropriate way to determine which one would be more effective in a given situation.

This article highlights the remote sensing method – research of orthophoto maps, which is the best way to determine agricultural land overgrowing with bushes.

Application of remote sensing data for determination of land degradation can be divided into 4 stages (Lapina & Baumane, 2015):

- collection of remote sensing data;
- processing of obtained orthophoto maps;
- data accumulation and storage;
- use of data.

Aim of the paper is to explore the possibilities of application of orthophoto maps in determination of land degradation. To achieve the aim, the following tasks were set:

- to analyse data of orthophoto maps in perspective for several years;
- perform SWOT analysis of determination of land degradation by orthophoto maps;
- to carry out the expert survey analysis

Materials and Methods

One of the forms of remote sensing is aerial photography. Aerial photography can be performed, for example, from aircraft, a remotely controlled model aircraft, helicopter and others. Most appropriate time for aerial photography is usually spring, between snow melting and leaf unfolding, and when the sun is high enough, there are no clouds; the ground surface is transparent (Baumane, Cintina, & Tabynbaeva, 2014).

Orthophoto maps are made from aerial photography with specialized software.

For the research, the Latvian Geospatial Information Agency orthophoto, scale of 1:10 000, which is freely available at the website of Latvian Geospatial Information Agency was used.

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 (Aerofotografēšana un ortofotokartes, b.g.).

Photogrammetry is often used in the context of remote sensing and the world has known the following definition (adopted in ISPRS conference in 1996) – photogrammetry is art, science and technology of obtaining reliable information about the Earth, its environment and other physical objects and processes, making data acquisition with a non-contact images and other sensor systems, their measurement analysis and representation.

In many countries, as well as in Latvia, since 1960 photogrammetry, which makes it possible to obtain visual and geometric information, has been very effectively used. Nowadays, due to evolving

technology and surface acquisition algorithms, there is an opportunity to work with acquisition of the surface geometry by the surface scanning and acquisition of point group from photographs. This method makes it possible to build a three dimensional object model and visualize objects with images, distinguishing surface from a few millimeters to microns.

Experience has shown that the use of GIS and analysis of aerial photographs and large-scale topographic maps obtained in different years can determine the changes of land use configuration; thus, it is possible to calculate their size and trends over time. Based on the facts, development of land-use path can be predicted. Furthermore, recommendations for spatial management (Barkāns, Lazdāns, & Orols, 2008) can be developed.

Researching the possibilities of application of orthophoto maps in determination of land degradation, Latvian Geospatial Information Agency overview map orthophoto images from 2005 to 2008 with orthophoto images from 2010 to 2011 were compared.

This study was conducted by using remote sensing method for determination of degraded lands.

Results and Discussion

Smarde municipality rural territory, which is located in Engure municipality (Figure 1), was selected as the research area. Engure municipality, on the coast of the Baltic Sea, is a local government in Zemgale, which was established at the time of the administrative and territorial reform. Engure municipality is characterized by one of the longest sea borders among all regions of Latvia – 56km.

Figure 1. Geographic location of Engure municipality.

For determination of land degradation in Smarde municipality rural territory, the Latvian Geospatial Information Agency's Map Browser (LĢIA karšu pārlūks, b.g.) was used. Orthophoto maps are in scale 1:10 000 (0.5 m/pix, colourful).

In Smarde municipality rural territory, three degraded territories (research objects) in which clearly visible degradation – agricultural land overgrowing with bushes and abandonment of built-up areas in Tukums airport territory is clearly visible, were assessed.

Figure 2. First research object orthophoto image, years 2005 – 2008.

Figure 3. First research object orthophoto image, years 2010 – 2011.

Comparing the first research object orthophoto images (Figure 2, Figure 3) from 2005 – 2008 and 2010 – 2011, land degradation in the form of agricultural land overgrowing with bushes can be observed.

Figure 4. Second research object orthophoto image, years 2005 – 2008.

Figure 5. Second research object orthophoto image, years 2010 – 2011.

Comparing the second research object orthophoto images (Figure 4, Figure 5) from 2005 – 2008 and 2010 – 2011, land degradation in the form of agricultural land overgrowing with bushes and cutting of forest land can be observed.

Comparing the third research object orthophoto images from 2005 – 2008 and 2010 – 2011, land degradation in the form of abandonment of built-up areas in Tukums airport territory can be observed.

Figure 6. Third research object orthophoto image, years 2005 – 2008.

Figure 7. Third research object orthophoto image, years 2010 – 2011.

Comparing these three degraded territories in Smarde municipality rural territory in the period from 2005 to 2011, it can be seen that land degradation had already taken place in such a short period of time. Using the following definition and scale (Scale 1:10000) orthophoto can already determine the impact of degradation in a relatively easy way, of course, the accuracy of such a scale and resolution orthophoto is not high, it could be said it is even low. However, such resolution orthophoto fulfils its function in the prevention of land degradation and using smaller scale, such as: 1:5000 or 1:2000 could achieve quite acceptable accuracy – up to 20 cm ('Metrum' veicis apbūves..., b.g.).

In Latvia, the company 'Metrum' has produced orthophoto with such a high resolution. Land surveying and territorial planning company 'Metrum', by using the company's aircraft and special aerial photography equipment, has made flights over the Gulf of Riga and the Baltic Sea coastal zone in territory of Latvia, identifying volumes of shoreline erosion and housing development in 300 meters dune protection zone.

Within the frame of the project, aerophoto images of coastline in length of 500 km and width from 500 to 1000 meters, from Lithuanian border to Estonian border have been obtained. By using aerophoto images, the orthophoto map of coastal areas in scale 1:2000 with a spatial resolution – 20 cm in nature was created. These are the most accurately obtained cartographic data by scale and quality up to this date about coastal area of Latvia. Previous orthophoto maps were in scale 1:10000 ('Metrum' veicis apbūves..., b.g.).

Newly acquired orthophoto materials were compared with the Latvian Geospatial Information Agency 2003–2005 orthophoto data. These data suggests that during last years around 65% of the total length of the Baltic Sea coastal zone in the territory of Latvia is affected by erosion in varying degrees. The main coastal erosion risk areas are in Limbazi, Tukums, Talsi, Ventspils and Liepaja municipality as well as Jurmala. There are places where coastal zone erosion in 3-4 years has washed away about 20 to 30 meters.

Coastal area orthophoto materials developed by 'Metrum' are applicable for development of spatial plan, for clarification of real property boundaries and protection zones, for economic activities, for example, construction or road infrastructure development monitoring. These data are applicable also for management of protected areas, monitoring of economic activity in the coastal zone, port development planning.

At the same time, also the laser scanning data in the form of point cloud are acquired that characterize the measured territory – land, trees, buildings. This information could be used to determine the amount of erosion, as well as for 3D modelling of territory. Obtained cartographic information could be used for the development of tourism and planning of infrastructure in the areas where there is an active vacationers flow (such as dune strip along the Talsi highway), as well as for control of the impact of

Table 1

SWOT analysis of application of orthophoto maps in determination of land degradation

Strengths	Weaknesses
• possibility to make observations over wide areas; • possibility to assess quickly the degraded territories; • available high-definition photo scenes; • no need to be located in area; • regular monitoring of degraded territories	• lack of experts; • changing situation in nature; • expensive hardware; • short period of time to carry out aerophotography; • impact of bad weather
Opportunities	**Threats**
• studies could promote exploration of degraded territories; • qualitative data extraction; • technological development; • could reduce the generation of degradation; • public funding for land degradation monitoring	• impact of national policy; • legislative changes; • impact of the economic situation; • innovations of information technology; • variable funding

human activity on coastal nature (‘Metrum’ veicis apbūves..., b.g.).

Services – aerial images, orthophoto maps, topographical plans and 3D models using the company’s specially equipped airplane PC-6, have been offered by ‘Metrum’ since 2007.

Currently, using aerial photography and laser scanning, ‘Metrum’ develops appropriate materials for specific needs, which could be applied for geospatial task solving in planning of territorial development, in research and development of communications, infrastructure and building solutions, as well as in disaster forecasting and liquidation, and other areas.

Researching the application of orthophoto maps in determination of land degradation, the Latvian Geospatial Information Agency orthophoto images from 2005 – 2008 and 2010 – 2011 were compared and SWOT analysis for application of orthophoto maps in determination of land degradation was carried out.

SWOT analysis is a method by which strengths and weaknesses are identified, as well as the existing opportunities or future threats for application of orthophoto maps in determination of land degradation (Table 1).

When all four critical elements of information are identified, based on them, application of orthophoto maps in determination of land degradation – the planned strategy for achieving the objectives can be implemented.

The main task of SWOT analysis is to split the available information to internal (strengths and weaknesses) and external (opportunities and threats) factors. When this work is done, the results of SWOT analysis show which factors (strengths and opportunities) can contribute to achieving the strategic objectives and which factors (weaknesses and threats) is an obstacle and which effects should be overcome or reduced (SVID analīze, b.g.).

Table 1 summarizes the SWOT analysis factors – strengths, weaknesses, opportunities and threats. In each section, there are five factors that affect every section.

After the creation of SWOT analysis, survey, which was performed experts from Latvia University of Agriculture was developed. In the survey, assessment of the importance of each factor (1 – insignificant, 5 – very important) was asked. The compiled survey data are shown in the diagrams.

Figure 8 featuring the results of SWOT analysis survey on the strengths. As it can be seen, the most significant factors of application of orthophoto maps in determination of land degradation is regular monitoring of degraded territories, possible to make observations over wide areas and available high-definition photo scenes; rating by experts – 4. While the factors – possibility to quickly assess the degraded territories, and it does not need to be located in area were evaluated on a scale from 1 to 5 with 3. None of the factors has been evaluated with 5.

Figure 9 features the results of SWOT analysis survey on the weaknesses. As it can be seen, the most significant weakness is lack of experts in the industry, which according to experts rating is rated 4.

While the factors – a short period of time to carry out aerophotography, expensive hardware and impact of bad weather – were rated with mark – 3. Factor – changing situation in nature was rated with mark 2. None of the factors has been evaluated with 5.

Figure 10 features the results of SWOT analysis survey on the opportunities. The most significant factor is that studies could promote exploration of degraded territories – this factor is rated with the mark 5, according to experts. Factors – could reduce the generation of degradation and qualitative data extraction is rated with the mark 4, but factor – technological development is rated with the mark 3.

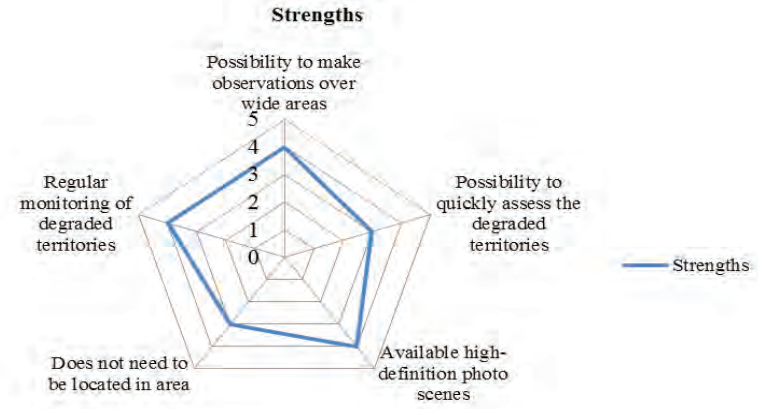

Figure 8. Results of SWOT analysis survey on the strengths.

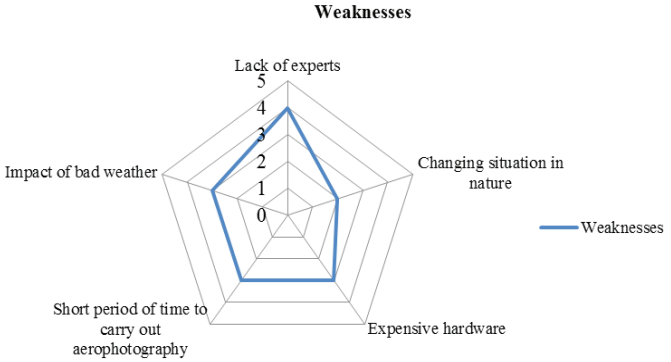

Figure 9. Results of SWOT analysis survey on the weaknesses.

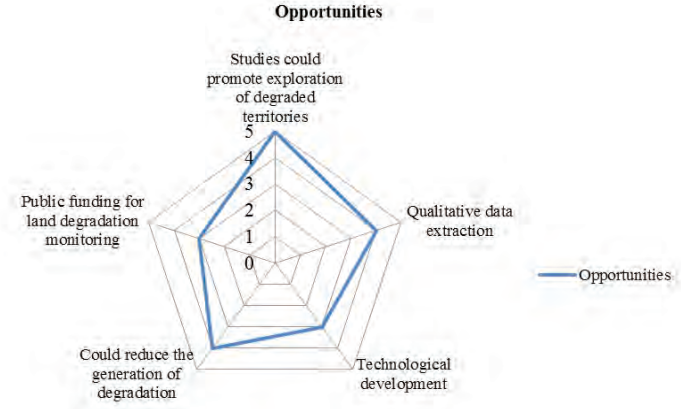

Figure 10. Results of SWOT analysis survey on the opportunities.

Impact of national policy, legislative changes and innovations of information technologies are assessed with the mark 4. Factors – variable funding and impact of the economic situation are assessed with the mark 3. None of the factors has been evaluated with 5.

Application of orthophoto maps in determination of land degradation is an effective method for monitoring of land degradation, and in Latvia it is also possible to use Latvian Geospatial Information Agency's Map Browser high-resolution Orthophoto maps from 1994 to 2015 which allows comparing the changes of degraded territories in 20 years. Of course, the situation changes in nature take place very rapidly and orthophoto materials are required for

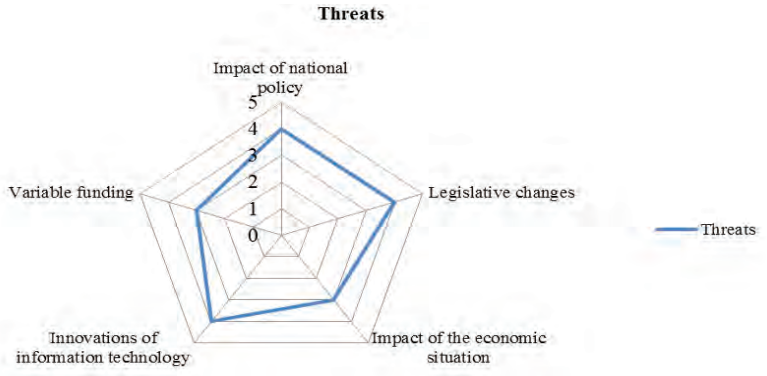

Figure 11. Results of SWOT analysis survey on the threats.

shorter periods of time; therefore, there is a need to take aerophotos in shorter period of time rather than rely on freely available orthophoto maps that can be outdated and no longer entirely fulfil its task – to successfully determine the land degradation.

As the results of SWOT analysis and survey show, orthophoto maps must have high resolution in order to successfully identify land degradation impacts and where it is likely to bring the greatest risks, because sometimes there is a need to book aerophotographs for certain areas with certain requirements and accuracy criteria that increase the costs of this process.

During the study, about 3,000 ha of degraded territories were inspected. For such an area, it is not required to use the aircraft that is designed for taking aerophotos, but it is fully sufficient to use the drone, which fully meets the criteria of orthophoto material definition.

Conclusions

1. To determine the land degradation and its occupied area, as well as to determine how the degraded land has changed over the years, it is possible to use publicly available orthophoto with high level of detail.
2. The study results proved that, based on orthophoto maps of Engure municipality from 2005 to 2011, mainly the following land degradation processes – agricultural land overgrowing with bushes and abandonment of built-up areas can be detected.
3. SWOT analysis proves that application of orthophoto maps in determination of land degradation is an effective method for monitoring land degradation process.

References

1. Barkāns, A., Lazdāns, D., & Orols, A. (2008). Rāznas Nacionālā Parka zemes lietojumu veidu analīze, izmantojot Ģis. (Analysis of Razna National Park types of land use applying GIS.) *LU 66. Zinātniskā konference. Ģeogrāfija. Ģeoloģija. Vides zinātne: Referātu tēzes*. Rīga: Latvijas Universitāte, 2008, 26-27. (in Latvian).
2. Baumane, V., Cintina, V., & Tabynbaeva, L. (2014). World experience in use of remote sensing data for determination of land degradation for conditions of Latvia. *Proceedings of international scientific - methodical conference "Baltic Surveying'14", Jelgava, Latvia, 7-9 of May, 2014* / Aleksandras Stulginskis University. Estonian University of Life Sciences. Latvia University of Agriculture. - Jelgava, 2014. - Vol. 2014, pp. 37-41. ISSN 2243-5999, ISSN 2243-6944 (online).
3. Latvijas Ģeotelpiskās Informācijas aģentūra. (2016). LĢIA karšu pārlūks. (Latvian Geospatial Information Agency Map Browser). Retrieved February 8, 2016, from http://kartes.lgia.gov.lv/.
4. Latvijas Ģeotelpiskās informācijas aģentūra (2008 – 2016). *Aerofotografēšana un ortofotokartes (Aerial photography).* Retrieved January 27, 2016, from http://map.lgia.gov.lv/index.php?lang=0&cPath=4_16&txt_id=23. (in Latvian).
5. Metrum (2010). *'Metrum' veicis apbūves izmaiņu un erozijas apjoma konstatāciju Latvijas teritorijas jūras krasta kāpu aizsargjoslā. ('Metrum' carries out findings of building change and volume of erosion in Latvian territorial sea protected coastal zone)* (in Latvian). Retrieved February 12, 2016, from http://www.metrum.lv/lv/jaunumi---publikacijas/publikacijas/?id=51. (in Latvian).
6. *SVID analīze. (SWOT analysis).* Retrieved February 15, 2016, from http://www.ltp.lv/cd/LV/lv/wso/index.cfm@fuseactionlearnl_id5318pl_id5310.htm. (in Latvian).

7. Лапина, А.С., & Баумане, В.З. (2015). Определение деградации земли в Латвии в муниципалитете Энгуре (Determination of land degradation in Latvia in Engure municipality) /Проблемы геологии и освоения недр*:* труды *XIX* Международного научного симпозиума имени академика М.А. Усова студентов и молодых ученых, Томск, Россия, 6-10 апреля 2015 г./ Министерство образования и науки РФ. Национальный исследовательский Томский политехнический университет. Томск, 2015. Том 1, с. 527-529. (in Russian).