UDK 528.88:631.459
Ba876

APPLICATION OF REMOTE SENSING DATA IN DETERMINATION OF LAND DEGRADATION

V. Baumane, V. Cintina, A. Lapina
Latvia University of Agriculture

Key words: remote sensing, satellite images, 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 is taking place the land degradation processes – water and wind erosion, coastal erosion, bogging of ameliorate areas, agricultural land overgrown with bushes and landscape depletion.

It is important to determine the land degradation and to take measures to prevent it. To carry out land degradation prevention measures, initially should determine the territories of degraded land. These territories can be identified differently – performing field work or performing data analysis. However, with the development of technologies and experience of land degradation assessment methods in the world, one of the most important developments has been use of satellite images and orthophoto maps. Processing satellite images and orthophoto maps with appropriate software, the information is obtained on degraded land areas that serve as a basis for further land degradation limitation and prevention measures for various institutions.

The cause of land degradation could be formation of bushes on agricultural land, coastal erosion, lack of maintenance of drainage systems and land bogging, pollution, landslides, abandonment of built-up areas and the soil degradation. On the other hand, types of soil degradation are: soil erosion, soil compaction, decline of organic matter in the soil, loss of soil biodiversity, decrease of soil pH level and soil pollution [1].

In degraded soils is reduced ability, for example, for biomass production in agriculture, nutrient and water storage, filtration and transformation, as well as reduced ability to maintain biological diversity and other functions.

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

Development of land bogging and wetland areas, including the ameliorated agricultural lands, in recent years is caused by the high precipitation. Drainage systems are no longer able to drain excess moisture, because they are not regularly inspected and maintained [2].

In order to promote sustainable use of land should prevent the causes and consequences of land degradation.

There are several methods to determine land degradation. This paper will focus on remote sensing method, by which it is best to determine agricultural land overgrowing with bushes and land bogging up process.

The most important object of interest of remote sensing is the Earth in general or some parts of it: the Earth surface, atmosphere, physical, natural and economic processes on Earth [3].

Using the remote sensing method often about the object can get the information that cannot be seen with the naked eye.This invisible information can be obtained with electromagnetic radiation, which is registered with a passive sensor. Remote sensing is based on two factors:

– electromagnetic radiation consisting of electromagnetic waves,

– objects and materials ability to reflect, to change the electromagnetic radiation.

Use of remote sensing data for land degradation determination can be divided into 4 stages:

– collection of remote sensing data;

– processing of obtained orthophoto maps and satellite images;

– data accumulation and storage;

– use of data.

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

– to analyze data of satellite images;

– to analyze data of orthophoto maps in perspective for several years;

– use the obtained results for determination of land degradation.

Materials and Methods

One of the remote sensing programs is Landsat, which launched its activities in 1970. Since 1970, remote sensing program Landsat is regularly making satellite images, which allows comparing the scenes over the years and study differences over the time. Its main objective is to build up the stock of Earth's satellite images, independently acquire data, which could be used for science, observing the Earth's surface and environmental change.

Analyzing satellite images it is possible to create different maps, such as soil maps, maps of flood affected areas, maps of urbanized areas, etc.

To use gathered information from satellites, on Earth have established a number of base stations [4]. With high-frequency radio waves the base stations receives the data from the satellites.

Fig. 1. shows all active remote sensing programs Landsat base stations locations on Earth.Visible circles around the base stations shows the approximate area where the station is capable of receiving information from satellite. Landsat satellites completely circle the Earth in every 16 days, spending in orbit 22 minutes, in 24 hours

circling 15 orbits. Satellite images are taken regardless of the weather or other factors [5].

Selecting satellite images for further processing the cloud coverage are essential. Should select as small as possible cloud coverage – 10 %, in satellite images should be distinctly visible surface of the earth.

For determination of land degradation is advisable to choose the summer, because in winter the ground is covered with snow, in spring is possible flooding, which complicates satellite images analysis, therefore for this research was chosen the period from April to August. The size of satellite images or the scan bandwidth is approximately 180×180 km.

All Landsat satellite images consist of seven different bands, each containing a different amount of the electro-magnetic spectrum. During Landsat scene processing, all the bands are combined. On the computer screen can display any color of the three primary colors: red, green and blue. Thus, at the same time in image can be displayed three bands.

Table 1 shows the examples of most frequently used satellite images band combinations.

Another form of remote sensing is aerial photography, where the photography from a height is taken. Aerial photography can be taken, for example, from the aircraft, unmanned remote–controlled aircraft, helicopter, etc. Most appropriate time for aerial photography usually is in spring, between melting of snow and leaf unfolding. When the sun is high enough and there are no clouds, then surface of land is visible.

Orthophoto maps are made from aerial photography with specialized computer programs.

For the research 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 [6].

Results and Discussion

As the research area was selected Engure municipality. Engure municipality is established at the time of the administrative and territorial reform local government in Zemgale, on the coast of Baltic Sea (Fig. 2). Engure municipality is characterized by one of the longest sea borders between all regions of Latvia – 56 km.

To define chosen surface objects: forests, water bodies, agricultural land, swamps, peat and mainly to identify degraded land –formation ofbushes on agricultural land and land bogging up process, should carry out field works. During the field work is necessary to find a plot, which is overgrown with bushes.

For creation of accurate classification must choose at least five plots with as similar futures to each other as possible.The sampling area cannot be less than 200×200 m, because satellite images resolution is 30 m. The sampling areas are required for the similar characteristic area finding in satellite images.

If it is not possible to go to the site, it is recommended to use the reference data, which shall be an amount not less than 10 reference data, in order to accurately reflect the information. In both cases, the quality control should be carried out. After data processing should go to the site and see whether the obtained results coincide with the situation on site.

For the study, as one of the sampling areas was chosen agricultural land in Engures municipality rural territory, which is not treated, it is now overgrown with bushes (Fig. 3).

For the processing of satellite images is used ERDAS Imagine software. The software fully provides the required functionality for the research, software carry out Landsat satellite images spectral band combination, as downoading satellite images each spectral band is in its own file, also it is possible to transform the data to the Latvia Geodetic Coordinate System LKS–92, creating clasification and other features.

After the field work is carried out, the essential of ERDAS Imagine software is based on the images visual analysis replacement the with numerical techniques.

The analysis of multispectral data and/or decision–making based on the reference data for identifying the ground surface for each image pixel is performed. Spatial resolution characterizes the field unit area described by pixel [7].

Pixel or cell is the smallest unit of image – a key element of the picture. It has:

– area – area is determined by pixel edge lengths;

– value – the numerical information, most often it is characterized by a pixel darkness/ lightness level;

– coordinates – describes the pixel location in the image or location in the real world described by pixel.

Spatial resolution is 30×30 m. The aim of classification process is to categorize all digital image pixels in one class.

In Figure 4 is displayed the establishment of the classification sampling area with agricultural land which is overgrown with bushes, in the ERDAS Imagine software (Fig. 4).

Second sampling area was selected in Engure municipality, Smarde municipality rural territory. Sampling area is agricultural land, where failing to maintain the land reclamation system promotes land bogging up process.Figure 5 shows the meadow, where in the result of big humidity begins to grow moisture–loving plants, as well as it can be seen that the water would not soak into the ground and it is not passed to land reclamation systems (Fig. 5).

Following the same principle was established classification sampling area for bog land. In Figure 6 is displayed the establishment ofclassification sampling area for bog land in the ERDAS Imagine software (Fig. 6).

Thematic map, created from satellite images, can also be used as a basis to find objects in terrain. If previously the sampling area is created, than looking at the satellite image specific spectral reflectance range, it can be used to find the object in another place.It is possible to do the classification without going to the field, however, it should be noted that the objects in question should be similar. After sampling area creation, in the satellite image automatically the same color pixels are marked. Therefore, new display layer is created, where it is possible to see agricultural lands, which are overgrown with bushes (Fig. 7).

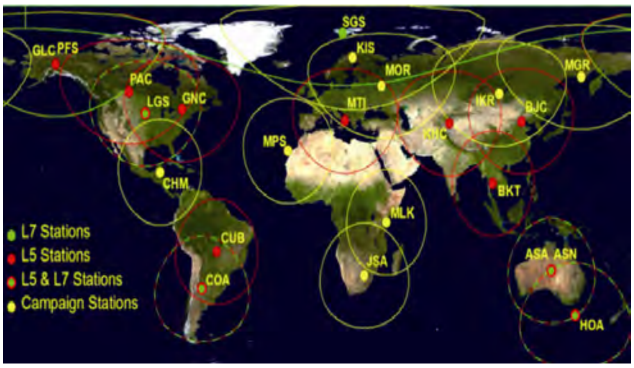
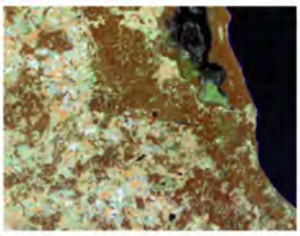


Fig. 1. Remote sensing program Landsat base stations placement on Earth

Table 1

Combinations of remote sensing program Landsat bands

	Satellite images band: 3, 2,1 red, green, blue. These color combinations are close to those obtained from Landsat satellite images. Suitable for the analysis of water habitats. It should be noted that this combination tends to be vague.
	Satellite images band: 4, 3, 2 red, green, blue. Similar characteristics as the band combination 3, 2, 1, but it contains infrared band 4, so the land – water boundary is more marked and you can see different types of vegetation. The vegetation is displayed in red, the water in black or dark blue.
	Satellite images band: 4, 5, 3 red, green, blue. With this band combination possible to better define the different types of vegetation, more distinct could see the land – water line transition. Most suitable combinations for determination of moisture.
	Satellite images band: 7, 4, 2 red, green, blue. This band combination are similar characteristics as the previous band combination 4, 5, 3, but the biggest difference is that the vegetation is displayed in green. This band combination was created by NASA for Landsat global mosaic.
	Satellite images band: 5, 4, 1 red, green, blue. This band combination have similar properties as 7, 4, 2 band combination, but it is more appropriate to depict agricultural vegetation.

For more accurately display of overgrown territories with bushes, disconnecting satellite image layer is obtained only created display layer (Fig. 8).

Analyzing satellite images with vegetation or bog lands should take into account the time when the satellite image is taken (Fig. 9; Fig. 10). For vegetation determination more appropriate time is summer months. For bog land determination often in spring and autumn there is higher moisture content than in summer. Analyzed satellite images is taken in early summer, so there is no very much bugged up lands, perhaps the situation would be different if satellite images would be taken in the spring, during floods.

Using Latvian Geospatial Information Agency's available orthophoto data, were examined few land units, where could be observed the land degradation. The changes of land degradation can be compared over a longer period of time. Therefore there were compared four orthophoto maps, each taken in different period of time. In orthophoto maps the best could see the land degradation type – agricultural land overgrowing with bushes.

Fig. 2. Engure municipality geographic location

Fig. 3. Agricultural land, which is overgrown with bushes (photo from the chosen sampling area)

Fig. 4. Sampling area with agricultural land which is overgrown with bushes, created by ERDAS Imagine software

Fig. 5. Insufficient maintained land reclamation systems

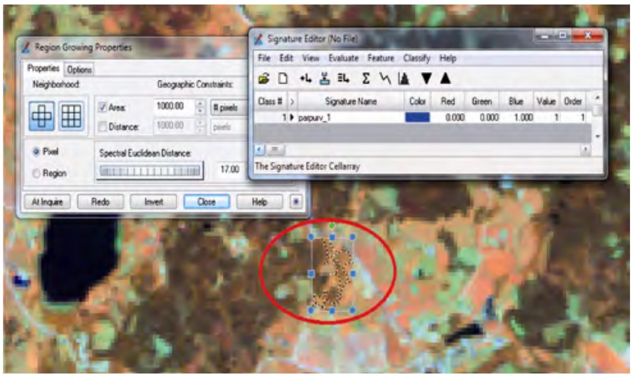
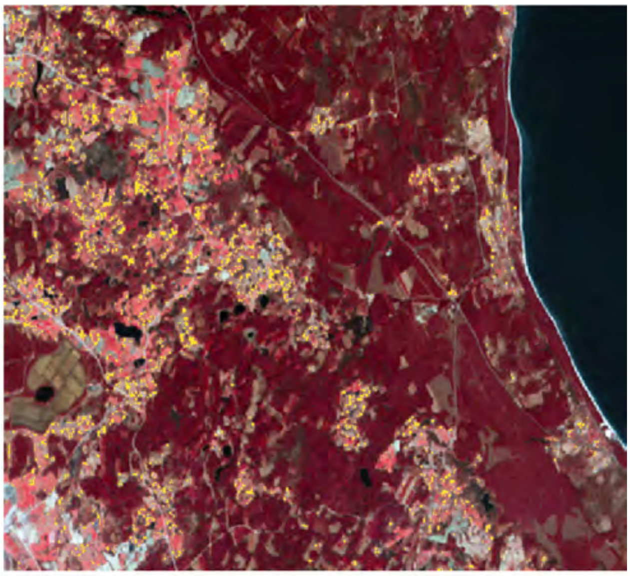
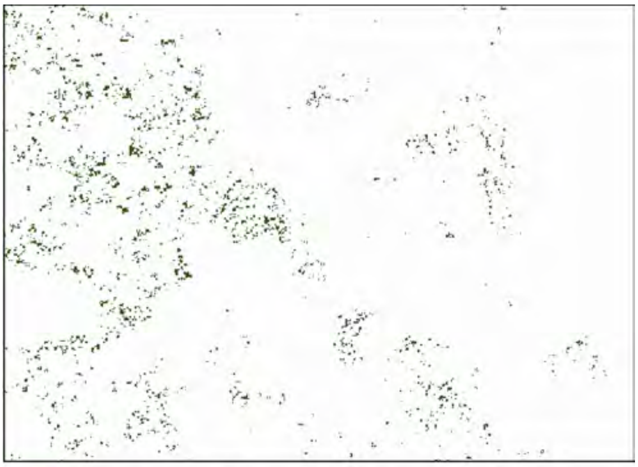


Fig. 6. Sampling area for bog land in the ERDAS Imagine software



– agricultural land, which is overgrown with bushes

Fig. 7. Satellite image with displayed bush areas in ERDAS Imagine software

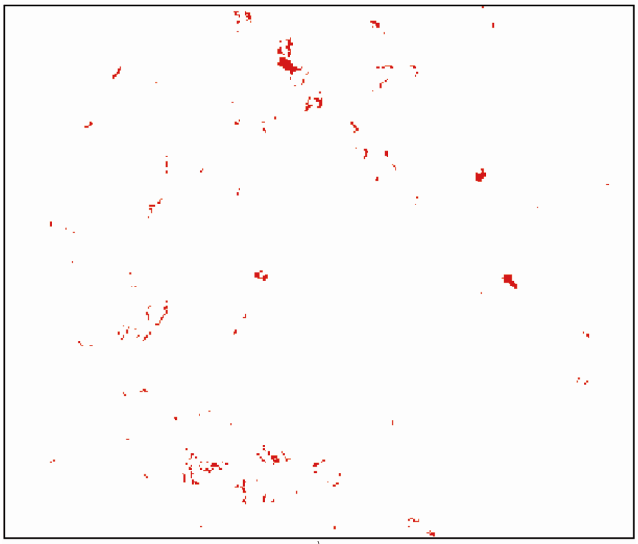


– agricultural land, which is overgrown with bushes

Fig. 8. Bush areas displayed in ERDAS Imagine software

– bog land display layer

Fig. 9. Satellite image with displayed bog lands



– bog land

Fig. 10. Bog lands leyer displayed in ERDAS Imagine software

June 26, 1994

June 4, 2007

June 19, 2011

June 3, 2013

Fig. 11. Aero photos from the first object

June 26, 1994

June 4, 2007

May 18, 2010

June 1, 2013

Fig. 12. Aero photos from the second object

June 26, 1994

June 4, 2007

April 20, 2010

June 3, 2013

Fig. 13. Aero photos from the third object

The first of the objects located in Engure municipality, Smarde municipality rural territorie. In Figure 11 can be seen aero photos from the location (Fig. 11). The first aero photo was taken on June 26, 1994, in the image visible area is used for agriculture and is not overgrown with bushes. Situation changes begin to appear in the second aero photo, which were taken on June 4, 2007, where is visible that there begin to appear small bushes.

The third aero photo, taken on June 19, 2011, clearly shows that the displayed area starts to overgrow with bushes. In the fourth aero photo, taken on June 3, 2013, must see that practically whole area is overgrown with bushes.

The second object is located in Engure municipality (Fig. 12), Engure municipality rural territorie. The first aero photo was taken on June 26, 1994, in the image visible area is used for agriculture and is not overgrown with bushes. The situation remains unchanged in the second aero photo, which were taken on June 4, 2007. In the third aero photo, taken on May 18, 2010, start to begin appear sparsely growing bushes. In the fourth aero photo, taken on June 1, 2013, must see that practically whole area is overgrown with bushes.

The third object is located in Engure municipality, Smarde municipality rural territorie. In Figure 13 is clearly visible signs of land degradation – agricultural land overgrowing with bushes (Fig. 13).

Examining orthophoto maps of these objects clearly can see land degradation signs – agricultural land overgrowing with bushes.

Conclusions

1. Agricultural land overgrowing with bushes and land bogging are major agriculture and environment – related problems.
2. Remote sensing using satellite images is more suitable for regions, where is need to study large areas, but remote sensing using aero photos can be suitable for small territories.
3. It is necessary to regularly accumulate reference data for some period to carry out remote sensing using satellite images.
4. Using orthophoto maps could detect such land degradation type as agricultural land overgrowing with bushes, but using satellite images is possible to detect land degradation types – agricultural land overgrowing with bushes and land bogging up.

References

1. Lapina A., Baumane V. (2015) Определение деградации земли в Латвии в муниципалитете Энгуре / А. С. Лапина, В. З. Баумане // 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
2. LatvijasValstsaugļkopībasinstitūts (2012) Lauksaim niecībaszemesizmantošanasefektivitātesuniespējunov ērtējums. Pieejams: http://www.lvm.lv/images/lvm/Atskaite_zemesefekt_LVM_2012_1.pdf

3. Jurēvičs K. (2007) LiDARsistēmas, to pielietojumsun problēmas. Rīgas Tehnis kāuniversitāte. Būvniecības fakultāte. – Rīga: RTU. – 91 l pp.
4. Baumane V., Cintina V., Tabynbaeva L. (2014) World experience in use of remote sensing data for determination of land degradation for condition / 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, p. 37–-41. ISSN 2243-5999, ISSN 2243-6944 (online)
5. Celms A., Ratkevičs A., Baumane V. (2014) Global navigation satellite system as technical solution element of farmland processing in Latvia // In: 13th International scientific conference “Engineering for rural development”: proceedings, Jelgava, Latvia, May, 29–30, 2014 Latvia University of Agriculture. Faculty of Engineering. – Jelgava, 2014. – Vol.13, 44. – 50.l pp. ISSN 1691-5976
6. Latvijas Ģeotelpiskās informācija saģentūrasmājaslapa. – Pieejams: http://map.lgia.gov.lv/index.php?lang=0&cPath=4_16&txt_id=23
7. Auniņš A. (2014) Tehnoloģi judotāsiespējaslētā kaivaiprecīzāka imonitoring ave ikšanai. – Pieejams: http://www.daba.gov.lv/upload/File/Prezentacijas/DAplani_131025_06_AAunins_tehno_iespejas.pdf

Застосування даних дистанційного зондування для визначення деградації земель

В. Баумане, В. Цинтіна, А. Лапіна

Розглянуто можливості застосування даних дистанційного зондування для визначення деградації земель за допомогою аналізу супутникових зображень і ортофотокарти.

Применение данных дистанционного зондирования для определении деградации земель

В. Баумане, В. Цинтина, А. Лапина

Рассмотрено возможности применения данных дистанционного зондирования для определения деградации земель путем анализа спутниковых изображений и ортофотокарты.

Application of remote sensing data in determination of land degradation

V. Baumane, V. Cintina, A. Lapina

The paper explores the remote sensing data application possibilities in determination of land degradation by analyzing satellite images and orthophoto maps.