WORLD EXPERIENCE IN USE OF REMOTE SENSING DATA FOR DETERMINATION OF LAND DEGRADATION FOR CONDITIONS OF LATVIA

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Abstract
This paper provides foreign scientists and specialists experience in defining land degradation using remote sensing data. Evaluated remote sensing data analysis capabilities and methods in different circumstances and for different results obtaining. This paper analyzes the land degradation researches, using remote sensing data of the planet‘s most degraded areas - Asia, Africa and South America. The results and methodology of evaluated researches can serve as a basis for further researches in Latvia.
Key words: land degradation, monitoring, remote sensing, map

Introduction

The basic idea of this paper is to promote the creation of new knowledge and technological recognition of remote sensing technology applications in one of the most important social and economic problems – identifying and evaluating the land degradation in Latvia, based on world experience. Within this paper with remote sensing is understood the reliable technology for obtaining information about the Earth, its environment and other physical objects and processes, making data acquisition with a non-contact image-forming and other sensor systems, its measurement analysis and representation, as well as, determination of qualitative and quantitative characteristics of objects, using aerial photographs and satellite images.

On the other hand with land degradation are understood land and its related resources (soil, forests, minerals, water) values and productivity decrise, as well as water coastal erosion, landscape degradation, loss of biodiversity, pollution and construction negative consequences. Basing on the bill "Land Management Law", formation of bushes in agricultural land, coastal erosion, poor drainage system maintenance and land swamping, the land, including the built-up area abandonment, pollution, landslides and soil degradation, can cause the land degradation.

The responsible institutions that can determine special rules for the use of land in areas where are undergoing processes of land degradation, or there is the risks of degradation, are Regional Environmental Department and local government. However, for those institutions to carry out the assigned tasks there is need for guidelines, for determination, assessment and prevention of land degradation.

Therefore, the objective of this paper is to explore the application possibilities of remote sensing data for determination of land degradation process, based on the world experience. To achieve the objective, following tasks were set – get acquainted with the researches on remote sensing data application possibilities for defining the degradation processes in world, to assess the world experience in this area and to present proposals for conditions of Latvia.

Methodology of research and materials

In the literature many methods have been developed for assessing land degradation. They range from field measurements, laboratory measurements of samples taken from the field, remote sensing applications and specifically the use of Normalized Difference Vegetation Index signals, expert assessment, and observations on changes in land productivity.

The process of remote sensing involves an interaction between incident radiation and the targets of interest. The figure above shows the imaging systems where the following seven elements are involved (Haboudane D., Bonn F., Royer A. 2002). Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors (Fig.1.). Electromagnetic Remote Sensing of the Earth Surface include: *Energy Source or Illumination (A)* - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest; *Radiation and the Atmosphere (B)* - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor; *Interaction with the Target (C)* - once the energy makes its way to the target through the atmosphere, it interacts with the

target depending on the properties of both the target and the radiation; *Recording of Energy by the Sensor (D)* - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation; *Transmission, Reception, and Processing (E)* - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital); *Interpretation and Analysis (F)* - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated; *Application (G)* - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

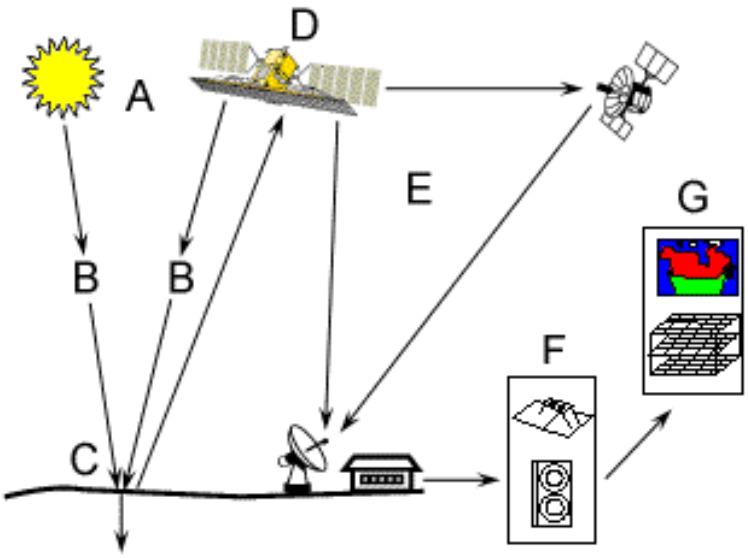

Fig. 1. Electromagnetic Remote Sensing of the Earth Surface.

For studies of land surface use Landsat, SPOT, Rapid-Eye, IKONOS satellite data.
For processing of remote sensing data are available both commercial and non-commercial software. Of commercial software the most widely used are ERDAS IMAGINE and ENVI.

Discussions and results

The factors affecting land degradation often vary depending on the characteristics of specific study areas because different regions may have significantly different causes inducing land degradation.
Land degradation is a gradual negative environmental process which can be accelerated by human activities. Due to its gradual nature, it takes some time (e.g. from a rainy season to several years) before manifesting observable symptoms in the field and is therefore often unnoticed until it is quite advanced. During its development, it leaves a trail of destruction which may be difficult and costly to eradicate should the responses to control the degradation be delayed.
Land degradation caused by deforestation, overgrazing, and inappropriate irrigation practices affects about 16% of Latin America and the Caribbean (LAC) (Metternicht G., Zinck J.A., 2009). This research addresses issues related to the application of remote sensing technologies for the identification and mapping of land degradation features, with special attention to the LAC region. The contribution of remote sensing to mapping land degradation is analyzed from the compilation of a large set of research papers published between the 1980s and 2009, dealing with water and wind erosion, salinization, and changes of vegetation cover. The analysis undertaken found that Landsat series (MSS, TM, ETM+) are the most commonly used data source (49% of the papers report their use), followed by aerial photographs (39%), and microwave sensing (ERS, JERS-1, Radarsat) (27%). About 43% of the works analyzed use multi-scale, multi-sensor, multi-spectral approaches for mapping degraded areas, with a combination of visual interpretation and advanced image processing

techniques. The use of more expensive hyperspectral and/or very high spatial resolution sensors like AVIRIS, Hyperion, SPOT-5, and IKONOS tends to be limited to small surface areas. The key issue of indicators that can directly or indirectly help recognize land degradation features in the visible, infrared, and microwave regions of the electromagnetic spectrum are discussed. Factors considered when selecting indicators for establishing land degradation baselines include, among others, the mapping scale, the spectral characteristics of the sensors, and the time of image acquisition. The validation methods used to assess the accuracy of maps produced with satellite data are discussed as well.

The protection and the sustainable management of soil resources in Africa are of paramount importance, particularly in the context of the uncertain impact of climate change and the increasing pressures of human activities (Hoffman M.T., Todd S., 2000). From the perspective of a policy-maker interested in topics such as food security and land degradation in Africa, this situation requires up-to-date and relevant soil information at regional and continental scales. To provide timely and reliable information on soils at synoptic scales, moderate and coarse spatial resolution satellite data offer many possibilities. The research reviews how a range of multispectral, thermal infrared, passive microwave and active microwave spaceborne sensors can be used in the delineation of soil units, as well as in the assessment of some of their key properties and threats to soil functions from pressures such as water and wind erosion, landslides and salinization. The research shows that remotely sensed data can be used for mapping soils in Africa but often need to be combined with ancillary data and field observations in order to be effective. Remote sensing is shown to be a key component of the emerging discipline of digital soil mapping.

A high resolution land degradation map of the research area in Somalia (Vargas R.R., Omuto C.T., Alim M.S., 2009) was produced by integrating three types of degradation indicators (loss of vegetation, soil physical degradation, and soil chemical degradation). Four classes were obtained and named as light, moderate, strong, and extreme depending on the magnitude of annual soil loss, soil nutrient deficiency, and loss of vegetation cover. A map of hot and bright spots was also produced.

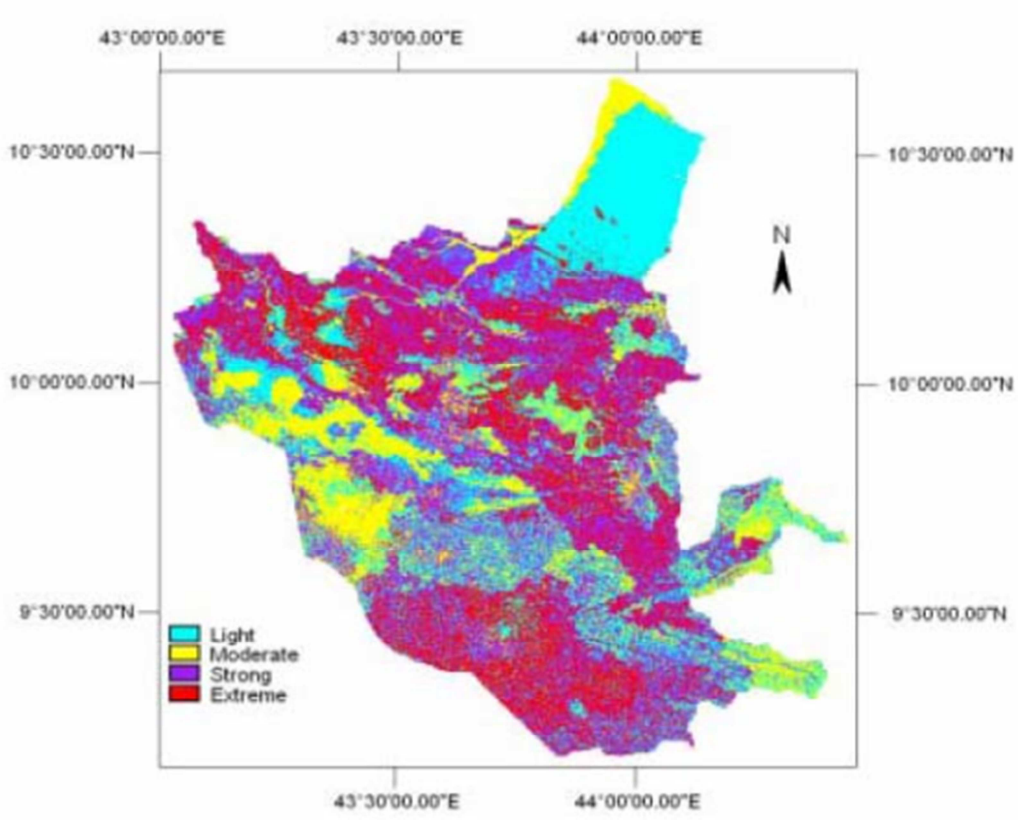

Fig. 2. Combined land degradation map of the research area in Somalia.

Land degradation assessment is a complex process. This is because multiple perspectives are needed to understand ecosystem processes and variability of ecological variables at different spatial scales. This section presents an overview of the methodologies applied to assess land degradation in the study

area. Detailed descriptions of these methodologies and the results can be found in the respective chapters (Waswa F., Gachene C.K.K., Eggers H., 2002). Figure 3. summarizes the key components of the methodologies applied in research of Waswa F., Gachene C.K.K., Eggers H.

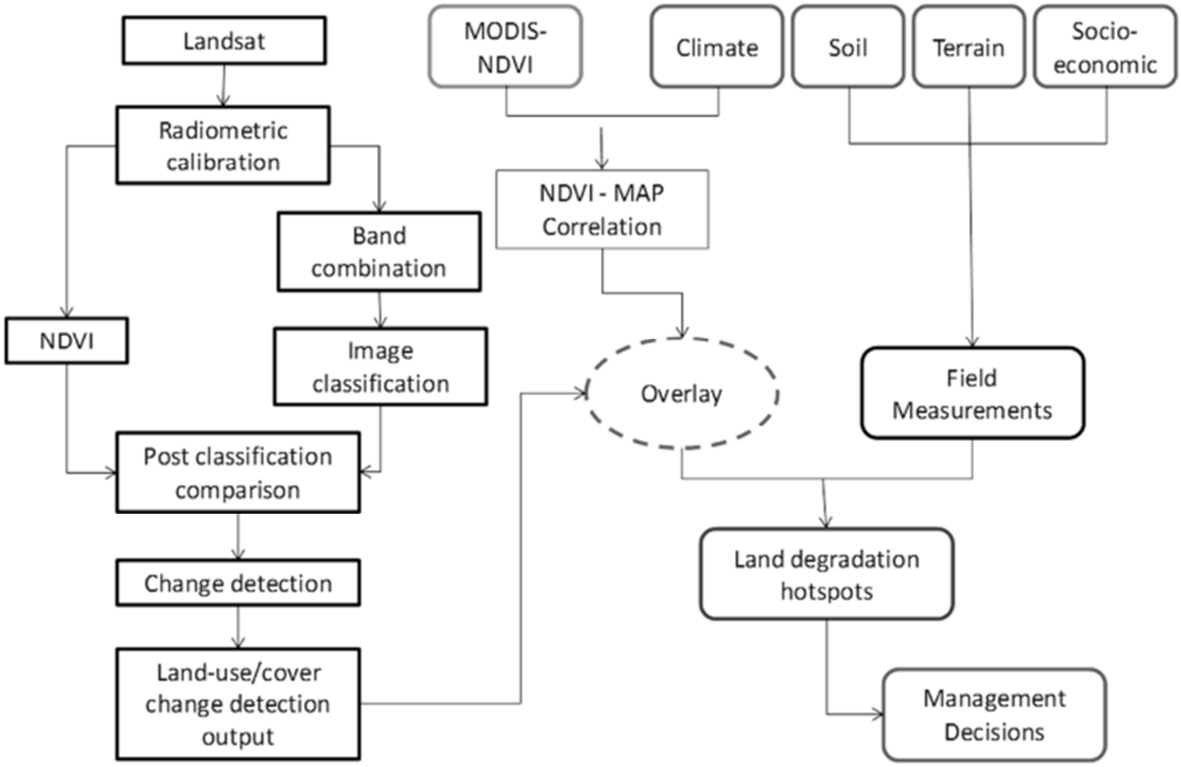

Fig.3. Schematic presentation of the land degradation assessment methodology.

In the world has been made significant land degradation studies using remote sensing data of the planet‘s most degraded areas - Asia, Africa and South America. Results and methodology has been practically verified in scientific publications. Previously gathered information could be as the basis for further land degradation studies in Latvia, using remote sensing data and its possible methods of analysis.

Conclusions and proposals

1. Worldwide the land and soil degradation is topical issue, which is justified by scientists and specialists in number of scientific publications.
2. In the world for processing of remote sensing data are used similar methods, which can be applied for assessment of some land degradation characteristics.
3. In Latvia it is necessary to develop a methodology for determination of land degradation; therefore it is necessary to conduct research basing on world experience, organizing the monitoring of land degradation using the potential of remote sensing.

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