

Cost-Effective Raster Image Processing for Geoecological Analysis Using “ISOCLUST” Classifier: a Case Study of Estonian Landscapes

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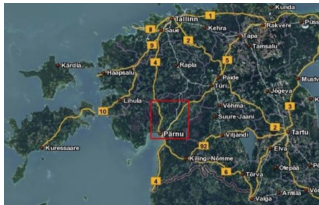
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Study Area: Pärnu Region, Estonia



Study Area

The research region encompasses coastal area of Baltic Sea: south-western Estonia

Spatial extent

Spatial extent of the study area is limited to the surroundings of Pärnu County.

Research Aim

GIS Analysis

The purpose of this study is following **two aims**:

first, a geographic (GIS) analysis of land cover types in the coastal landscapes of western Estonia, Pärnu surroundings at two various temporal dates (**1992** and **2006**)

IDRISI GIS

second, an overview of the technical methods enabling image processing by different tools of IDRISI GIS software"

Landsat TM Images

Hence, the main research methods consists in processing and classification of satellite remote sensing data Landsat TM aimed at land cover types recognition and thematic mapping.

Landscapes

South-West Estonia: Unique Environment

Landscapes

Examples

South-west Estonia is known for unique environmental settings: mild maritime climate, broad beaches, coniferous pine forests on the coastal zone

Landscapes here are rich and world-known for their diversity, variability, unique composition structure and high esthetic value

Types of Landscapes Landscape types include, for example, mixed and broadleaved forests, traditional agricultural semi-natural landscapes, wooded meadows, plant communities, heathland, bogs and moors, complex anthropogenic areas with different land use structure, shrubland, grasslands, birch-dominating coastal areas and flooded meadows

Examples of Landscapes: Baltic Sea Coasts

Examples

Landscapes: Baltic Sea Coasts. Photos: author.



Marine Landscapes: Pärnu Coasts

Examples

Marine Landscapes: Pärnu Coasts. Photos: author.

MARINE LANDSCAPES: PÄRNU SEA COASTS



Lacustrine landscapes: Luitemaa Nature Conservation Area

Examples

Lacustrine landscapes: Luitemaa Nature Conservation Area. Photos: author.

Lacustrine landscapes: Luitemaa Nature Conservation Area

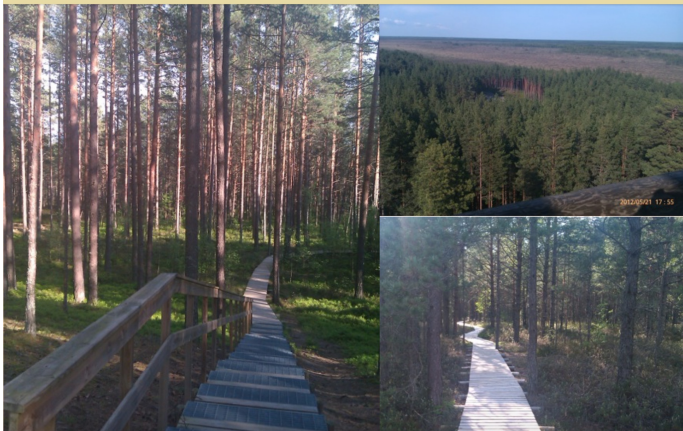


Forest landscapes: Luitemaa Nature Conservation Area

Examples

Forest Landscapes: Luitemaa Nature Conservation Area.
Photos: author.

Forest landscapes: Luitemaa Nature Conservation Area



Anthropogenic Impacts

Tourism Activities

- Pärnu region is traditionally popular as a **tourism destination** due to favorable combination of factors:
- geographic value: advantageous location on the coasts of Baltic Sea
 - social value: good facilities for the tourism and tourism reputation
 - environmental value: unique nature (marine landscapes, pine forests)

Agricultural Activities

Pärnu region is also known for traditional **agricultural activities** (field crops cultivation, intensive planting, etc), as well as extensive **housing development** in the rural area.

Human Pressure

All these factors create additional human pressure on the local ecosystems and may lead to fragmentation of the landscape structure.

Ecohouses Construction

Examples

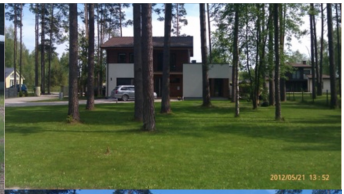
Ecohouses Construction Photos: author.



Examples: Eco-housing

Examples

Eco-housing Photos: author.



Data

The research data used in this project include vector and raster types of data:

Raster data:

Thematic raster layers (GeoTIFF) Landsat TM including scenes taken on **18 June 2006** and **03 June 1992**.

Both images cover summer months, thus enabling vegetation coverage to be easily recognized.

The images were downloaded from the Earth Science Data Interface, Global Land Cover Facility.

Vector data:

CORINE vector layers (abbreviation from **Coordination of Information on the Environment**), developed by the European Environmental Agency, EU Commission).

The CORINE data were stored in ESRI format shape-files.

They contain information on land use types provided by the Estonian Land Board and available at the University of Tartu

Methods

- GIS Projects The GIS projects has been organized and executed in two different software: **Arc GIS 10.0** and **IDRISI GIS Andes 15.0**.
- Landsat TM The raster processing GIS approach and classification was applied in the current work towards Landsat TM two images."
- ISOCLUST The method is based on the ISOCLUST unsupervised classification executed by means of IDRISI GIS.
- Machine Learning The ISOCLUST available in IDRISI GIS performs the most of the image processing workflow in semi-automatically regime
- Land Cover Classes It results in a map with pre-defined number of 16 land class categories which enable to compare two different stages of landscape development: "**earlier**" and "**now**".
- Objectivity The ISOCLUST method was chosen, since it enables to avoid subjectivity in classification.

Workflow Step-1

IMPORT

Initially, the data of Landsat TM were imported to IDRISI Andes GIS from **GeoTIFF** format to IDRISI specific format **.rst**, through **Data Provider Format** import.

As each Landsat TM scene is a multispectral image with several spectral bands, each band was displayed and visualized as a separate image.

COLOR COMPOSITE

Afterwards, the images were composed using **Color Composite** function.

The combination of three bands was made as a single color composite image (bands 2-3-4).

This composition displays urban areas distinctively, which enables to clearly recognize them

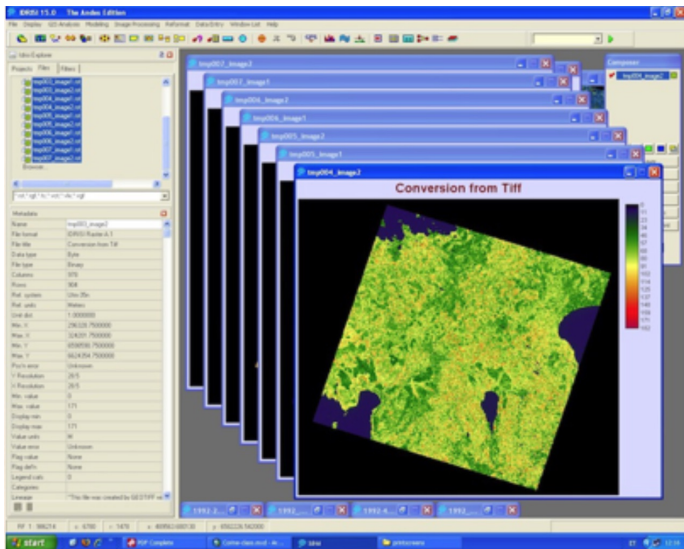
PROJECT

Then data were organized in a created project in **IDRISI GIS**.

Workflow Step-1

Examples

Image Processing



Workflow Step-2

CLASSIFICATION

The next step includes application of chosen classification method of ISOCLUST approach towards images processing. ISOCLUST classifier technique is based on the histogram peak selection technique"

Analysis of Spectral Signatures

The ground principle of the classification consists in the analysis of spectral signatures that are individual for each land cover class.

Analysis of Spectral Reflections

The analysis of spectral reflections strongly depends on the local surface features: texture, structure, color, etc.

Spectral Signatures

Information on spectral signatures is received by the satellite sensors and recorded on the images (in this case, Landsat TM). This information is used for the image classification.

Examples

Information Extraction: Using individual characteristics of objects, derived from the multispectral Landsat TM bands, information from the images was extracted, analyzed and used for land classification

Workflow Step-3

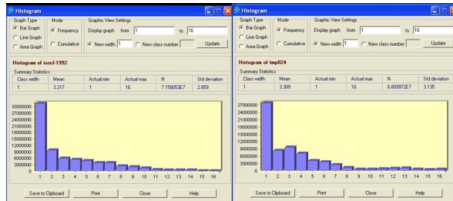


Image
Comparison

2006 vs 1992

Changes in land cover types in selected Estonian landscapes are shown on the histograms on 1992 and 2006.

In 2006 the urban area became larger than in 1992 (land cover class "3" on the histogram). This can be explained by various reasons.

The most important reason is intense suburbanization => the major process in the current urban dynamics of modern Estonia: intensive construction of summer homes and cottages in the coastal area.

New buildings and houses created along the Pärnu Bay, => increased area of urban areas.

Impact Factors

Buildings

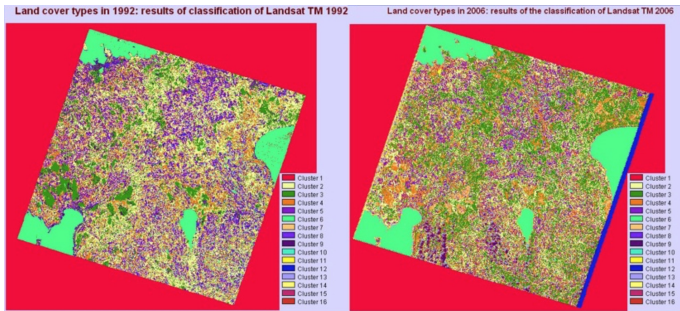
Image Processing

ISOCLUST

ISOCLUST classification of the images enabled to create thematic maps of the same study areas

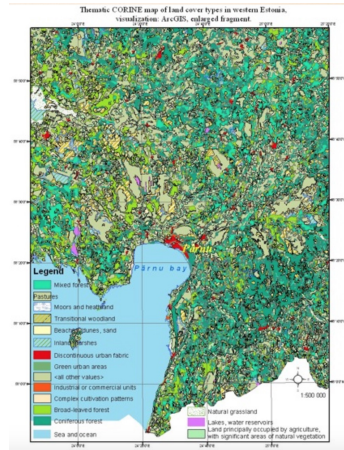
CORINE

According to CORINE, there are 16 land cover types typical for the study area.



Land Cover Classes

- discontinuous urban fabric
- industrial or commercial units
- green urban areas
- pastures
- complex cultivation patterns
- agriculture lands with grass
- broad-leaved forest
- coniferous forest
- mixed forest
- natural grassland
- moors and heathlands
- transitional woodland
- beaches, dunes, sand
- island marshes
- water bodies
- sea and ocean



Thanks

Thank you for attention !



Photo: author.

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CORINE vector layers, **IDRISI GIS 15.0** and **ArcGIS 10.0**.

Bibliography

S. Gauger, G. Kuhn, K. Gohl, T. Feigl, P. Lemenkova, and C. Hillenbrand, "Swath-bathymetric mapping", The expedition ANTARKTIS-XXIII/4 of the Res. Vessel 'Polarstern' in 2006. Berichte zur Polar- und Meeresforschung // Rep. on Polar and Marine Res. **557**, edited by K. Gohl, 38–45, ISSN: 1618-3193 (2007), <https://www.coldregions.org/vufind/Record/288392>, In English Ant. Acc. No.: 85104. CRREL Acc. No.: 63000887; illus., incl. sketch maps.

K. Gohl, G. Eagles, G. B. Udintsev, R. D. Larter, G. Uenzelmann-Neben, H. W. Schenke, P. Lemenkova, J. Grobys, N. Parsiegla, P. Schlueter, T. Deen, G. Kuhn, and C. D. Hillenbrand, "Tectonic and Sedimentary Processes of the West Antarctic Margin of the Amundsen Sea Embayment and Pine Island Bay", in **2nd Open Science Conference 29th SCAR on 'Antarctica in the Earth System' (2006)**, <https://www.scar.org/events/>, Info.

K. Gohl, G. Uenzelmann-Neben, G. Eagles, A. Fahl, T. Feigl, J. Grobys, J. Just, V. Leinweber, N. Lensch, C. Mayr, N. Parsiegla, N. Rackebrandt, P. Schloter, S. Suckro, K. Zimmermann, S. Gauger, H. Bohlmann, G. L. Netzeband, and P. Lemenkova, *Crustal and Sedimentary Structures and Geodynamic Evolution of the West Antarctic Continental Margin and Pine Island Bay*, (Bremerhaven, Germany, 2006), https://epic.Alfred%20Wegener%20Institute.de/29852/1/PE_75.pdf.

M. Klaučo, B. Gregorová, U. Stankov, V. Markovic, and P. Lemenkova, "Interpretation of Landscape Values, Typology and Quality Using Methods of Spatial Metrics for Ecological Planning", in **Environmental & climate technologies. proceedings of the 54th conference (2013)**.

M. Klaučo, B. Gregorová, U. Stankov, V. Marković, and P. Lemenkova, "Landscape metrics as indicator for ecological significance: assessment of Sitno Natura 2000 sites, Slovakia", in **Ecology and environmental protection, Proceedings of International Conference 0**, pp. 85–90, <http://elib.bsu.by/handle/123456789/103362>.

M. Klaučo, B. Gregorová, U. Stankov, V. Marković, and P. Lemenkova, "Determination of ecological significance based on geostatistical assessment: a case study from the Slovak Natura 2000 protected area", **Central European Journal of Geosciences 5**, 28–42, ISSN: 1896-1517 (2013), <https://www.degruyter.com/view/j/geo.2013.5.issue-1/s13533-012-0120-0/s13533-012-0120-0.xml?format=INT>.

G. Kuhn, C. Hass, M. Kober, M. Petitot, T. Feigl, C. D. Hillenbrand, S. Kruger, M. Forwick, S. Gauger, and P. Lemenkova, *The response of quaternary climatic cycles in the South-East Pacific: development of the opal belt and dynamics behavior of the West Antarctic ice sheet*, (Bremerhaven, Germany, 2006), https://epic.Alfred%20Wegener%20Institute.de/29852/1/PE_75.pdf.

P. Lemenkova, "Cost-Effective Raster Image Processing for Geoecological Analysis using ISOCLUST Classifier: a Case Study of Estonian Landscapes", in **Modern problems of geoecology and landscapes studies, Proceedings of the 5th International Conference**, edited by A. N. Vitchenko, G. I. Martinkevich, B. P. Vlasov, N. V. Gagina, and V. M. Yatsukhno 0, pp. 74–76, ISBN: 978-985-476-629-4, <https://www.elib.bsu.by/bitstream/123456789/103641/1/geocconf80.pdf>

P Lemenkova, "Rural Sustainability and Management of Natural Resources in Tian Shan Region, Central Asia", in International conference 'celebrating pastoral life', Heritage and economic develop. Proceedings International Conference, edited by F. Papageorgiou O, pp. 81–89, ISBN: 978-960-6676-22-2.

P Lemenkova, "Opportunities for Classes of Geography in the High School: the Use of 'CORINE' Project Data, Satellite Images and IDRISI GIS for Geovisualization", in Perspectives for the development of higher education, Proceedings of 7th International Conference, edited by V. Pestis, A. A. Duduk, A. V. Sviridov, and S. I. Yurgel O, pp. 284–286, ISBN: 978-985-537-042-1, https://www.ggau.by/downloads/prints/Sbornik_72014_konferencii_perspektivy_razvitiya_vysshej_shkoly.pdf.

P Lemenkova, "Monitoring changes in agricultural landscapes of Central Europe, Hungary: application of ILWIS GIS for image processing", in Geoinformatics: theoretical and applied aspects, Proceedings of 12th International Conference O.

P Lemenkova, "Impacts of Climate Change on Landscapes in Central Europe, Hungary", in Current Problems of Ecology, Ecological monitoring and management of natural protection, Proceedings of 8th International Conference, Vol. 2 O, pp. 134–136, <https://elib.grsu.by/katalog/173327-393652.pdf>.

P Lemenkova, "Current Problems of Water Supply and Usage in Central Asia, Tian Shan Basin", in Environmental and Climate Technologies, Proceedings of the 54th Conference, edited by M. Roša (2013), pp. 11–16, <https://ect-journals.rtu.lv/article/view/issect.2013.002/275>.

P Lemenkova, "Effects of Socio-Economic Changes in the Post-Soviet Estonia on the Landscapes Diversification and Tourism Development", in Contemporary trends in tourism and hospitality, Abstract Book, edited by N. Mimica-Dukić (University of Novi Sad, Department of Geography, Tourism and Hotel Management, 2013), p. 73, <http://www.dgt.uns.ac.rs/ctth2013/>.

P Lemenkova, "Current Development of Tourism and Recreation on Baltic Sea Coasts: New Directions and Perspectives", in The Image and Sustainability of Tourist Destinations, Proceedings of the 6th International Tourism Congress, edited by P Almeida, J. P Jorge, J. Costa, and F Dias (2013), pp. 126–132, ISBN: 978-989-97395-1-2, <http://itc.ipleiria.pt/previous-editions/itc13/itc13-proceedings/>.

P Lemenkova, "Geospatial Technology for Land Cover Analysis", Middle East and Africa (MEA) Geospatial Digest (2013), <https://www.geospatialworld.net/article/geospatial-technology-for-land-cover-analysis/>, e-magazine (periodical).

P Lemenkova, "Water Supply and Usage in Central Asia, Tian Shan Basin", in Civil engineering, architecture and environmental protection, Phidac-2012, Proceedings of the 4th International Symposium for Doctoral studies in the Fields of Civil Engineering, Architecture & Environmental Protection, edited by Z. Grdic and G. Toplicic-Curcic (Sept. 2012), pp. 331–338, ISBN: 978-86-88601-05-4.

P Lemenkova, "Seagrass Mapping and Monitoring Along the Coasts of Crete, Greece", M.Sc. Thesis (University of Twente, Faculty of Earth Observation and Geoinformation (ITC), Enschede, Netherlands, Mar. 8, 2011), 158 pp., <https://thesiscommons.org/p4h9v>.

P. Lemenkova, "Using ArcGIS in Teaching Geosciences", Russian, B.Sc. Thesis (Lomonosov Moscow State University, Faculty of Educational Studies, Moscow, Russia, June 5, 2007), 58 pp., <https://thesiscommons.org/nmjgz>.

P. Lemenkova, "Geoecological Mapping of the Barents and Pechora Seas", Russian, B.Sc. Thesis (Lomonosov Moscow State University, Faculty of Geography, Department of Cartography and Geoinformatics, Moscow, Russia, May 18, 2004), 78 pp., <https://thesiscommons.org/bvwcr>.

P. Lemenkova, *Ecological and Geographical Mapping of the Baltic Sea Region in the Gulf of Finland*, Russian, Moscow, Russia: Lomonosov Moscow State University, Mar. 30, 2002, <https://zenodo.org/record/2574447>, Term Paper.

P. Lemenkova and I. Elek, "Clustering Algorithm in ILWIS GIS for Classification of Landsat TM Scenes: a Case Study of Mecsek Hills Region, Hungary", in *Geosciences and environment, Near-surface geophysics, Proceedings 3rd International Conference*, edited by S. Komatina-Petrovic O.

P. Lemenkova, B. Forbes, and T. Kumpula, "Mapping Land Cover Changes Using Landsat TM: A Case Study of Yamal Ecosystems, Arctic Russia", in *Geoinformatics: theoretical and applied aspects, Proceedings of the 11th International Conference* O, <https://elibrary.ru/item.asp?id=24527736>.

P. Lemenkova, B. Forbes, and T. Kumpula, "ILWIS GIS for Monitoring Landscapes in Tundra Ecosystems: Yamal Peninsula, Russia", in *Remote sensing and global surveillance, 3rd International Geosciences Students Conference* (2012), ISBN: 978-86-913953-5-3.

H. W. Schenke and P. Lemenkova, "Zur Frage der Meeresboden-Kartographie: Die Nutzung von AutoTrace Digitizer für die Vektorisierung der Bathymetrischen Daten in der Petschora-See", *German, Hydrographische Nachrichten* **25**, 16–21, ISSN: 0934-7747 (2008).

I. Suetova, L. Ushakova, and P. Lemenkova, "Geoecological Mapping of the Barents Sea Using GIS", in *Digital cartography & gis for sustainable development of territories, Proceedings of the International Cartographic Conference* (2005), <https://icaci.org/icc2005/>.

I. Suetova, L. Ushakova, and P. Lemenkova, "Geoinformation mapping of the Barents and Pechora Seas", *Geography and Natural Resources* **4**, edited by V. A. Snytko, 138–142, ISSN: 1875-3728 (2005), http://www.izdatgeo.ru/journal.php?action=output&id=3&lang_num=2&id_dop=68.