Federal State Autonomous Educational Institution for Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA (RUDN University)

Institute of Environmental Engineering

COURSE SYLLABUS

Mapping and GIS-technologies in MSW Management

Recommended by the Didactic Council for the Education Field for the specialization:
05.04.06 "Ecology and nature management"

The course instruction is implemented within the professional education programme of higher education:

«Integrated Solid Waste Management» (Network program with L.N. Gumilyov Eurasian National University)

2022

1. COURSE GOAL(s)

The course is designed to help students the in-depth study of the method of remote sensing of the Earth and the features of its application for solving the problems of integrated management of production and consumption waste.

- ## 2. REQUIREMENTS FOR COURSE OUTCOMES

The course implementation is aimed at the development of the following competences:
GC-7.1; GC -7.2; GC -7.3; SPC-3.1; GPC -3.2; GPC -3.3; GPC -3.4; GPC -3.5; GPC -5.1; GPC -5.2; GPC -5.3; PC-5.1; PC-5.2; PC-5.3

Competence code	Competence descriptor	Competence formation indicators (within this course)
GC-7	Able to use basic knowledge in the field of information culture	**GC-7.1** Able to use basic knowledge in the field of information culture
		GC-7.2 Formulates a real data processing problem in terms of a real problem
		GC-7.3 Knows the principles and techniques of modern corporate information culture and the basics of the digital economy
SPC-3	Able to apply environmental research methods to solve research and applied problems of professional activity	**SPC-3.1** Knows how to identify and has the skills to solve problems, tasks of scientific research in the field of urban geography, environmental problems of cities
		GPC -3.2 Owns modern methods for assessing geoecological information to solve theoretical and practical problems of nature management
		GPC -3.3 Possesses the skills of predicting meteotropic reactions, assessing the climatic potential of regions, assessing the objectivity of climate change scenarios
GPC -5	Able to solve the problems of professional activity in the field of ecology, nature management and nature protection using information and communication, including geoinformation technologies	**GPC -5.1** Knows the theoretical, methodological and practical foundations for the use of information technology in environmental expertise
		GPC -5.2 Owns modern methods for assessing environmental information to solve theoretical and practical problems of environmental safety expertise of nature management
		GPC -5.3 Knows how to choose and apply an algorithm for solving environmental problems and implements algorithms using software
PC-5	the ability to develop standard environmental measures and assess the impact of planned structures or other forms of economic activity on the environment	**PC-5.1** Able to assess the impact on the environment of the designed enterprise and facilities, predict and evaluate the negative consequences
		PC-5.2 Able to develop standard environmental measures
		PC-5.3 Possesses the skills of environmental design and preparation of special documentation at the pre-project stage of the project life cycle

As a result of course studying, the student must:

Know:
- theoretical foundations of remote sensing;
- mechanisms and principles of the RSE images obtaining
- basic techniques for photointerpretation the remote sensing images;
- basic techniques of geoinformatics;

Be able to:
- use the methods of aero and space images photointerpretation to solve practical problems in the management of production and consumption waste;
- use the GIS software to solve practical tasks;
- use spectral indices to solve practical tasks
- use spatial analysis of territory to solve practical tasks;

Own :
- skills in working with design and engineering documentation;
- skills of working with normative - legal documentation.

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

Discipline *Mapping and GIS-technologies in MSW Management* refers to the **Electives** (block 1 of the curriculum).

Within the higher education programme students also master other disciplines (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course.

Table 3.1

The list of the higher education programme components that contribute to the achievement of the expected learning outcomes

Competence code	Competence descriptor	Previous courses/modules, internships*	Subsequent courses/modules, internships*
GC-7	Able to use basic knowledge in the field of information culture	IT in ecology and natural resources management	Research work in the term including projects / Industrial / pedagogical practice Research work on thesis State Exam degree Diploma
SPC-3	Able to apply environmental research methods to solve research and applied problems of professional activity	-	Research work in the term including projects / Industrial / pedagogical practice Research work on thesis State Exam degree Diploma
GPC -5	Able to solve the problems of professional activity in the field of ecology, nature management and nature protection using information and communication, including geoinformation technologies	Landscape and geochemical aspects of waste impact	Research work in the term including projects / Industrial / pedagogical practice Research work on thesis State Exam degree Diploma
PC-5	the ability to develop standard environmental	-	Research work in the term including projects /

			Industrial / pedagogical practice Research work on thesis State Exam degree Diploma
	measures and assess the impact of planned structures or other forms of economic activity on the environment		

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the discipline is **3** credit units.

Table 4.1. Types of academic activities during the period of the HE program(me) mastering

Types of academic activities		Total hours	Semester(s)			
			1	**2**	**3**	**4**
Contact academic hours						
Lectures		17	17			
Lab works						
Seminars (workshops/tutorials)		17	17			
Self-study		47	53			
Evaluation and assessment (exam; pass/fail grading)		27	33			
The total course workload	hours	**108**	**108**			
	credits	**3**	**3**			

5. COURSE CONTENT
Table 5.1. Course Modules and Contents

	Title of Course Modules	Content	Types of academic activities
1.	Introduction.	The study of the physical basics for remote sensing, the study of types and means for remote sensing. Remote sensing data processing software: a variety of GIS, QuantumGIS interface, loading raster data, vector layers creation, Openstreetmaps, satellite images, georeferencing.	L, S
2.	Basic principles of photointerpretation	Photointerpretation. photointerpretation signs. Features of recognition of artificial and natural objects. Semi-automatic classification. Multispec	L, S
3.	Spectral indices	Data analysis with QGIS: variety of indices, their significance and practical application, NDVI calculation, Introduction to the QGIS raster calculator	L, S
		landscape indexes. Building index.	
4.	Ways to solve problems	Vector analysis tools: random points layer creation, spatial analysis	L, S

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Classroom for Academic Activity Type	Classroom equipment	Specialized educational / laboratory equipment, software and materials for mastering the course (if necessary)
Lecture	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless Internet connection. Software: Microsoft Windows, MS Office / Office 365, MS Teams, Chrome (latest stable release), Skype. Microsoft Windows 7 corporate. License No. 5190227, date of issue March 16, 2010 MS Office 2007 Prof , License # 6842818, date of issue 09/07/2009
Seminars	Classroom, equipped with a set of specialized furniture; whiteboard; a set of devices includes portable multimedia projector, laptop, projection screen, stable wireless	
Computer Lab	Computer Lab for conducting classes, group and individual consultations, current control and intermediate certification, equipped with personal computers (in the amount of 12), a board (screen) and technical devices of multimedia presentations.	QuantumGIS, Multispec
For Self-Study	Classroom for self-study (can be used for seminars and consultations), equipped with a set of devices includes laptop, stable wireless.	No

7. RECOMMENDED SOURCES FOR COURSE STUDIES

a) **Main reading:**
   1. Editors: John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos, 2001. Manual of Geospatial Science and Technology, November 2001, Vol 1 Part 1and II.
   2. Martin Wegmann , Jakob Schwalb-Willmann , Stefan Dech An Introduction to Spatial Data Analysis: Remote Sensing and GIS with Open Source Software (Data in the Wild) 1st Edition, Kindle Pelagic Publishing, 2020
   3. E.O. Wilson , Dawn J. Wright , Christian Harder GIS for Science, Volume 3: Maps for Saving the Planet. Esri Press, 2021, $228
   4. Jindong Li Satellite Remote Sensing Technologies Springer, Singapore, Space Science and Technologies, 2021, 421 rub
   5. Remote Sensing and Image Interpretation, 7th Edition, Thomas Lillesand , Ralph W. Kiefer , Jonathan Chipman , $ 736
   6. List of available Indices Index DataBase A database for remote sensing indices. URL: https://www.indexdatabase.de/db/i.php
   7. Suarez Kozov N. Application of **remote sensing** for monitoring of flood areas (Application remote sounding for monitoring zones flooding): article on the English language / KN Suarez, OD

Trujillo, OJ Giraldo// Bulletin Russian university friendship peoples : Engineering research . - 2019. - No. t . 20(1). - S. _ 66 - 78. - ISSN 18230.

8. Ujaval Gandhi End-to-End Google Earth Engine (Full Course Material) A hands-on introduction to applied remote sensing using Google Earth Engine. https://courses.spatialthoughts.com/end-to-end-gee.html

9. Otto Huisman and Rolf A. de By Principles of Geographic Information Systems An introductory textbook The International Institute for Geo-Information Science and Earth Observation (ITC), webapps.itc.utwente.nl

10. Jonathan Campbell, MIchael Shin, UCLA Essentials of Geographic Information Systems, Publisher: Saylor Foundation https://open.umn.edu/opentextbooks/formats/249

b) **Additional reading**

1. T. Takagi, T. Oguchi, J. Matsumoto, MJ Grossman, MH Sarker, MA Matin (2007) Channel braiding and stability of the Brahmaputra River, Bangladesh, since 1967: GIS and remote sensing analyses, Geomorphology 85, 294–305.

2. John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos, (Editors), 2001. Photogrammetric and remote sensing considerations; Chapter 16, Manual of Geospatial Science and Technology, Vol 1 Part 4 Pages 233 – 252

3. John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos (Editors), 2001. The remote sensing process: how do we collect the required in situ and remotely sensed data? Chapter 17, Manual of Geospatial Science and Technology, November 2001, Vol 1 Part 4 Pages 253 – 275K.

4. Manual of Remote Sensing: American Society of Photogrammtery and Remote Sensing.

5. George Joseph: Fundamentals of Remote Sensing; Universities Press India Pvt Ltd, Hyderabad,India

6. Editors: John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos, 2001. Manual of Geospatial Science and Technology, November 2001, Vol 1 Part 1and II.

7. Paul M. Mather, 1999. Computer Processing of Remotely Sensed Images: An Introduction. John Wiley

8. T. Takagi, T. Oguchi, J. Matsumoto, MJ Grossman, MH Sarker, MA Matin (2007) Channel braiding and stability of the Brahmaputra River, Bangladesh, since 1967: GIS and remote sensing analyses, Geomorphology 85, 294–305.

b) databases, information and reference and search systems, Internet sources:

1. Interregional public organization for promoting the development of the market for geoinformation technologies and services Web site of the GIS Association: http://www.gisa.ru

2. Association of developers, manufacturers and consumers of equipment and applications based on global navigation satellite systems "GLONASS / GNSS-Forum": http://aggf.ru/

3. Intersectoral journal of navigation technologies Vestnik GLONASS: http://vestnik-glonass.ru/

4. State and prospects of the Russian satellite navigation market in 2010: an analytical review. – M: 2011 http://aggf.ru/analitika/AGGF_2011.pdf

5. Introduction to geoinformation systems / Web-site "GIS-Lab and authors" (http://gis-lab.info/docs/giscourse), Aug. 2007

6. Basic GIS - RECOD platform. http://ssc.rekod.ru/content/services/3

Internet-based sources

1. ELS of RUDN University and third-party ELS, to which university students have access on the basis of concluded agreements:
   - RUDN Electronic Library System - RUDN EBS http://lib.rudn.ru/MegaPro/Web

- ELS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- EBS "Lan" http://e.lanbook.com/
- EBS "Trinity Bridge"

2. Databases and search engines:
- electronic fund of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https:// www .yandex.ru/
- Google search engine https://www.google.ru/
- abstract database SCOPUS http:// www .elsevierscience.ru/ products / scopus /

8. MID-TERM ASSESSMENT AND EVALUATION TOOLKIT

Evaluation materials and a point- rating system* for assessing the level of competence formation (part of competences) based on the results of mastering the discipline **Mapping and GIS-technologies in MSW Management** are presented in the Appendix to this Work Program of the discipline.

DEVELOPER:

Associate Professor of the EM Department		**Kapralova D.O.**
Position	Signature	Name, Surname

HEAD OF DEPARTMENT:

Director of the EM		**Kucher D.E.**
Position	Signature	Name, Surname

HEAD OF PROGRAMME:

Senior Lecturer of the ES&PQM Department		**Popkova A.V.**
Position	Signature	Name, Surname

ASSESSMENT TOOLKIT

for the course

Mapping and GIS-technologies in MSW Management
course title

05.04.06 "Ecology and nature management"
field of studies / speciality code and title

«Integrated Solid Waste Management» (Network program with L.N. Gumilyov Eurasian National University)

higher education programme profile/specialisation title

master
graduate's qualification (degree)

Passport to Assessment Toolkit for Course Mapping and GIS-technologies in MSW Management

Field of Studies / Speciality 05.04.06 "Ecology and nature management"
_{code}

Course: Mapping and GIS-technologies in MSW Management
title

Competences (competences in part) under assessment	Course module under assessment	Course topic under assessment	Tools to assess higher education programme mastering level						Points for topic	Points for module
			Class work				Self-studies	Exam/Pass-fail assessment		
			Test	External	Lab work	Lection	Homework			
GC-7 SPC-3 GPC -5 PC-5	Introduction.	The study of the physical basics for Earth Remote Sensing, the study of types and means for remote sensing. Remote sensing data processing software: a variety of GIS,	1	10	10	1		4	26	38
		QuantumGIS interface, loading raster data, vector layers creation,								
		Openstreetmaps, satellite images, georeferencing.			10			2	12	
		Rationale for the use of remote sensing data for the purposes of waste recycling								

GC-7 **SPC-3** **GPC -5** **PC-5**	Basic principles of photointerpretation	Photointerpretation. photointerpretation signs. Features of recognition of artificial and natural objects. Semi-automatic classification. Multispec	1		15	1		3	20	20
GC-7 **SPC-3** **GPC -5** **PC-5**	Spectral indices	Data analysis with QGIS: variety of indices, their significance and practical application, NDVI calculation, Introduction to the QGIS raster calculator landscape indexes. Building index.	2		15	2		3	22	22
	Ways to solve problems	Vector analysis tools: random points layer creation, spatial analysis	1		10	1	5	3	20	20
Total			5	10	60	5	5	15	100	100

Passport to Assessment Toolkit for
Course Mapping and GIS-technologies in MSW Management

course title

QUESTION CARD No 1

QUESTION 1 What is meant by remote sensing? What is remote sensing data?
QUESTION 2 What are the automated interpretation methods?

Developer_____(Kapralova D.O.)
signature
Head of Educational Department_____(Kucher D.E.)
signature

_____
day, month, year

EXAM QUESTIONS

1. What is meant by remote sensing? What is remote sensing data?
2. What are the main advantages of using remote sensing
3. Describe the main stages in the development of remote sensing technology. Name the main trends in the development of remote sensing technology.
4. Describe the steps involved in remote sensing and data analysis.
5. What are the transparency windows of the earth's atmosphere?
6. Classify imaging systems by technology taking pictures.
7. What are the methods of transmitting remote sensing data to Earth?
8. What data formats are mainly used by remote probing?
9. What are the main elements of the ground and orbital segments remote sensing systems.
10. What are the main characteristics of remote sensing data?
11. What characteristics of the COP depend on the height of the satellite?
12. How is computer interpretation of images made?
13. Describe the steps for interpretation of images.
14. What is the purpose of interpretation of images?
15. What are interpretation signs? What kind of signs do you know?
16. What equipment is used for interpretation?
17. What are the automated interpretation methods?
18. What is image correction and restoration used for?
19. What is the difference between improving the visual perception of pictures and image conversion? What are they used for?
20. In what areas can remote sensing data be used?
21. How is the area under crops can be estimated?
22. How can remote sensing data be used to study urban growth?
23. How can remote sensing data be used to study landfills and illegal dumps?
24. How remote sensing can be used to prevent and combat consequences of emergencies?

25. In what main areas are remote sensing data used in solving problems of assessing natural resources and the environment?
26. Name the applied tasks that can be attributed to the tasks of detection and control of emergency situations.
27. What are the requirements for software solutions in the field of remote sensing of the Earth?
28. What are the stages of primary processing of remote sensing data?
29. What is an orthorectified image and orthomosaic?
30. Define the concept of interferometry.
31. Describe the process of building digital elevation models using radar survey materials.
32. In what areas are remote sensing radar equipment mainly used?
33. What are the advantages of remote sensing radar?
34. What tasks is the geocoding processor intended for?
35. What is georeferencing, geocoding and orthorectification?
36. Describe the process of interferometric processing.
37. What is stereo processing used for? Describe the process of fulfillment

Note * Practice case/task inclusion is subject to the teacher's discretion.

The set of exam question cards is complemented by the assessment criteria developed by the teacher and approved at the department meeting.
Assessment criteria:
(*in compliance with the legal regulations in force*)

Test question examples

1) Examples of natural forms of remote sensing are:
    a. vision,
    b. sense of smell
    c. hearing
    d. touch
2) The rights to the primary Earth remote sensing data obtained using the Earth remote sensing equipment installed on the aircraft belong to
    a. State
    b. Aircraft owner
    c. To the whole people
    d. Depends on the country
    e. commercial property
3) Sciences that use remote sensing data
a. Geology
b. Geography
c. Astronomy
d. Physics
e. Economy
f. Sociology
g. Geometry
4) The concept of remote sensing appeared in
    a. 19th century
    b. XX century
    c. XXI century
5) The main technical factors affecting the information content of satellite images are

a. Composition of the atmosphere
b. Used equipment
c. Satellite country of origin
d. Orbit type (or flight altitude) e. Presence of clouds
f. season

Example of Lab work task

Automated identification of technogenic load based on Landsat satellite images using the VIBI index.

Purpose of the work: to master the tools and to study in practice the use of indices allowing to identify changes in the technogenic load.

General description.

The VIBI index (vegetation index built-up index) - literally can be translated as the vegetation index, the building index developed in 2012 by a group of researchers (D. Statakis, K. Perakis, I. Yu. Savin Deciphering urban areas using Landsat satellite data // Research Earth from Space. 2012. No. 5. P. 22.).

A method for recognizing urbanized areas (more efficient than existing indices), which is a normalized combination of the well-known NDVI and NDSI (normalized difference soil index) indices - a normalized difference soil index. Approbation of the developed approach on the test site showed its advantage over the existing indices.
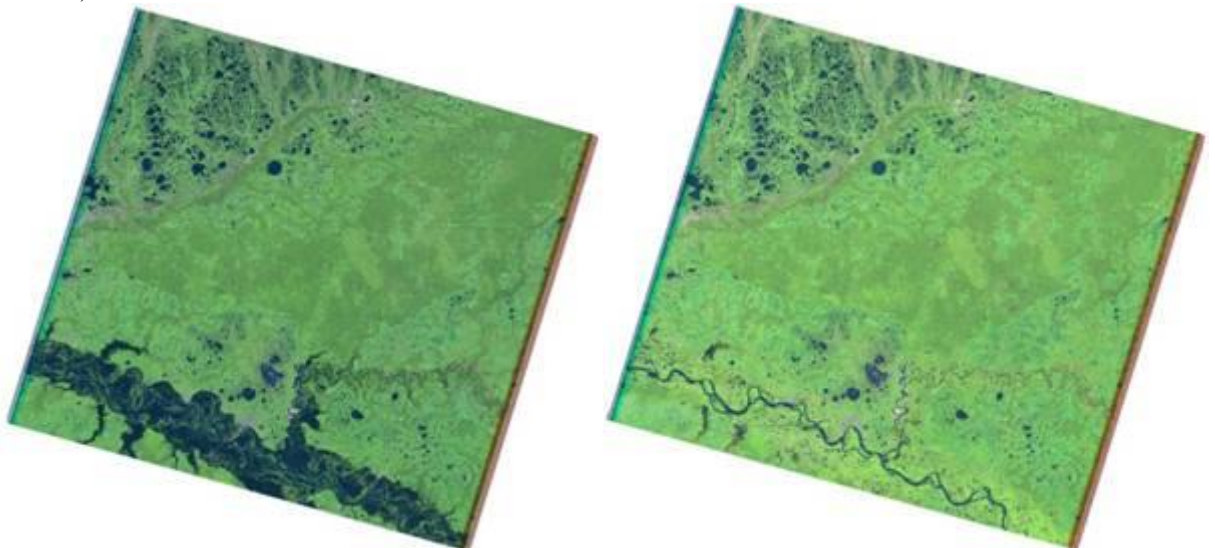
$$VIBI = \frac{NDVI}{NDVI + NDSI} = \frac{\frac{b4 - b3}{b4 + b3}}{\frac{b4 - b3}{b4 + b3} + \frac{b5 - b4}{b5 + b4}},$$

The task for the laboratory work.

1. Form a color image from Landsat-5 monochromatic channels (channels 5,4,3 must be used).
   2. Calculate VIBI for the provided images.
   3. Calculate the difference between the obtained VIBI indices for 2007 and 2011. Determine which pixel values (negative or positive) correspond to the appearance and disappearance of objects in the image. Pixel values of the resulting image in the range from -0.2 to 0.2 will record no changes or minor changes. Large negative or positive pixel values indicate the appearance or disappearance of objects.
   4. Based on the VIBI index, identify changes associated with man-made objects.
   5. Form the results of the work in the form of a card.
   The order of laboratory work No. 4.
   1. Use the composite bands tool. Create a fake color synthesized image for two Landsat images (channels 5,4,3 must be used).

   2.

Figure 1 - Color-synthesized image of satellite images obtained by combining channels 5,4,3

2. Use the raster calculator tool. Calculate VIBI index for two original Landsat 5 images using the formula:

$$VIBI = \cfrac{\cfrac{b4 - b3}{b4 + b3}}{\cfrac{b4 - b3}{b4 + b3} + \cfrac{b5 - b4}{b5 + b4}}$$

In the raster calculator tool, you must use the Float () operator so that the output raster is not an integer, otherwise it will only have three values -1, 0, 1. The Float () operator denotes the value type used to store 32-bit floating point values ... The approximate range is $\pm 1.5 * 10\text{-}45$ to $\pm 3.4 * 10\text{-}38$, with an accuracy of 7 digits. If you do not use the Float () operator, then the values will be integers (no decimal places), this is not enough to perform correct classification.

(Float(b4 - b3) / Float(b4 + b3)) / (Float(b4 - b3) / Float(b4 + b3)) + (Float(b5 - b4) / Float(b5 + b4))
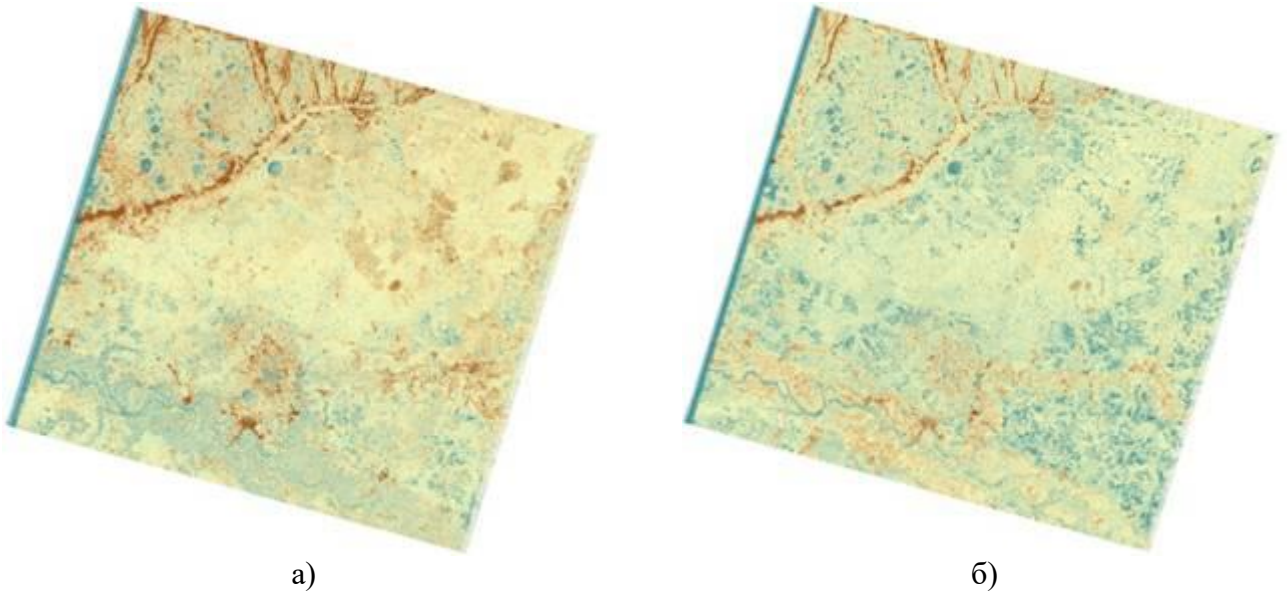

a)   б)

Figure 2 - Raster images obtained using the VIBI index

3. Use the raster calculator tool. In the raster calculator tool, use the Float () operator. Calculate the difference between the obtained VIBI indices for 2007 and 2011. Determine which pixel values (negative or positive) correspond to the appearance and disappearance of objects in the image.

Pixel values of the resulting image in the range from -0.2 to 0.2 will record no changes or minor changes. Large negative or positive pixel values indicate the appearance or disappearance of objects.
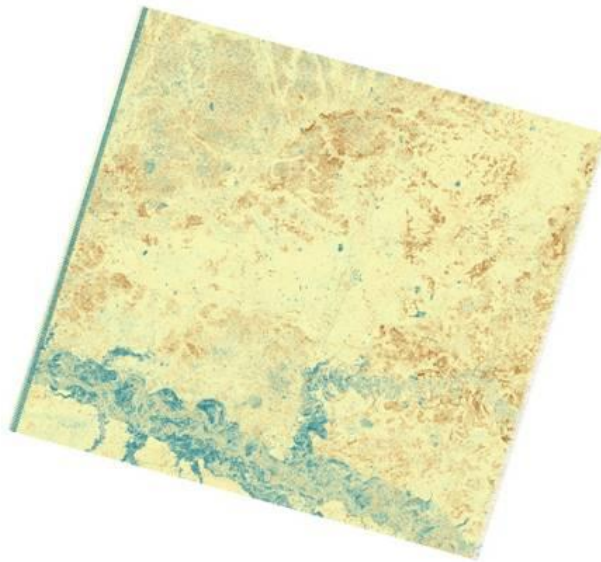
Figure 3 - Raster image obtained as a result of calculating the difference of VIBI indices

4. Use the tools reclassify, raster to polygon and merge. Create a mask of technogenic objects for each image obtained using the VIBI index - filter out pixels with a value less than 0.97. The resulting raster layers are vectorized and combined into one vector file.
5. After completing these steps, you will get a mask of technogenic objects in the images for 2007 and 2011.
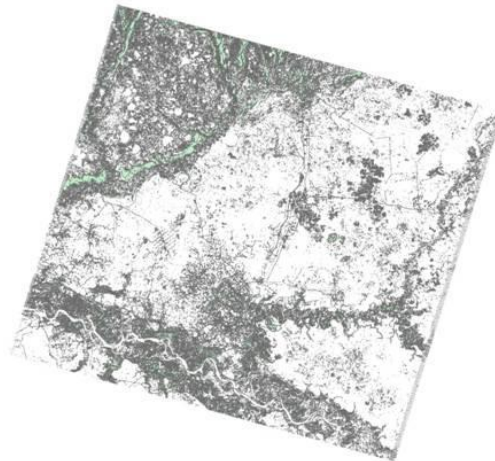

Figure 4 - Vector mask of technogenic objects

5. Use the extract by mask tool. Crop the raster image obtained in step # 3 using the mask (vector layer) obtained in step # 4. This action is necessary to exclude objects that are not technogenic from the raster layer.
6. Use reclassify tools. Reclassify the raster image obtained in point # 5 into ranges:
   □ from -2 up to -0,2 (appearance OR disappearance) – was defined in clause # 3;
   □ from -0,2 up to 0,2 (little or no changes);
   □ from 0,2 up to 2 (appearance OR disappearance) – was defined in clause # 3;.

Figure 5 - Fragment of a color-synthesized image with the classification of appeared and disappeared objects

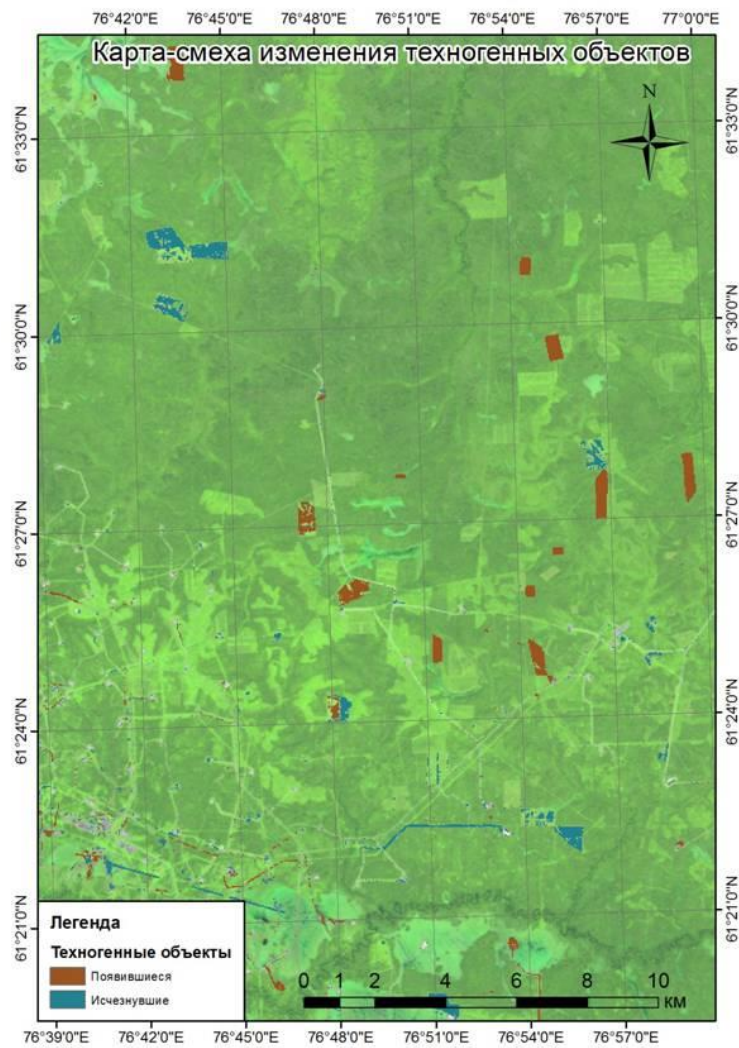7. The results of the work should be presented in the form of a map.

Figure 6 - An example of a card design

The assessment of all results of mastering competencies is carried out in accordance with the scale of the international point-rating system ECTS. In accordance with the calculated grading system (*see toolkit passport), the student gains the required points.

The set of exam question cards is complemented by the assessment criteria developed by the teacher and approved at the department meeting.

Assessment criteria:

(*in compliance with the legal regulations in force*)

The assessment of all results of mastering competencies is carried out in accordance with the scale of the international point-rating system ECTS. In accordance with the calculated grading system, the student gains the required points.

Work in class: depends on the complexity of the topic.

The grade is given for attendance and active work at a seminar or lecture (lectures are held in an interactive form) - answers to current questions, notes, discussion. The student is present at the lesson, participates in the discussion, does not hesitate to answer questions - maximum score. The student is absent or the task is not prepared - 0 points.

Tasks of Self-studies: - acquisition of skills of independent practical work in the recommended software and application of various research methods; - developing the ability to independently and critically apply the material being studied. The SR technology should ensure the acquisition of knowledge, the consolidation and systematization of knowledge, the formation of skills and abilities. The proven technology is characterized by an algorithm that includes the following logically related student actions: - reading a text (textbook, manual, lecture notes); - note-taking of the text; - problem solving and exercises; - answers to control questions;

Final certification: A student is considered to have successfully passed the milestone or final certification if the total score for all activities at the time of certification exceeds 50% of the maximum possible score (lecture work, practical assignment, tests).

The final grade for the semester is added up as the sum of points for all types of student activities (*see toolkit passport) and can reach a maximum of 85 points,

The final test is given by the student voluntarily, if he scored the minimum possible score for certification - 51 points. In other cases, the test is mandatory and is estimated at a maximum of 15 points, as a result, the total score is derived taking into account the result of passing the test and the final grade corresponds to the international ECTS scale.

Tentative list of assessment tools

п/п	Assessment tool	Brief features	Assessment tool representation in the kit
		Class work	
1	Survey/Quiz	A tool of control, organized as a special conversation between a teacher and students on topics related to the course under study, and designed to clarify the amount of students' knowledge in a particular section, topic, problem, etc.	Questions on the course topics /modules
2	Test	A system of standardised tasks that allows the teacher to automate the procedure for measuring the student's level of knowledge and skills	Tests bank
4	Control work	A tool of control organised as a classroom lesson, at which students need to independently demonstrate the acquisition and mastering of the educational material of the course topic, section, or sections.	Questions on the course topics /modules
5	Lab work	The system of practice tasks aimed at the students' practical skills formation	Practice tasks bank
11	Exam	The evaluation of the student's work during the semester (year, the entire period of study, etc.); it is designed to identify the level, soundness and systematic nature of theoretical and practical knowledge gained by the student, formation of independent work skills, development of creative thinking, ability to synthesise the acquired knowledge and apply it to solve practice tasks.	Examples of tasks/questions/exam question cards
14	Multi-level tasks and assignments with varying difficulty	The tasks and assignments differ in terms of the following levels: a) reproductive level allows the teacher to evaluate and diagnose the students' knowledge of factual material (basic concepts, algorithms, facts) and the students' ability to correctly use special terms and concepts, recognize objects of study within a certain section of the discipline, b) reconstructive level allows the teacher to evaluate and diagnose the students' abilities to synthesise, analyse, generalise factual and theoretical material and formulate specific conclusions, establish cause-and-effect relationships, c) creative level allows to evaluate and diagnose students' skills to integrate	Set of multi-level tasks and assignments with varying difficulty

| 8 | Homework | The tasks and assignments differ in terms of the following levels:
a) reproductive level allows the teacher to evaluate and diagnose the students' knowledge of factual material (basic concepts, algorithms, facts) and the students' ability to correctly use special terms and concepts, recognize objects of study within a certain section of the discipline,
b) reconstructive level allows the teacher to evaluate and diagnose the students' abilities to synthesise, analyse, generalise factual and theoretical material and formulate specific conclusions, establish cause-and-effect relationships,
c) creative level allows the teacher to evaluate and diagnose students' skills to integrate knowledge of various fields, argue their own point of view. | Set of multi-level tasks and assignments with varying difficulty |

Criteria for assessing students' knowledge

Points BRS	Traditional grades in the Russian Federation	Points for transferring grades	Grades	ECTS grades
86 - 100	5	95 – 100	5+	A
		86 – 94	5	B
69 - 85	4	69 – 85	4	C
51 - 68	3	61 - 68	3+	D
		51 - 60	3	E
0 - 50	2	31 - 50	2+	FX
		0 - 30	2	F

Explanation of the rating table:

A	"Excellent" - the theoretical content of the course is mastered completely, without gaps, the necessary practical skills for working with the mastered material are formed, all the training tasks provided for by the training program are completed, the quality of their implementation is estimated by a number of points close to the maximum.
B	"Very good" - the theoretical content of the course is mastered completely, without gaps, the necessary practical skills for working with the mastered material are basically formed, all the training tasks provided for by the training program are completed, the quality of most of them is estimated by a number of points close to the maximum.

C	"Good" - the theoretical content of the course has been mastered completely, without gaps, some practical skills in working with the mastered material are not sufficiently formed, all the training tasks provided for by the training program have been completed, the quality of none of them has been assessed with a minimum number of points, some types of tasks have been completed with errors.
D	"Satisfactory" - the theoretical content of the course has been partially mastered, but the gaps are not significant, the necessary practical skills for working with the mastered material are basically formed, most of the training tasks provided for by the training program have been completed, some of the completed tasks may contain errors.
E	"Mediocre" - the theoretical content of the course is partially mastered, some practical work skills are not formed, many training tasks provided for by the training program are not completed, or the quality of some of them is estimated by a number of points close to the minimum.
FX	"Conditionally unsatisfactory" - the theoretical content of the course has been partially mastered, the necessary practical skills have not been formed, most of the training tasks provided for by the training program have not been completed, or the quality of their implementation has been assessed with a number of points close to the minimum; with additional independent work on the course material, it is possible to improve the quality of the implementation of educational tasks.
F	" Definitely unsatisfactory" - the theoretical content of the course has not been mastered, the necessary practical work skills have not been formed, all the completed training tasks contain gross errors, additional independent work on the course material will not lead to any significant improvement in the quality of the training tasks.

Example of a control work

1) Name the research method and explain your conclusion (formalization, analysis and synthesis, induction and deduction, analogy, etc.)

2) Come up with the purpose of the study, the main objectives and the relevance of this study on the situation from the fairy tale about Cinderella.

3) On what basic philosophical principles is scientific activity based?

4) Think over the structure of UFO observations, determine the scale of measurements, funds of measuring instruments, conceptual means of observation, means of fixing observations.

5) Can an observation be wrong? Why. Explain.

6) Why is it necessary to carefully and in advance plan the experiment?

7) What does the Law of Information Dispersion say (in your own words)? How can it be applied in practice?

8) What is the difference between pertinence and relevance (in your own words)?

9) What is the main principle of the traditional classification of invention methods? What is the difference between the approach and TRIZ?

10) Is it possible to apply survey methods (questionnaires or interviews) in the natural sciences?

11) What is a sample? Why should we use different sample types?

12) Can we completely avoid measurement/experimental errors?

13) What are the basic principles for assessing the value of scientific work.

14) What is metrology?

DEVELOPER:

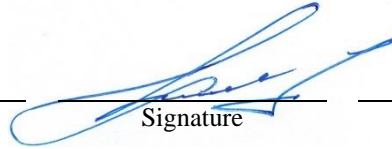| Associate Professor of the NM Department		**Kapralova D.O.**
Position	Signature	Name, Surname

HEAD OF DEPARTMENT:

Director of the NM Department		**Kucher D.E.**
Position	Signature	Name, Surname

HEAD OF PROGRAMME:

Senior Lecturer of the ES&PQM Department		**Popkova A.V.**
Position	Signature	Name, Surname