# NAVOI STATE UNIVERSITY

## TMAM1304 FUNDAMENTALS OF MODELLING IN SOIL SCIENCE — COURSE SYLLABUS

### Faculty of Natural Sciences and Medicine | Department of Biology | Master's Programme: 70810203 Soil Science

## COURSE PASSPORT & ACADEMIC METADATA

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|---|---|---|---|
| **Course Title:** | Fundamentals of Modelling in Soil Science | **Course Code:** | TMAM1304 |
| **Course Type:** | Compulsory (Master's) | **Field of Study:** | 700000 Engineering, Processing and Construction; 710000 Engineering |
| **Programme:** | 70810203 Soil Science (Master's Degree) | **Academic Year:** | 2026–2027 |
| **Semester:** | 3 | **Form of Education:** | Uzbek |
| **ECTS Credits:** | 4 ECTS Credits | **Total Workload:** | 120 Hours (30 Lectures, 30 Practical, 60 Independent Study) |
| **Curriculum Reference:** | 1.07 | **Weekly Contact Hours:** | 4 |
| **Assessment:** | Final written examination | **Aligned UN SDGs:** | SDG 2 (Zero Hunger); SDG 13 (Climate Action); SDG 15 (Life on Land) |




## 1. Course Description & Scope

"Fundamentals of Modelling in Soil Science" introduces modelling approaches used in modern agriculture, soil science, and ecology. The course focuses on applying mathematical, statistical, numerical, and computer-based methods to represent soil processes and support practical decisions in land use and agricultural management.

The course covers conceptual and mathematical models of soil-water movement, heat transfer, dissolved substances and salt transport, soil organic matter and carbon dynamics, erosion, nutrient balance, soil–plant–atmosphere systems, contaminants, spatial soil variability, biological activity, climate-related degradation, and data-driven prediction. The syllabus also introduces model calibration and validation and the use of modelling outputs to improve soil productivity, resource efficiency, and environmental protection.

## 2. Course Aims & Professional Competencies

Course Aim: To develop students' theoretical knowledge and practical skills in modelling soil processes and applying modelling results to agricultural production, soil fertility management, land use, and environmental protection.

### Course Objectives:

- Improve crop productivity and product quality through evidence-based analysis of soil and crop systems.
- Support the improvement and spatial consistency of soil fertility through assessment and modelling of soil properties.
- Promote rational land use and appropriate environmental protection decisions.
- Develop the ability to analyse model inputs, evaluate outputs, and use simulations to compare management scenarios.

## 3. Prerequisites

Required prior knowledge: Soil Science (TPRSHB13412), Agrochemistry (AGKMB13410), and Agricultural Mechanisation (QXMB1206).

## 4. Course Learning Outcomes

- Explain the principles of mathematical modelling of physical, chemical, and biological processes in soil, including the Richards equation, Fourier law, convection–dispersion equations, and conceptual models.
- Use relevant modelling software packages and approaches, including HYDRUS-1D, RUSLE, RothC, and DSSAT, to simulate soil moisture, salt transport, erosion, and carbon dynamics.
- Statistically analyse soil parameters used in models, including hydrophysical properties, bulk density, and humus content, and explain the purpose of model calibration and validation.
- Develop scenarios for predicting changes in soil fertility, salinisation, and degradation under climatic and anthropogenic influences.
- Apply digital and analytical approaches to represent soil–plant–atmosphere (SPAC) processes and construct or interpret mathematical models and digital representations.
- Assess and forecast soil-resource conditions, salinity, moisture deficits, and agro-ecological stability using modelling tools and GIS technologies.
- Use modelling results to justify resource-efficient agricultural practices, including drainage, leaching requirements, and optimisation of fertilisation regimes.
- Plan and conduct mathematical or simulation experiments to test soil-science hypotheses and communicate results in scientific reports or articles.

## 5. Course Structure & Workload Allocation

The course comprises 30 lecture hours, 30 practical-class hours, and 60 hours of independent study. The detailed lecture and practical topic lists are omitted in this syllabus summary, following the requested format.

| Activity Type | Curriculum Focus | Total Hours Allocation |
|---|---|---|
| Lectures | Modelling principles and applications to soil-water, heat, salt, carbon, erosion, nutrients, agro-ecosystems, contaminants, spatial variability, and climate-related change. | 30 contact hours |
| Practical Classes | Statistical and regression analysis; soil hydrophysical parameters; simulation; GIS-based spatial modelling; model calibration, validation, and error assessment. | 30 contact hours |
| Independent Study | Comparative model analysis, simulations, literature review, statistical evaluation, and preparation of reports or presentations. | 60 hours |
| **Total Workload** | **Complete academic module** | **120 hours total (4 ECTS)** |

## 6. Independent Study Tasks

- Compare the Van Genuchten and Brooks–Corey models for estimating soil hydrophysical functions (6 hours).
- Model soil-moisture distribution under different irrigation methods, such as drip and furrow irrigation, using HYDRUS-1D (6 hours).
- Use RothC and Century models to assess soil carbon sequestration and humus balance (6 hours).
- Review applications of RUSLE and WEPS for modelling water and wind erosion (6 hours).
- Analyse how DSSAT, APSIM, and AquaCrop represent the soil–plant–atmosphere system (6 hours).
- Model leaching requirements in irrigated soils and compare alternative management regimes (6 hours).
- Investigate spatial modelling of heavy-metal and dust contamination in industrial and mining areas (6 hours).
- Assess potential changes in soil fertility and desertification risk under climate scenarios (IPCC RCP/SSP) (6 hours).
- Review digital soil mapping using remote sensing data (Sentinel, Landsat) and machine-learning methods (6 hours).
- Calculate statistical error measures, including RMSE, NSE, and $R^2$, for model calibration and validation (6 hours).

## 7. Teaching Technologies & Methods

- Lectures and guided discussion
- Practical or laboratory activities followed by interpretation of results
- Case studies
- Group work

- Brainstorming
- Student presentations
- Collaborative work

## 8. Requirements for Earning Course Credits

Students must master the theoretical and methodological concepts of the course, present analytical results accurately, demonstrate independent reasoning about the processes studied, complete the assigned tasks, and pass the final written examination.

## 9. Assessment Criteria

- Excellent (5; 90–100 points): Demonstrates comprehensive understanding of the course; explains concepts accurately and logically; understands theoretical and practical significance; answers questions clearly; completes independent tasks fully; and applies theoretical knowledge to different situations.
- Good (4; 70–89.9 points): Understands the main concepts and their practical significance; explains topics with adequate scientific and logical consistency; answers questions correctly; and completes the assigned tasks.
- Satisfactory (3; 60–69.9 points): Demonstrates a general understanding but gives limited explanations, may make some errors or show gaps in reasoning, and provides incomplete or unclear answers.
- Unsatisfactory (2; 0–59.9 points): Shows insufficient preparation or understanding, fails to complete independent tasks, provides substantially incorrect or unclear answers, or does not demonstrate the required knowledge.

## 10. Recommended Literature & Information Sources

### Core Literature


- Bobomurodov, Sh. M., & To‘ychiyev, A. (2021). Methods of IT and Modelling in Soil Science and Agrochemistry. Tashkent: Fayz-Media. 254 p. (Title translated from the original syllabus.)
- G‘ofurov, A. A., & Razzoqov, A. (2019). Digital Mapping of Soil Erosion and Measures to Combat It. Tashkent. (Title translated from the original syllabus.)
- Xoliqov, B. M., & Bo‘riyev, S. (2020). Soil Fertility and Salt-Regime Management in Irrigated Soils. Tashkent: Navro‘z. (Title translated from the original syllabus.)


### Additional Literature


- Presidential Decree of the Republic of Uzbekistan No. PF-5847 (8 October 2019), “On Approval of the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030.”
- Artikova, H., Nafetdinov, Sh., Hojiyev, S., & Salimova, H. (2022). Plant Nutrition and Fertiliser Application. Study and Methodological Guide. Durdona Publishing. 158 p. (Title translated from the original syllabus.)

- Karimov, M. U. (2016). Fertiliser Application Systems. Tashkent: Navro‘z. 608 p. (Title translated from the original syllabus.)
- Hengl, T., & MacMillan, R. A. (2019). Predictive Soil Mapping with R. OpenGeoHub Foundation.
- Webster, R., & Oliver, M. A. (2007). Geostatistics for Environmental Scientists. University of Reading and Rothamsted Research.


### Information Sources

- Agro.uz: https://www.agro.uz
- Agroworld Uzbekistan: https://www.agroworld.uz
- AgroExpo Uzbekistan: https://www.agroexpouzbekistan.com
- AKIS: https://www.akiskr.uz
- Agro-Business: https://www.agro-business.uz
- Ministry of Higher Education, Science and Innovation: https://www.edu.uz
- ZiyoNET: https://www.ziyonet.uz

## 11. UN Sustainable Development Goals (SDG) Alignment

- SDG 2 — Zero Hunger: Modelling soil fertility, nutrient balance, crop-water needs, and agricultural productivity can support more reliable and sustainable food production.
- SDG 13 — Climate Action: Climate scenarios and simulations can help assess potential climate-related changes in soil moisture, salinity, carbon dynamics, and degradation risk.
- SDG 15 — Life on Land: Soil erosion modelling, digital soil mapping, and the assessment of degradation and contamination can support sustainable land management and soil protection.