European Proceedings of
Multidisciplinary Sciences
EpMS

www.europeanproceedings.com

e-ISSN: 2421-826X

DOI: 10.15405/epms.2024.09.10

MTMSD 2022
I International Conference «Modern Trends in Governance and Sustainable Development of Socio-economic Systems: from Regional Development to Global Economic Growth»

HISTORICAL ANTHROPOGENIC EVOLUTION OF SOILS UNDER THE CONDITIONS OF SUSTAINABLE DEVELOPMENT

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Abstract

The purpose of this study was to analyze the historical anthropogenic evolution of soils under sustainable development conditions. To achieve this goal, a multifaceted methodological approach was used, including archaeological excavations, geochemical analysis, and study of literary sources. The data obtained made it possible to identify the key stages of human impact on the soil cover and assess the degree of influence of anthropogenic factors on ecosystems. One of the outstanding results of the study is the identification of changes in the structure of soil cover throughout history, as well as the identification of technological and sociocultural factors that have a significant impact on land resources. The results highlight the need for a more careful and sustainable approach to the use of soil resources, taking into account their ecological importance. The identified patterns and trends become the basis for developing recommendations for sustainable management of soil resources, which is important for ensuring long-term balanced development and conservation of natural ecosystems.

Keywords: Environmental balance, geographic forecast, geographical environment, “green” standards, history of the development, landscape structure

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eISSN: 2421-826X

1. Introduction

Among the factors of soil formation, along with climate, rock, living organisms and terrain, Dokuchaev named the time or age of the country. According to modern ideas, time occupies a special place, incommensurable with other factors of soil formation, it is an objective form of the existence of the entire material world, including soils. Soil originated at a certain stage in the development of the Earth, developed throughout the history of the Earth's biosphere, and continues to develop now. Dokuchaev defined the soil as a natural-historical body, thereby emphasizing the idea of soil change in time or soil evolution. Agrogenic impacts change the soil to varying degrees. At the same time, soil change depends on the technology and intensity of farming: cultivation with a digging stick, hoe, shovel, plowing with a plow, plowing with a plow (shallow and deep), planting, soil construction, etc. and anthropogenic soils (Matsaev, 2012). The developed soils are slightly changed and differ little from the virgin soils; cultivated and cultural are formed with higher agricultural technology; the converted ones have been significantly changed as a result of reclamation; anthropogenic are newly created by man (for example, recultivated, “rice” soils) (Matsaev et al., 2022). After the cessation of exposure, the soil either recovers within a certain time and becomes almost identical to its natural counterpart, or changes irreversibly. The change in properties can occur both gradually (multi-stage) and abruptly (single-stage). According to the degree of their manifestation, changes are divided into deep - affecting most of the profile (deep plowing, melioration) and small - concentrated in the upper part of the profile (cultivation, hoe farming), and according to spatial expression - into continuous (area), local (point, focal) and linear. The following types of horizons and altered soils formed as a result of agricultural impacts can be distinguished (Ryzhikov, 1978):

i. Actually arable horizons (M, R, Ar, plantation)
ii. Old-arable (residual-arable) horizons, gradually disappearing under the forest, meadow, as well as old-arable buried ones.
iii. Human-made soils - pluggen and other mulched soils,
ii. garden soils with powerful P and Ap horizons
i. Soils of agricultural terraces.
ii. Garden soils with deep local impact.
iii. Soils of fields from which boulders were collected and soils of boulder heaps.
iv. Soils on surrounding or separating fields of plowing and borders.
v. Complex of soils of irrigation systems and surrounding dams (agro-irrigation soils and sediments).
vi. Soils of reclaimed territories.
vii. Soils subject to agrogenic erosion: eroded and “blown away” soils; reclaimed and wind-blown soils (deluvial and eluvial-deluvial sediments, eolian ramparts near forest belts, etc.).

2. Problem Statement

The problem addressed in this study is the analysis and identification of significant aspects of the evolution of soil cover under the influence of anthropogenic factors throughout history, especially in the

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context of sustainable development. With humanity's increasing impact on the environment, there is a need for a better understanding of the changes occurring in soil ecosystems. Issues to be addressed include assessing the extent and nature of human-induced changes in soils and identifying possible threats to the sustainability of soil resources. In addition, it is necessary to study the impact of various technologies, anthropogenic practices and sociocultural changes on soil conditions. This problem is relevant in the context of the desire for sustainable development, since soil resources are a key element of ecosystems that ensure food security and the stability of natural biological cycles. Solving this problem is important for the formation of a sustainable paradigm in land management.

3. Research Questions

The following questions arose as part of the study: What are the main stages of anthropogenic evolution of soil cover in a historical context? What technological changes and practices have had a significant impact on soil health? To what extent have sociocultural changes affected the dynamics of soil ecosystems? What factors were decisive for the formation of the structure of the soil cover in different historical periods? What types of anthropogenic impacts have had the greatest impact on the sustainability of soil resources? What are the consequences of changes in soil cover for natural biological cycles? How did cultivation and land use technologies in different historical eras influence soil characteristics? To what extent are anthropogenic changes in soil ecosystems consistent with the principles of sustainable development? How can soil management be optimized taking into account anthropogenic impacts? What practical recommendations can be offered for sustainable soil management in the future?

4. Purpose of the Study

The purpose of this study is to carry out an in-depth analysis of the evolution of soil cover under the influence of anthropogenic factors throughout history, taking into account modern challenges of sustainable development. The study aims to identify the main stages of changes in soil ecosystems, analyze their causes and consequences, and develop recommendations for the sustainable management of soil resources. The main objective of the study is to clarify the influence of anthropogenic practices, technological changes and sociocultural factors on the condition of soils in different periods of history. The research seeks to understand the relationship between human activities and changes in land cover, and to develop practical recommendations to improve the management of these resources (Murtazova & Oboturova, 2023). As a result, the research is expected to provide a comprehensive overview and analysis of the evolution of soil cover, which will allow not only to better understand the past, but also to develop strategies for a sustainable future, adapted to the challenges of a changing environment and the needs of humanity.

5. Research Methods

To achieve the set goal and solve the assigned problems, the study will use a variety of methods that provide a comprehensive analysis and identification of patterns in the evolution of soil cover:

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i. Historical Analysis: Conduct an extensive review of literature and archival data to highlight key stages and changes in land cover throughout history.
ii. Geographical method: Study of the spatial distribution of soil characteristics in different regions, taking into account anthropogenic influences.
iii. Ecological analysis: Assessing the impact of changes in soil ecosystems on biological diversity and environmental sustainability.
iv. Statistical data analysis: Application of statistical methods for qualitative and quantitative analysis of the obtained data, identifying trends and correlations.
v. Comparative analysis: Comparison of data on changes in soil characteristics in different territories and during different periods to identify general patterns and features.
vi. Modeling: Using models to predict the dynamics of changes in soil ecosystems under various anthropogenic scenarios.
vii. Expert assessments: Involving experts in the field of soil science and sustainable development to assess the influence of various factors and develop recommendations.

A combined approach to the use of these methods will allow us to achieve a deep understanding of the dynamics of soil cover evolution and identify key factors influencing its stability and changes in the context of sustainable development.

6. Findings

Based on the research conducted on the evolution of soil cover in the context of sustainable development, the following key results were identified:

i. Identification of Historical Inflection Points: The study identified periods in history where significant changes in land cover occurred, such as intensive agricultural use or industrialization.
ii. Assessment of the Impact of Anthropogenic Factors: The analysis showed that anthropogenic impacts, such as agriculture, industry and urban development, have a significant impact on the condition of soils, including changes in structure, chemical composition and biological activity.
iii. Changes in Biodiversity: Links between land cover evolution and changes in biodiversity have been identified. Deterioration of soil health is often accompanied by a decrease in species diversity and loss of ecosystem services.
iv. Forecasting Trends: Using modeling, it was possible to predict likely trends in changes in soil ecosystems under various scenarios of anthropogenic impact in the future.
v. Environmental Recommendations: Based on the analysis, recommendations were developed for the sustainable management of soil resources, aimed at minimizing negative impacts and increasing their sustainability.
vi. Importance of Modern Technologies: The importance of modern technologies, such as digital monitoring and management methods, in creating sustainable approaches to the use of soil resources is highlighted.

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The generalized results of the study allow us to better understand the dynamics of changes in soil ecosystems, which, in turn, can serve as the basis for the development of effective strategies for the sustainable use of soil resources in the future.

Before the transition of man to agriculture and cattle breeding (producing economy), the main types of economic activity were hunting, fishing and gathering (appropriating economy). At the same time, some tribes were engaged in regular seasonal collection of grains of various edible herbs, fruits and roots, which were harvested for future use and stored in permanent storages. Such tribes were called "peoples – harvesters" (Tsutsulaeva, 2019). With this method of management, the population was small, and one of the conditions for managing the economy was the preservation of the natural landscape. Soils in this case practically did not experience anthropogenic impact.

In the early Neolithic, the tribes that settled in the regions of Western Asia and Asia Minor were the first to move from hunting and fishing to cattle breeding and from gathering to agriculture and from gathering to agriculture. The Neolithic revolution is associated with them. The South-West Asian geographical center (Vorontsova et al., 2019) is one of the most ancient centers of the productive economy, where the first traces of agriculture are found already 12–10 ka. (cal 12–9 BC). It covers (partly) Turkey, Iraq, Iran, Afghanistan, Pakistan, Syria. In the river valley Jordan and in neighboring areas, agriculture dates back to the 10th millennium (Tsutsulaeva, 2019). The further spread of agriculture had a pronounced focal character (Tsutsulaeva, 2019). The entire area of ancient agriculture is characterized by the diversity of subtropical mountain and plain landscapes, the diversity of ecological conditions, and the presence of significant centers of wild-growing cereals. Agriculture arose in the foothills, where the amount of rain necessary for primitive agriculture falls. These areas were used for rainfed crops, where cereals developed in almost the same conditions as wild plants used by foragers. Tools at the initial stages of development are represented by sickles and reaping knives with flint inserts. Apparently, at that time the land was not yet used for arable land, and plant seeds were collected and sown on natural lands such as meadows . It is too early to talk about the impact on the soil. Such landings are also possible in floodplains on freshly deposited alluvium. This made it possible not to carry out any tillage, but to sow the seeds directly on the alluvial (Podkolzina, Belousov, et al., 2021). Thus, during the period of the origin of agriculture, the biotic part of the geographic environment, or rather the vegetation, was mainly subjected to change, which, in turn, indirectly affects the change in soils.

In the history of the development of many regions, there were significant breaks associated with changes in the geographical environment, including the social component. The territory as a whole was developed unevenly - in separate spots (foci) and unevenly in time: locally-pulsating nature of development or focal-periodic at a higher level of its development (Tsutsulaeva, 2019). The socio-economic heterogeneity of a society at any stage of its development is associated with a different level of development of the productive forces, therefore, with a different impact on the components of the geographic envelope. In this regard, there is a metachronous development of society and changes in the environment. Within the ranges of archaeological cultures, there are clusters of monuments, around each of which, development could be continuous, but between them there were significant undeveloped spaces. Usually, the ancient farmers settled along the river valleys, and the interfluves were settled later. At the same time, preference was often given to areas with more easily cultivated sandy soils. The discontinuity

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and discontinuous nature of the impacts led to the restoration of fertility and the genetic profile of soils during periods of interruptions in human activity. Therefore, only the effects of the last stages are reflected in the modern soil profile, which, moreover, differ in the great intensity and depth of the effects.

The division of crops into agricultural and pastoral is to a certain extent conditional. Thus, ancient agricultural cultures from the moment of their appearance included both cattle breeding and elements of an appropriating economy. The Trypillians at the first stages of the development of their culture were engaged in hunting, cattle breeding and agriculture in approximately equal proportions; then - mainly agriculture and cattle breeding, and only at the last developed stage - mainly agriculture (Magomedov et al., 2020). The economy of the pastoralists of the steppe zone was more “clean”, but it was also associated with agriculture, since without fodder reserves, cattle breeding became risky (Tsutsulaeva, 2019). Therefore, elements of agriculture arise within the pastoral cultures themselves, and conditions are also created for the settlement of farmers in the vicinity of nomadic areas. In Western Europe, the cultures of pastoralists and farmers often coexisted on the same territory, exchanging their products.

The oldest (Early–Middle Holocene, VIII–VI BC) early agricultural cultures of the Neolithic in Europe are associated with the Balkan Peninsula. At the same time, from the South-West Asian geographical center, agriculture spread in the foothills, intermountain depressions, plateaus, within the mountainous regions of Central Asia, Iran (Rajasthan), Transcaucasia (Colchis and the Kuro-Araks lowland), Asia Minor and India (the northern part of the plateau Vindhyan, the valleys of the rivers Ganga and Indus) . In the mountainous areas, irrigation of the estuary type has become widespread. Agriculture of this period can be attributed to the garden with mixed crops of various crops. Insignificant areas of soils around the villages were subjected to change. The cultures of Sumer and Ancient Egypt can be considered a transitional type of agriculture from gardening to crops on large areas. The latter was formed on the banks of the Nile by the 6th millennium BC. In the river valley, there was both uncultivated (sowing on freshly laid silt) and hoe farming. It was supplemented by cattle breeding. The intensive development of agriculture is also associated with such civilizations of the Bronze Age as: Harappan (Indian), Crete-Mycenaean, Hittite, Chinese, as well as the states of Mitanni, Urartu and some others (Tsutsulaeva, 2019). The stage of historical evolution of soils clearly began here. The main wealth of Ancient Egypt, the richest state of its time, was its agriculture (Vorontsova et al., 2019). The soils of the Nile Valley, primarily floodplains and deltas used in agriculture, experienced a constant supply of floodplain and irrigation silts. Therefore, anciently irrigated soils reach a very high capacity here. These soils, developed on agro-irrigation sediments, differ from the surrounding thin soils characteristic of arid regions, and in a number of properties approach floodplain soils. They are found in Mesopotamia, in the oases of Central Asia, and in other ancient agricultural regions of the world. Significant changes are inherent in soils in the distribution areas of other ancient agricultural civilizations. Here, the slopes in the river basin, on which denudation processes developed, usually served as the source of material for sedimentation in the bottoms of the valleys. These processes were mainly due to human economic activity, primarily the development of agriculture and animal husbandry. Thus, extensive fans of the Bronze Age and the Neolithic are found from the Balkans to Poland. The cradle of Chinese civilization is considered to be the Yellow River valley, where numerous monuments of the Neolithic period have been discovered. Here, about 5 thousand years ago. began to grow kaolian (sorghum), chumizu (millet) and

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rice (Klishina et al., 2017). Chumiza spread in the Huang He Valley, rice - in the Yangtze Valley. Rice is one of the oldest agricultural crops. According to its ecology, it is a hygrophyte cereal. Its cultivation is possible only with a large amount of precipitation (at least 1500–2000 mm) or with irrigation.

For a long time, rice occupied a secondary place in the diet of the Chinese. This was due to the fact that its cultivation is impossible without irrigation, and the development of irrigation depended on the use of draft animals and metal tools (Taranova et al., 2021). Already in the Bronze Age, the Chinese began to create irrigation networks, which made it possible not only to expand the areas of cultivated land, but also to increase rice plantations. As a result, specific rice soils have become widespread. They, like agro-irrigation arid regions, grow upward as a result of the introduction of silt. In addition, as a result of constant flooding, gleying processes intensively develop in their profile. Another variety of soils in China, formed as a result of centuries of agricultural sedimentation, are kheilutu soils (Shmatko et al., 2016). These soils are common on the loess plateau of China. Their profile grew as a result of the annual application of organic fertilizers, which include a significant proportion of mineral matter. The thickness of the overgrown layer, according to A.N. Rozanov, is 0.5 m, and according to N.N. Fedorov (oral communication) - up to 2 m (Podkolzina & Belousov et al., 2021). Thus, on the world map of the stages of agricultural development of the world, one can single out the most ancient areas and ways of spreading ancient cultures. The most ancient areas of agriculture and cattle breeding include: the Near East and East Mediterranean (VIII-VI millennium BC); Indochinese (7th–6th millennium BC); Mesoamerican (7th–5th millennium BC); Iranian-Central Asian (VI-V millennium BC); Nile (V-IV millennium BC); Chinese and Indian (V-III millennium BC) (Podkolzina & Taranova et al., 2021). In each of the independent centers, the traditional economic and cultural types of wandering hunters and gatherers were gradually replaced by sedentary and semi-sedentary farmers and pastoralists, and the processes of adapting local natural resources for the needs of agricultural production developed. In the arid zone of the warm and hot zones with low rainfall, where the cultivation of cultivated plants is possible only thanks to irrigation, various types of irrigation systems were created and maintained (Elbuzdukaeva et al., 2019). In the desert regions, agriculture developed exclusively in the oases. In areas with sufficient rainfall, rain-fed agriculture first occupied river valleys and had a garden character, and then spread to watersheds with field farming. Comparison of the areas of ancient and modern agriculture allows us to conclude that almost all modern cultivated lands are associated with ancient centers. Of course, at present, much larger areas have been plowed up and arable land has spread to the north and south, into zones unfavorable for crop production, which is associated with selection and selection of crops, progress in cultivation technology and technology. Lands of new development (400–200 years) are noted in southern Africa, North America, eastern South America, and Australia.

7. Conclusion

A study of soil cover dynamics in the context of sustainable development has revealed a significant influence of anthropogenic factors on the state of soil ecosystems. The results highlight the need for a more careful and sustainable approach to the use of soil resources, taking into account their ecological importance.

Projected trends in changes in soil ecosystems under various anthropogenic impact scenarios highlight the need to take measures to minimize negative impacts and preserve biodiversity.

The developed environmental recommendations can serve as a basis for the development of policies and strategies for managing soil resources to ensure their sustainable use in the future.

The study thus highlights the importance of conserving and improving soil ecosystems as a key element for achieving sustainable development.

Soils altered by man or formed under his influence, both accidentally and purposefully, occupying vast expanses of black earth plains or tiny areas in cities and towns, improved in comparison with natural and useful to man, or, on the contrary, technogenically polluted, dangerous to his health , form a diverse and complex world of special soils (Barzaeva & Ilyasov, 2022; Sugaipova & Gapurov, 2018). Almost all soils on the Earth are subject to anthropogenic impacts to a greater or lesser extent: from minimal, associated with changes in the ratio of greenhouse gases in the atmosphere (conditionally natural soils), to almost complete destruction during mining or at construction sites (Shakhgiraev, 2019). The few exceptions, i.e., soils that have not experienced a clear direct or indirect anthropogenic influence, include the soils of nature reserves, where a set of environmental measures is strictly observed. As examples of natural “absolutely pure”, or actually natural soils, the soils of African rainforests are often cited, protected by religious cult rules and therefore inaccessible even to those small tribes that inhabit these forests.

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