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Thematic Issue on Problems of Geography

Sustainable Land Management and Land Degradation Neutrality

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Abstract—The active development of the concept of sustainable land management (SLM) is inextricably linked with approaches to land degradation neutrality (LDN). It is considered that so-called good land management practices make it possible to prevent or reduce the risk of land degradation and reverse it while maintaining the productivity potential and ecosystem functions. Based on analysis of the correspondence of good practices to SLM parameters and the hierarchy and typology of land management developed on this basis (with the categories of *practice, model, type, class*), it is shown that individual practices and technologies do not always lead to the achievement of land degradation neutrality and, conversely, it is not always achieved by sustainable land management approach. SLM modeling using qualitative rating scales and radar charts has shown high effectiveness in visualizing the integrity of models and adjusting them to achieve the best result. An improved typology is proposed with three main classes of land management: simple, supported, and expanded. Particular attention is paid to the *other forms* class, which includes natural functioning, long-term abandonment of land, and destructive land management. An algorithm scheme to recognize sustainable land management in the case of land degradation is proposed, as is an inverse algorithm to achieve land degradation for different land management models. A hypothesis has been put forward about the landscape–ecological framework of SLM, which makes it possible to explain the causes of the discrepancy between the estimates of LDN for objects of different scales: achieving land degradation neutrality in a certain territory is possible not so much by continuous coverage of this territory with good SLM practices as by preserving the framework of SLM models, types, and classes.

Keywords: land resources, land degradation neutrality (LDN), land management typology, landscape–ecological framework, land degradation, good practices, sustainable land management

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Sustainable land management (SLM) is an integrated approach to addressing the problems of land resource degradation and maintaining the potential of land productivity and ecosystem functions. The formation of the SLM concept began in the late 1980s and early 1990s and was associated with the preparation of the UN Conference on Environment and Development in Rio de Janeiro in 1992. The Framework for Evaluating Sustainable Land Management [1, 2] formulated five basic assumptions that define SLM as a combination of technologies, strategies, and actions to integrate simultaneously socioeconomic principles with environmental concerns to maintain or improve production/services, reduce production risks, protect the potential of natural resources, and prevent soil and water degradation, while being economically viable and socially acceptable.

The recent active development of the concept of sustainable land management is inextricably linked with the application of land degradation neutrality (LDN) approaches in accordance with Goal 15 of the 2030 Agenda for Sustainable Development, adopted in 2015: "Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" [3]. It is commonly considered that technologies and practices of sustainable land management can prevent, reduce the risk, and mitigate adverse effects of irrational use and reverse land degradation [4–7].

Despite the huge number of works (according to Google Scholar, more than 1.6 million on the hashtag "sustainable land management" for 2010–2022), with

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all the variety of approaches and elaboration of the SLM issue, the understanding of the sustainability of land management and its interpretation remains debatable. Even the translations of the term itself into Russian differ: *устойчивое землепользование (sustainable land use), рациональное использование земель (rational use of lands), устойчивое управление земельными ресурсами (sustainable management of land resources)*. Different authors interpret SLM through different approaches: integrated soil fertility management [8], conservation agriculture and improved pasture management [9], improved water and forest management [10], conservation of natural resources for food production [11], increased soil organic carbon [12], restoration of ecosystems in general [13]. The Food and Agriculture Organization of the United Nations (FAO) considers SLM as a path to minimize land degradation, restore degraded areas, and ensure the optimal use of land resources for the benefit of present and future generations [14]. An important aspect is the reflection of the economic component of sustainable land management. The Economics of Land Degradation Initiative defines SLM as a set of possible technologies, practices, and approaches to manage land resources at the local level, and numerous projects on the economic valuation of ecosystem services confirm that investments in sustainable land management successfully pay off [15]. To date, the most accepted and succinct definition of SLM is "the use of land resources, including soil, water, animals, and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions" [16, p. 46].

Therefore, on the one hand, the concept of sustainable land management has become widespread, while on the other hand, existing approaches do not make it possible to determine the sustainability of a particular land management practice and technology. The authors rely mainly on environmental indicators, such as soil erosion rates or water quality; however, these parameters are not always decisive for the selection of best SLM practices and depend mainly on the type of land management and natural area. Generally accepted criteria for the effectiveness of the applied measures and the sustainability of impacts are not formulated. As a rule, they are established by expert assessment depending on the target direction of a particular technology at the local level, the degree of land degradation, the risk of degradation processes, and the need for radical intervention to combat land degradation and preserve ecosystem functions. For example, article [17] considers the introduction of SLM practices and technologies as a way to mitigate the negative impact of droughts on the productivity of farmland, pastures, forests, and forest plantations. Works [7, 12] show that sustainable land management practices contribute to the maintenance and increase in the reserves of soil organic carbon, which is considered as one of the main indicators of the state of an ecosystem and a key criterion for selecting SLM technologies.

The concept of land degradation neutrality has made it possible to reassess sustainable land management approaches, as evidenced by a large number of works over the past 5–7 years (more than 17 500 on the hashtag "sustainable land management land degradation neutrality" according to Google Scholar). According to the definition approved by the 12th Conference of the Parties of the United Nations Convention to Combat Desertification (UNCCD) [18], land degradation neutrality (LDN) is "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remains stable or increases within specified temporal and spatial scales and ecosystems." The development of this concept made it possible to propose consideration of ways to achieve LDN through a hierarchy of responses—activities aimed at avoiding, reducing, and reversing land degradation [6]. We suggest evaluating the effectiveness of these measures (SLM practices and technologies) through achieving land degradation neutrality in a specific area [19]. Work [7] emphasizes that sustainable land management is one of the main mechanisms for achieving LDN. The possibility of choosing the best practices for sustainable land management and modeling the achievement of land degradation neutrality at various levels is shown in article [20], and work [21] demonstrates the possibility of using the "LDN index" as a simple and effective tool indicating effective land policy and the reduction of land degradation risks in a region or farm. Finally, based on the integrated consideration of the SLM and LDN approaches, we formulated and for the first time proposed for use in Russia a definition of the concept of *land degradation*, referring to any categories of lands and farmlands: "a set of a wide range of natural and anthropogenic causes, phenomena, and processes leading to a decrease in the economic and/or natural potential of lands and the ecosystem services they provide or their resistance to negative impacts" [22, p. 63].

However, despite these direct proposals and the apparent simplicity of the working hypotheses, no algorithms have yet been developed for applying LDN approaches to assessing SLM. The cause was revealed through a detailed analysis of land management types [20]. It has been found that not all so-called good land management practices contribute to the achievement of land degradation neutrality, and, conversely, not every case of neutrality is necessarily associated with any land management model. This, at first glance, paradoxical and unexpected conclusion made it possible to rethink the relationship between SLM and LDN and formulate the objectives of this work:

• analysis of the substantive compliance of sets of good practices with SLM parameters;

• analysis of the interrelations between LDN and SLM and development of approaches to the typology of SLM models;

• development of an algorithm for recognizing SLM in the case of achieving LDN and vice versa;

• formulation of a hypothesis about the SLM landscape–ecological framework.

Materials and methods. The objects of our study are the so-called "successful" (best and good) practices and technologies of sustainable land management, described in various sources, mainly on international knowledge exchange platforms. The main global platform that implements SLM approaches is the WOCAT network (World Overview of Conservation Approaches and Technologies) [23]—a global database recommended by the UNCCD for documenting, evaluating, disseminating, and exchanging experience in applying best practices for land degradation prevention and land and water resource conservation. This database contains more than 2000 successful practices from 133 countries.

FAO also provides numerous scientific reference materials and databases for both professionals and local land users: FAOSTAT, TERRASTAT, AQUASTAT, and FORIS; they contain information on agriculture, land, water, and forests. They summarize the data of the Land Resources Information Management Systems (LRIMS), the Global Terrestrial Observing System (GTOS), the FAO/UNESCO Digital Soil Map of the World, the FAO/IIASA Global Survey of Agroecological Zones (GAEZ), the Forest Resources Assessment (FRA), the Land Cover Network (GLCN), and the program "Land Degradation: Land Degradation Assessment in Drylands" (LADA). International initiatives such as the Asia–Pacific Agroforestry Network (APAN), the Asia Watershed Management Network (WATMAN), the Integrated Saline Soil Management Network (SPUSH), and the Central Asian Countries Initiative for Land Management (CACILM) provide detailed descriptions of good land management practices and experience in combating land degradation at the local and regional levels.

There are no similar network resources in Russia yet; however, educational and specialized scientific publications have accumulated extensive experience in the development, implementation, and dissemination of practices aimed at combating water and wind soil erosion; waterlogging, salinization, alkalinization, and compaction of soils; and soil and water pollution. Technologies to determine the optimal relation of mineral fertilizers, the calculation of the allowable load on pastures, the creation of structures for protective forest belts, forest management, etc., are described. An example of one of the most actively developing databases on the exchange of experience in the application of resource-saving technologies is the Agroecocommission platform (good practices using precision farming technologies, mineral and organic fertilizers, and soil organic carbon reserves monitoring) [24].

The methodology for the analysis of good land management practices and models within the framework of this study relies on our previously published approaches to the typology of land management objects [20, 25]. Let us recall the most significant of them.

The notions of *land management object* and *land management model* are defined. A land management object is understood as an integral landscape and economic object with definite boundaries on the ground, within which the effectiveness of the applied practices and the achievement of LDN are assessed. A land management model means the central image of a set of practices and technologies (as opposed to particular local practices) that have similar technological methods, natural and socioeconomic conditions, potential land degradation risks (including anthropogenic impacts), and the possibility and ways to achieve land degradation.

A set of nine features to recognize land management sustainability is proposed: natural negative impact, anthropogenic negative impact, degradation risk, natural/initial potential, self-restoration ability, artificial balance/restoration, adaptation technologies, innovative technologies for capacity building, and sufficiency of resources and socioeconomic conditions. Approaches to the typology of SLM models are formulated, and a hierarchy of land management practices is described with the identification of the categories of *practice, model, type*, and *class*. The classification is based on the nature of the resources used (natural, supported, expanded), and the types, on the leading feature for a given class.

Approbation of the approaches listed has shown that the identification of types and classes of SLM models is progressive since it makes it possible to substantiate the recommendations for choosing specific practices. At the same time, their implementation is difficult due to the unfinished system of expert assessment of the land management sustainability parameters and the lack of clear algorithms for LDN identification.

To improve the approaches, we developed a qualitative scale based on five generalized SLM parameters, assessed by the degree of their manifestation (see Table 1). The integral evaluation and visualization of the results was performed using radar charts (Fig. 1).

Analysis of sets of land management practices. Since it is difficult to reflect the full results of the analysis of different practices and models within the framework of an individual article, we will show them using some examples, demonstrating the impact of individual and integrated practices on the sustainability of land management models. Three models are considered below:

Table 1. Qualitative scale for characterizing the degree of manifestation of the evaluation parameters

Generalized land management sustainability parameters	Degree of manifestation				
	none or very low	low	medium	high	very high
(1) Adverse natural processes and phenomena (current), NP	5	4	3	2	1
(2) Adverse anthropogenic impacts and resultant processes (current), AP	5	4	3	2	1
(3) Risk of development of degradation phenomena (potential degradation processes), Rk	5	4	3	2	1
(4) Natural and/or expanded land potential, LP	1	2	3	4	5
(5) Ability of lands for self-restoration, adaptation technologies, compensatory and restoration measures, R	1	2	3	4	5

restoration and maintenance of mountain pastures (see Fig. 1a), irrigation on saline soils (see Fig. 1b), and antierosion farming systems on rainfed lands (see Fig. 1c). The diagrams help us to come to the following conclusions.

Any practice described by individual polygons always has better characteristics than the initial state, assumed as “business-as-usual”—the initial state without the use of good practices and characterized by the worst characteristics of the parameters estimated (“1” on the accepted scale). The area of each polygon can be considered as a relative measure of the overall effectiveness of the respective practice. Each practice is focused, as a rule, on enhancing only certain parameters of the model, for example, reducing the intensity of adverse anthropogenic and natural processes, preventing risks, and increasing the adaptive capacity or self-restoration ability; other parameters may be improved indirectly or not affected at all by a particular practice.

An SLM model is a set of good practices, and only their combination can lead to an increase in the sustainability of the model as a whole. In this system, the integrity of the SLM model is described by the total area of the figure, including the outer perimeter of all polygons. The acuteness of the angles of the final figure can serve as a sign of an imbalance in the set of practices chosen for a particular case.

When striving for the highest possible sustainability, an SLM model should include practices that have maximum values in all parameters. This is achieved by adding practices aimed at improving the missing parameters. The examples provided deliberately do not represent all the practices that fit the selected models to demonstrate the synergistic and cumulative effects of amplification. For example, the grazing model could be complemented by fencing practices that aim to enhance the self-restoration of the ecosystem and reduce risks to a minimum; the irrigation model, by a technology for the use of salt-tolerant crops, which is distinguished not only by reducing risks but also by increasing the potential for restoration and reducing the negative impact of natural processes; and the antierosion model, by terracing of slopes, which reduces the risks and negative consequences of anthropogenic processes and increases the potential of the system.

Although some practices do not reflect improvement to the greatest extent in some selected parameters, they nonetheless strengthen the overall sustainability weight of the respective SLM model and its integral or synergistic effectiveness. These, in particular, include many practices aimed at improving or restoring and maintaining infrastructure (roads, communications, and other fundamental structures, as well as engineering measures).

Pentagrams of sustainable land management models are presented schematically to reflect the principle of the study, although it is obvious that the parameters of the model can be expanded to the original nine features or more (for example, to include socioeconomic efficiency parameters); qualitative scales can also be modified (for example, to include more than five ranks of the proposed nominative scale, to reflect numerical values, etc.).

The approach proposed for modeling and visualizing SLM makes it possible to characterize practices, techniques, and technologies in a new way from the standpoint of their success or sustainability: each practice is considered as part of a specific SLM model and is aimed at improving its parameters/features. The sustainability of a land management model is determined proceeding from a comprehensive analysis of the practices assessed within the boundaries of a territory on quantitative and qualitative scales. It is also important to identify bottlenecks in land management and justify the introduction of a necessary set of practices (technologies) aimed at implementing sustainability parameters (reduction of risks and the intensity

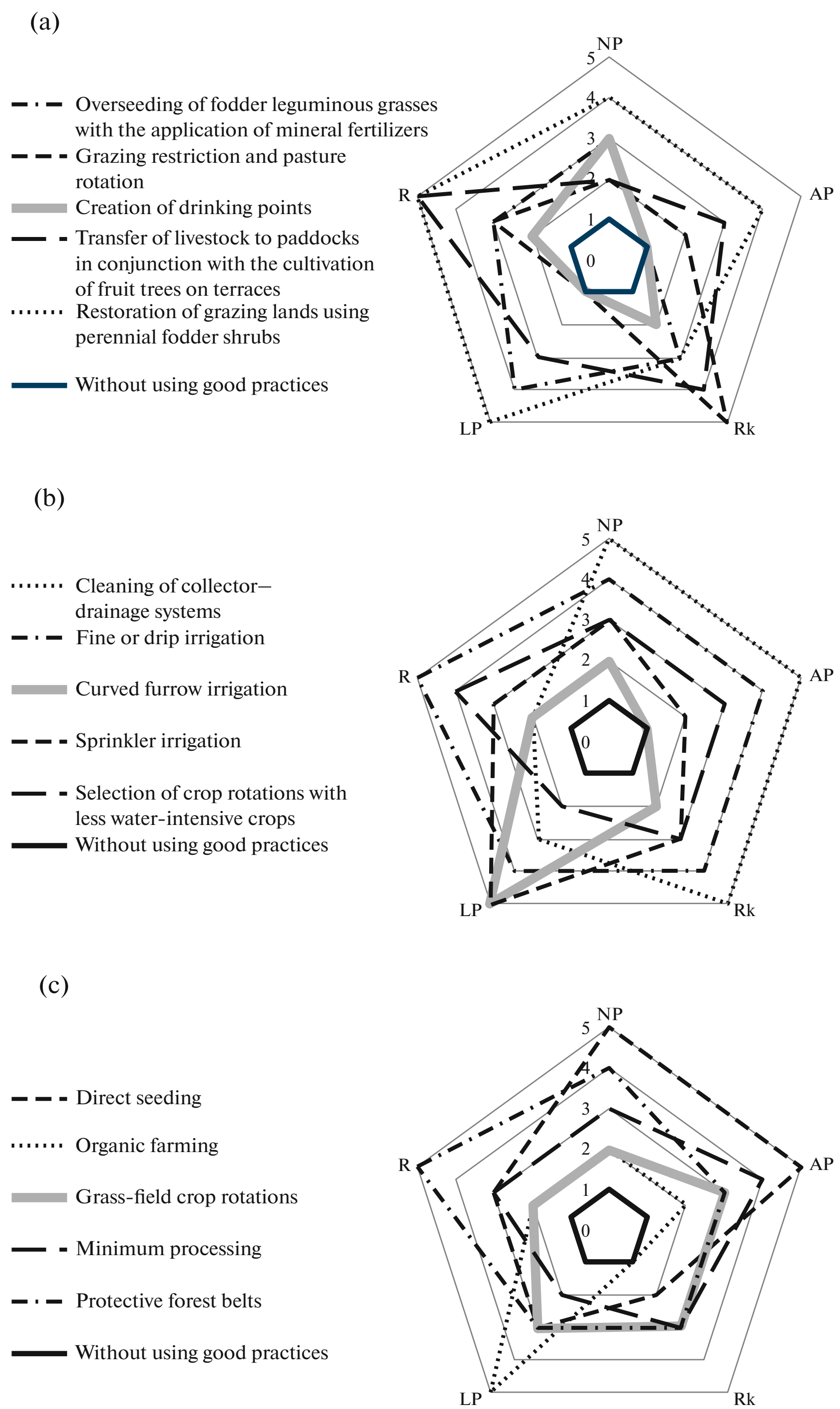

Fig. 1. Examples of analysis of models of sustainable land management. (a) Restoration and maintenance of the productivity of mountain pastures; (b) irrigated agriculture on saline soils; (c) anti-erosion systems of agriculture; NP AP, Rk, LP, R (see designations in Table 1).

of negative processes, compensatory measures, or self-restoration maintenance).

LDN and SLM nexus: Improving the typology of land management models. As was noted above, the modern development of the SLM concept is inextricably linked with the application of LDN approaches. However, testing the working hypothesis that any practice of sustainable land management or their combination leads to the achievement of land degradation neutrality and that the fact of established neutrality testifies to the sustainability of land management has shown that this seemingly obvious thesis is not always observed and cannot be considered as an axiom. [20]. The main cause of the discrepancy lies primarily in the fact that the establishment of land degradation neutrality is carried out without a semantic analysis of the balance of ecosystem functions and services and is based on formal features alone. The latter are usually signs of negative dynamics of land cover, productivity, and soil organic carbon reserves (global indicators of LDN) or their analogues and additional indicators of the national and local levels [6, 20, 21, 26]. The above examples of land management models clearly demonstrate that the sustainability of land management is also significantly influenced by conceptual features: the risk of degradation, the natural and actual potential of lands, their restoration ability, and natural processes and phenomena.

Generalization of the results of the analysis of various land management models made it possible to improve our typology [20]. The updated version (Fig. 2) retains (with minor changes) the three main SLM classes—simple, supported, and expanded. Each of them is considered from the standpoint of exploited resources, potential (natural and current), restoration ability, the possibility of achieving LDN in the short or long term (see Fig. 2a), risks, degradation processes, and the set of SLM practices (see Fig. 2b). Particular attention is paid to the class *other forms* (the attribution of which to SLM is questionable), which includes natural functioning; long-term abandonment of land; and destructive land management, which leads to a complete or partial loss of the natural potential.

In the context of this typology and the above methodology for analyzing SLM models, it can be concluded that individual practices cannot always be classified as sustainable, especially in cases where active measures are needed to rehabilitate or maintain the current (expanded) potential of the land or when practices are poorly coordinated with each other or are aimed at different purposes (for example, obtaining economic or environmental benefits). This confirms once again that the use of the term *sustainable land management* (or *SLM practices*) in relation to specific practices or technologies does not make sense since it refers only to land management models. Such models include a set of elements (practices, technologies) that it would be better to term as *successful* or *best*.

Compared to the information in [20], the principle of typifying SLM models (within the corresponding classes) is also preserved—according to the leading features of the observed natural or current potential; however, the updated typology seems to be more rigorous and justified. It is proposed to assess the potential of land using a comparison with the initial state (LDN baseline) and to select accordingly a set of good practices for an SLM model of a particular type. In this case, the proposed approach is fully consistent with the concept of land degradation neutrality in relation to the requirements on the "baseline" [6, 27]. An example of such a typology for the grazing model of sustainable land management is shown in Fig. 3. We see that the SLM type with high natural potential corresponds to a low risk of degradation and a minimum set of measures necessary to achieve land degradation neutrality. On the contrary, for the SLM type with low natural potential, an expanded set of measures is required for achieving LDN and reducing the risks of land degradation.

The refined typology of SLM models made it possible to specify the cases when the achievement of LDN should be considered as a sign of SLM (Fig. 4a) and the cases when a set of good practices will lead to the achievement of LDN (Fig. 4b). To this end, additional notions of *active* and *passive* land management practices are introduced into the algorithms. By passive ones, we mean the actual absence of any special actions aimed at maintaining natural or anthropogenic ecosystems. In some cases (for example, protected areas or fallow lands, which we attribute to *other forms*), such situations can also be considered as a way of land management, even sometimes aimed at restoring or not deteriorating land. However, their distinctive feature is the absence (or cessation) of direct anthropogenic intervention at a given point in time. Active practices in any case involve some form of external influence or ecosystem change. Figure 4a shows that in the case of establishing land degradation neutrality on formal grounds (indicators), only active land management practices in combination with self-restoration and sufficient compensatory and supporting measures can be characterized as models of sustainable land management.

Conditionally sustainable are models in which, even in the case of passive practices, natural processes contribute to the achievement of LDN according to formal indicators (old-growth forests, long-term fallows). Figure 4b demonstrates that, despite a certain set of good active practices, LDN cannot be achieved if compensatory measures are insufficient or not coordinated or if these practices do not account for the necessary length of the self-restoration period of natural systems. On the contrary, in some passive practices, the achievement of LDN is quite possible, both in the case of trends perceived as positive and in the case of negative processes.

The proposed algorithms for matching LDN and SLM are clearly confirmed by the latest works [28, 29], which show that the dynamics of land degradation is largely due to natural or natural–anthropogenic factors and processes (for example, the climatic factor [29], Holocene landscape dynamics [28], and changes in hydrology and hydrogeology under the development of irrigation systems [30]), which have a higher transformative potential than individual land management practices. The latter act as triggers for these processes, changing them in a positive or negative direc-

Fig. 2. Land management classes. (a) Exploited resources, potential, resilience, and the possibility of achieving LDN in the future; (b) risks, degradation processes, and the set of SLM practices.

tion, and determine the intensity and type of processes and regimes established using global or additional indicators [31] (soil erosion, salinization and desalinization, soil compaction and structuring, accumulation or loss of organic matter). Respectively, in addition to assessing the possibility and degree of achieving LDN according to formal indicators, it is also important to assess the risks of not achieving land degradation neutrality (see Figs. 2a, 3, 4b). The risks of non-achievement of LDN can manifest themselves against the background of the widespread use of good practices and land management models, which seems to be still another promising research topic.

Thus, the thesis discussed above was confirmed that land degradation neutrality and sustainable land management are not always in direct correspondence,

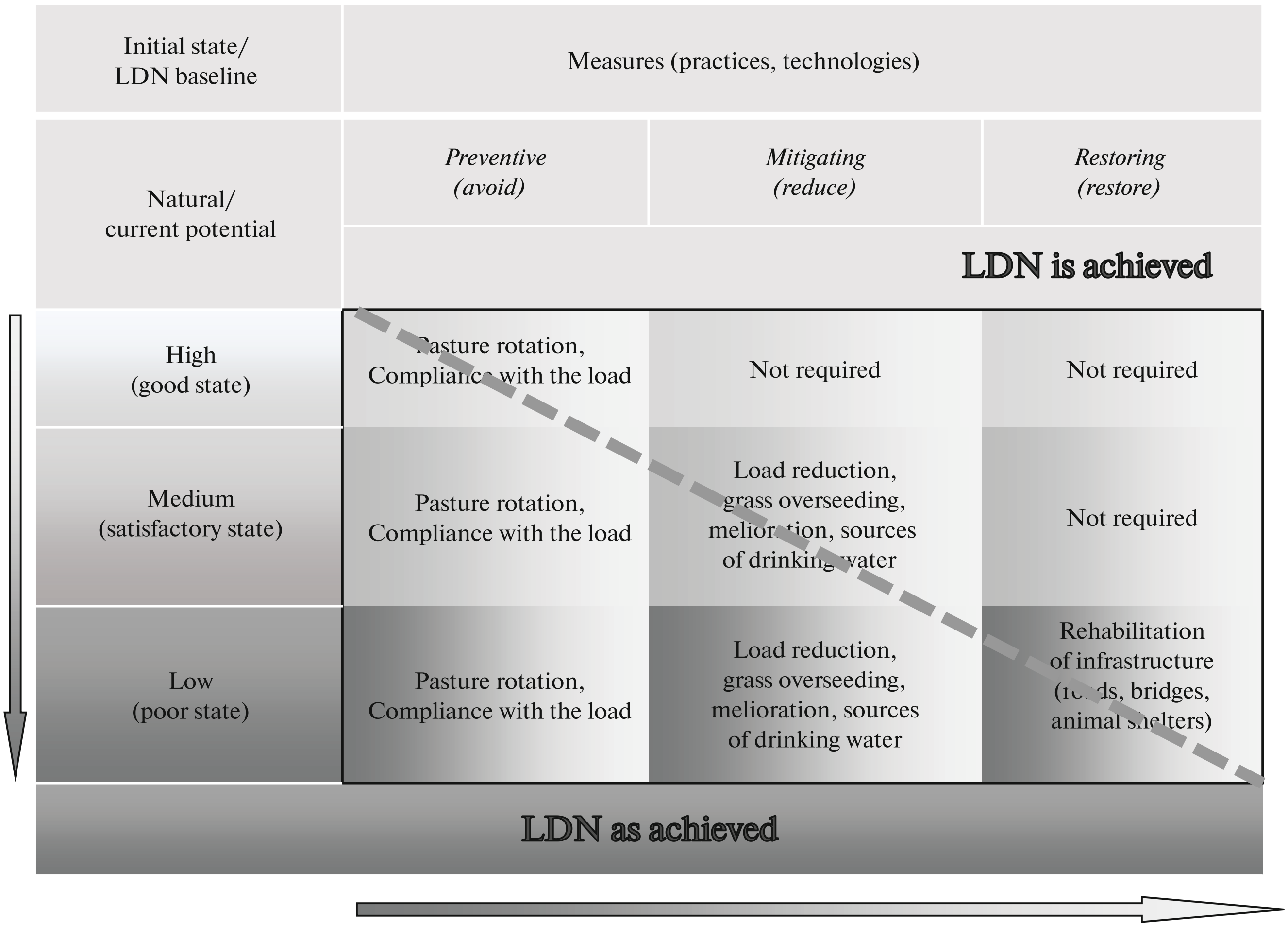

Fig. 3. SLM types. Schematic diagram (by the example of the SLM model for grazing livestock) of the formation of an integral set of good practices depending on the initial state (baseline) and the hierarchy of compensatory measures. The arrows indicate the direction of change in the risk of degradation: light color corresponds to low risk; intense color corresponds to high risk.

which makes it necessary to consider each specific case. The developed typology of SLM models and the proposed recognition algorithms will help with this.

SLM landscape–ecological frame. The practical application of the algorithms for comparative analysis of SLM and LDN based on the developed typology of SLM models made it possible to draw attention once again to the fact that the scale of the problem under consideration plays an important role in establishing land degradation [32, 33]. Thus, individual administrative regions, areas, and countries can be considered to have achieved land degradation, although at the level of their farms, landscapes, and localities it may be absent, even within potentially sustainable objects, for example, biosphere reserves.

Understanding the causes of this phenomenon with account for the proposed typology of sustainable land management, as well as the geographical analysis of the spread of its practices, together with the features of the modern management system in Russia, have made it possible to put forward a hypothesis that the possibility of achieving LDN in a certain territory is due not so much to the continuous coverage of this territory by good practices of sustainable land management as to the preservation of the ecological framework of SLM models, types, and classes. Such a framework includes two types of basic elements: sites where neutrality is achieved (we call them *cores*) and a spatially distributed structure of SLM models, where neutrality can be achieved through the selection of a set of appropriate land management practices and technologies. This framework (if the appropriate structure and a given number of cores are preserved), apparently, should allow us, at a minimal cost, to maintain the sustainability of land management and its specific models in the territory, which are distinguished by high natural potential or efficient land management technologies. These include, for example, tracts of arable land on which adaptive landscape and soil-conservation technologies are used, a net-

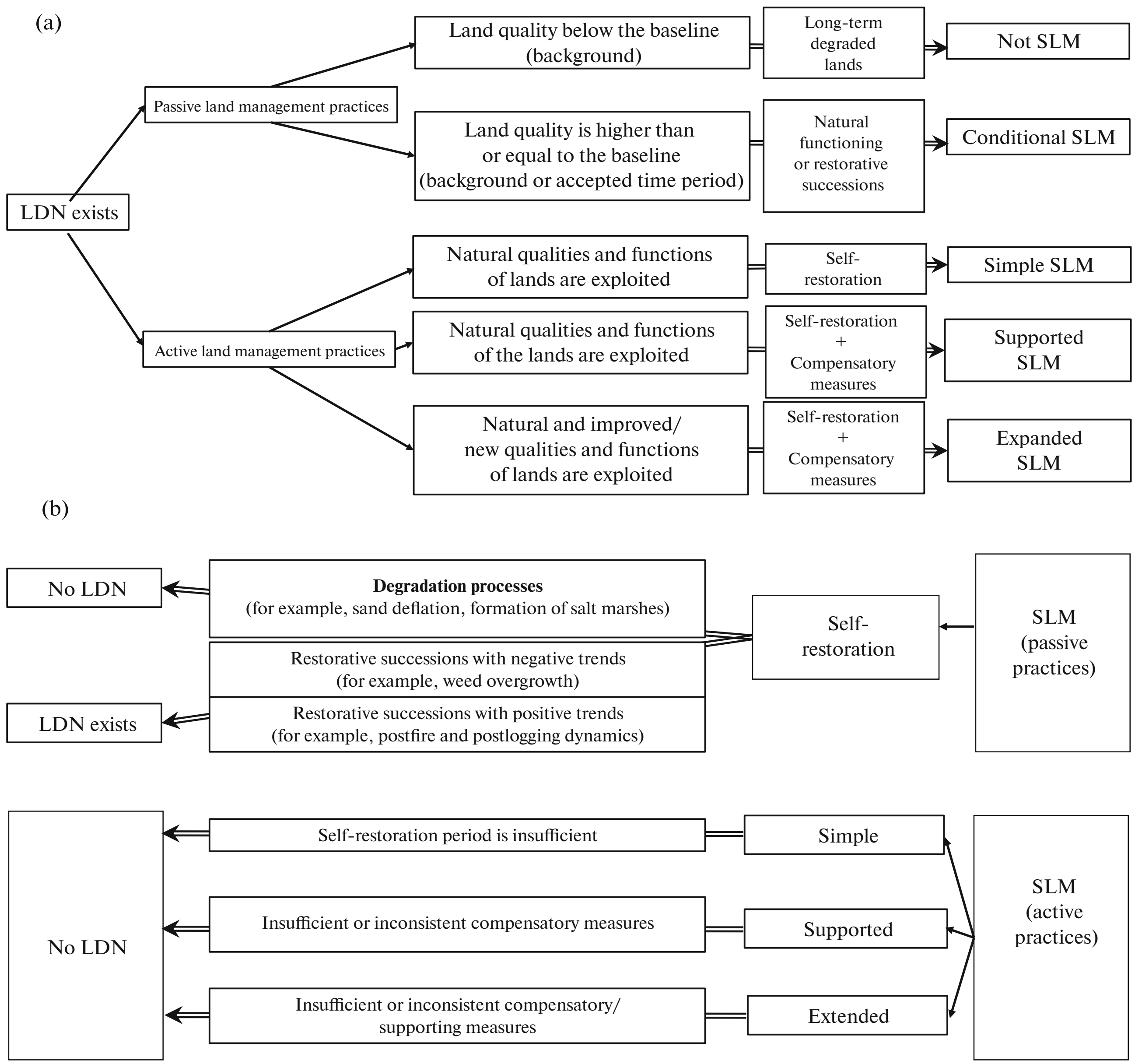

Fig. 4. Relationship between sustainable land management and land degradation neutrality. (a) SLM recognition algorithm in the case of LDN establishment; (b) inverse algorithm for the possibility of establishing LDN for different SLM models.

work of shelter belts, hydrological networks of river basins with their floodplains and valleys, protected natural areas, and the ecological corridors between them.

It seems that to predict more correctly the sustainability of land management and achieve land degradation neutrality in specific areas, this hypothesis should be developed in the directions that follow from the developed SLM typology and algorithms for identifying SLM models using LDN approaches:

• Substantiation of the boundaries of the SLM landscape–ecological frameworks for territories with similar natural conditions (for example, within the boundaries of watersheds, soil districts, and regions) and/or types of economic activity (arable farming, pasture lands).

• Consideration of the cores of the landscape–ecological frameworks of SLM as the main territorial elements within which the goal of achieving LDN is reached and which can serve as local models (gravity points) for the long-term maintenance and expansion of the natural potential of the territory.

• Analysis of the role of SLM landscape–ecological frameworks in reducing land degradation risks and obtaining multiple benefits, in particular, in the field of biodiversity conservation, climate change mitigation and adaptation, and reduction of social and economic vulnerability.

• Study of the heterogeneity of the frameworks in connection with the differentiation of SLM models and cores in terms of the uneven spatial and temporal effect of their application: for example, watering of previously drained peatlands in Belarus and the Russian Non-Chernozem region (water reclamation) has a significant spatial effect. Others, such as soil-saving no-till direct sowing technologies, have a long-term cumulative effect associated with the restoration of naturelike soils. Still others have both a cumulative and a spatial effect, including on adjacent and even remote territories (the creation of a system of forest belts on individual agricultural tracts or vast territories).

• Study of the heterogeneity of the frameworks in the context of their constituent SLM models since a framework can be represented by homogeneous or different classes of sustainable land management models (simple, supported, expanded, etc.). It is necessary to understand this to determine how to achieve neutrality within a particular framework.

• Assessment of the sustainability of homogeneous and heterogeneous frameworks: while in the conditions of individual farms it is enough to monitor the sustainability of specific models to maintain SLM, for heterogeneous objects it is the landscape–ecological framework that requires monitoring and not individual clusters of LDN and SLM models, and even less so, individual good practices. This approach is determined by the dynamism of land management systems, their susceptibility to external factors (melioration, development, climate change), and the interaction of its elements, characterized by a change in risks and processes (in the event of such changes, the proposed approaches involve adjusting the set of practices, including the hierarchy of measures to maintain, mitigate, restore, and, in special cases, review the SLM models implemented in problem clusters).

• Dynamics of the formation of frameworks and the characteristic time for the implementation of adaptation measures and technologies.

• Development of approaches to assessing the impact of socioeconomic factors on the effectiveness of land management practices.

* * *

The active development of the concept of sustainable land management in recent years is inextricably linked with the application of land degradation neutrality approaches. It is generally accepted in land management science and practice that SLM technologies and practices can mitigate the adverse effects of unsustainable land management and achieve land degradation neutrality. However, studies show that positive effects are not always observed. To understand the causes of these discrepancies, an analysis of good land management practices described in specialized international databases for the exchange of information on SLM parameters was carried out and ways to describe SLM models using visualization tools were demonstrated.

Previously published [21] approaches to the typology of land management objects have been confirmed: the main terminology, the prospects of a semantic description of sustainability (unsustainability) through a set of features, and a hierarchy of land management methods with the identification of the categories of *practice, model, type*, and *class*. A qualitative scale for assessing the degree of the manifestation of features of sustainable land management has been proposed, and, on its basis, an assessment has been made of the set of land management practices for three selected SLM models: restoration and maintenance of mountain pastures, irrigation on saline soils, and anti-erosion farming systems on rainfed lands.

SLM modeling using the proposed method has demonstrated its high efficiency in visualizing models and adjusting them to achieve the best result and integrity of SLM approaches in relation to specific models. The given examples of visualized models of sustainable land management clearly demonstrate the causes of the possible inconsistency in achieving the goals of LDN and SLM practices. It was revealed that the sustainability of land management, in addition to achieving land degradation neutrality with the help of certain technologies, is influenced by parameters such as the risk of degradation, the natural and actual potential of lands, their restoration ability, and natural processes and phenomena.

An improved typology of land management classes is proposed: simple, supported, and expanded. A schematic diagram of the identification of types of sustainable land management based on a hierarchy of measures and an assessment of the initial state (baseline) of land degradation neutrality has been drawn up. Assigning a practice to one type or another makes it possible to put forward proposals for an adequate set of successful measures to improve the SLM model and achieve LDN.

An algorithm scheme for recognizing SLM in the case of achieving LDN, as well as an inverse algorithm for the possibility of achieving LDN with different SLM models, has been developed. Emphasis is placed on the need to assess the risks of not achieving neutrality. A hypothesis has been put forward about the landscape–ecological framework of SLM, which makes it possible to explain the causes of the discrepancy between the LDN estimates for objects of different scale levels. It has been established that the achievement of land degradation neutrality in a certain area is largely due to the preservation of the framework of models, types, and classes of land management. Promising directions for the further development of this hypothesis are proposed, concerning the determination of the dimensions of landscape–ecological frameworks, their composition, dynamics, applicability for various objects, and monitoring of their state.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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