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Editorial

Preface: Arable Land Quality: Observation, Estimation, Optimization, and Application

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1. Introduction to the Special Issue—Arable Land Quality: Observation, Estimation, Optimization, and Application

Food security is a worldwide challenge that is related to the basic human needs of sustainable development [1]. Nearly a billion people do not regularly consume enough calories for an active, healthy lifestyle [2]. In 2019, the IPCC pointed out that the sustainable use of arable land plays an important role in reducing soil erosion, eliminating hunger, and coping with climate change. This poses a daunting challenge around the world: how to protect the stability of farmland ecosystems and meet the growing global food demand [3–5]?

Affected by local climate conditions, landforms, soil properties, agricultural infrastructure construction levels, and socioeconomic conditions, the attributes of arable land and its externalities present significant regional differences and diversified leading factors. To study the characteristics of arable land, the conception of "arable land quality" has been proposed and developed in dispute. In the last thirty years, the conception of "arable land quality" has experienced a long-term research process, and its theoretical connotation has been greatly enriched [6]. The conception of "arable land quality" is derived from "soil quality," while it goes beyond "soil quality". "Soil quality" focuses on the function of soils to support agricultural production and ecosystem stability [7–9], while "arable land quality" considers both natural endowments and human activities related to arable land systems and the concept of "Agropedogenesis" was developed [10]. Initial studies highly valued the crop productive capacity of arable land, which makes climate conditions, landforms, soil properties, and agricultural infrastructure core factors of arable land quality. Then, the influence of economic development and farmland management level on arable land quality was integrated [11–13]. Based on previous studies, the conception of "arable land quality" has developed from farmland productivity and cultivation suitability to the coupling of the intensive use of arable land with the healthy development of farmland ecosystems. Du et al. [14] defined arable land quality as "the degree of arable land functions that meets specific human needs", which can be classified as soil quality, construction quality, space quality, eco-environmental quality, and aesthetics and cultural quality. In conclusion, arable land quality is driven by the interaction between the natural system, the human demand,

and the utilization system, as well as being the comprehensive expression of farmland ecosystem functions. It covers the various dimensions of the status of arable land (e.g., crop output, carbon sequestration, soil property, water and soil erosion, fragmentation, intensive use, biodiversity). Analyzing the status and change in arable land from these perspectives should all be within the scope of this issue.

Recognizing the spatial heterogeneity of arable land quality and its regional factors is crucial for exploring sustainable arable land use paths and policies based on trading off the increase in arable land use intensity and the protection of farmland ecosystem health. This is because, first, protecting high-quality arable land is of great importance in safeguarding national food security [15,16]. For instance, the arable land productive capacity of China obeys a significant heavy-tailed distribution: 53% of the total arable land productive capacity of mainland China has been provided by 20% of the counties with high arable land quality [16]. Second, developing agricultural intensification and land consolidation is more suitable in high arable land quality areas, where the output–input ratio tends to be higher [17,18]. Third, protecting and developing high-quality arable land is crucial for protecting farmland ecosystem health and improving the carbon sequestration capacity and land degradation prevention capability of arable land [19,20]. Fourth, arable land quality should be considered when delimiting the red line for farmland protection, optimizing the spatial distribution of arable land, and promoting conservation farming techniques [16,21].

National governments attach great importance to protecting the arable land quality. Since the 1960s, many countries have launched national evaluation projects of arable land quality, and the evaluation content ranges from potential productivity to comprehensively considering soil health, ecological stability, and crop yield [22], e.g., "Land Capability Classification" in the USA [23], "Framework for Land Evaluation" [24,25], "Land Evaluation and Site Assessment (LESA)" [26], "Integral Land Evaluation" in Canada [27], "Framework for evaluating sustainable land management" [28], and "The Environmental Assessment of Soil for Monitoring Project" in the EU [29]. As a country with more than forty centuries of agricultural history, China has carried out many national arable land quality surveys throughout history, which date back to the seventh century BC (recorded in "The Ritual of Zhou"). Since the late 1940s, protecting arable land quality has gradually become a core tenet of China's arable land protection strategy. Multiple national field-scale evaluations of arable land quality have been launched [30]. Under the support and traction of these practical projects, observation and monitoring techniques as well as simulation models related to arable land quality have been steadily improved, and scientific data and practical experience have been gradually accumulated. Nevertheless, there are still various challenges in the study of arable land quality.

2. Challenges in Studying Arable Land Quality: From Science to Policy

Challenges in studying arable land quality are mainly related to cognition of regional leading factors, indicator observation and simulation techniques, and comprehensive evaluation theories and methods. Exploring these issues is of great significance for sustainable development.

First, existing spatial estimation practices of arable land quality have difficulty accounting for the change process and interactions of main factors of arable land quality. Application of statistical analysis methods (e.g., Pearson correlation index; principal component analysis; etc.) is not enough to answer and verify questions such as "what are the regional leading factors to arable land quality and how do they influence arable land quality" [16]. Long-term surveys and observations at the point scale should be carried out to explore the internal logic of leading factors of arable land quality on landscape and regional scale in the human–environment system [31].

Second, multiscale characteristics and regional differences in arable land quality indicators bring challenges to data acquisition, standardization, and evaluation. Methodological and technical support should be provided for constructing arable land quality observation networks and promoting theory and innovative methods of land-computing science [32]. On the one hand, methods that fuse ground surveys and remote sensing observations should be explored to present the spatial pattern of arable land quality indicators, especially for indicators related to agricultural infrastructure construction and management. This is because in practice, these indicators are mainly estimated by investigators' subjective scores [6]. Some exploratory studies provide good ideas. For instance, Li et al. [33] proposed a new method to estimate natural soil productivity and farmland management activities using long time series NDVI data. On the other hand, professional equipment for data collection of arable land quality indicators should be developed, especially for the measurement of soil life [34]. Furthermore, big data processing technology for arable land quality data should be developed to provide higher and more stable computing performance [35–39].

Third, arable land quality is generally estimated using the weighted average method with the disadvantage of a smoothing effect, and the weight determination methods (e.g., delphi method; entropy weight method) and the index calculation method have difficulty presenting complex nonlinear characteristics of arable land quality. In the study cases of Kong et al. [40], Wen et al. [41], and Ma et al. [42], the theoretical logic of comprehensive arable land quality estimation has been developed. However, methods derived from complex systems science (e.g., complex network; chaos; emergence) and machine learning models (e.g., self-organizing map; random forest; deep learning) should be explored for estimating arable land quality [43,44].

Fourth, the spatial heterogeneity of arable land quality determines the crop yield, carbon sequestration, water and soil loss, and other ecosystem functions at both the micro and macro scales. Applications of arable land quality estimations deepen the evaluation of farmland ecosystem services and explore sustainable arable land use paths. To achieve these targets, the influencing mechanism of arable land quality on farmland ecosystem functions and arable land use (e.g., marginalization; land use transitions; "non-food" phenomenon) should be studied.

Fifth, another challenge is to propose and to implement effective arable land quality protection policies [16]. High-level policy intervention, if done properly, can be a powerful force for good. In order to succeed, it is crucial that adaptive policies are coordinated with local social, environmental, economic, and cultural contexts [45]. Regionally suitable arable land protection targets based on local natural, economic, and social conditions should be designed, and policies related to arable land ecological protection should be developed. Furthermore, guaranteed implementation of arable land protection policies is difficult owing to the lack of effective payback and incentive strategies. The cost of breaking land management regulations is low, and effective reward strategies for outstanding policy implementation are lacking. It must be made clear who is primarily responsible for farmland-related damage to build competence in a department of arable land protection.

3. Major Topics in This Special Issue

This Special Issue on "Arable Land Quality: Observation, Estimation, Optimization, and Application" is dedicated to advancing our understanding of the patterns, regional leading factors, and influences of arable land quality. We invited case and modeling studies as well as synthesis and theory papers that achieve the following:

1. Theories and methods for arable land quality evaluation and regional practices;
2. Observation and simulation of arable land quality indicators;
3. Spatiotemporal variation in regional arable land quality and its main factors;
4. Arable land quality, soil functions and ecosystem health;
5. Arable land quality, ecosystem services and agricultural intensification;
6. Landscape optimization considering arable land quality;
7. Applications of arable land quality in land use and restoration;
8. Paths for protecting arable land quality.

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