Approaches to building and evaluating sustainable agricultural systems in the member states of the Eurasian Economic Union

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Abstract. The paper is devoted to analyzing the issues of agricultural sustainability in the member states of the Eurasian Economic Union, a regional organization connecting Russia, Kazakhstan, Belarus, Armenia, and the Kyrgyz Republic. We note that there is no single study that comprehensively addresses this highly important issue; therefore, a review of major approaches to building and evaluating agricultural systems is conducted with the purpose of their further application in the Eurasian Economic Union. The paper distinguishes the total of four approaches and provides their brief overview: (1) a balance between energy and matter in sustainability and innovations; (2) water and soil consumption in agricultural production; (3) potential environmental impacts; (4) energy dimension in sustainable agricultural systems.

1. Introduction

There is a growing pressure on the environment coming from human activity, which is manifested in the number of land being used for agricultural production, pollution, extinction of species, acidification of oceans, climate change, etc. [1, 2]. The growing use of fossil fuel and chemical pesticides, the deterioration of land and water, the need to guarantee the supply of agricultural products to the growing population, and the demand to obtain effective agricultural practices, such as intensification of agriculture, also demonstrate the significance of building and evaluating sustainable agricultural systems in various parts of the world, including within the Eurasian Economic Union.

A significant number of experts believe that the sustainable potential of the agricultural systems of the member states of the Eurasian Economic Union is still underdeveloped and not fully investigated. However, the importance of sustainable development of agricultural systems is really hard to overestimate. It is necessary to bear in mind that sustainability and innovations require significant transformations within agricultural systems, focusing on the production, transformation, distribution and consumption of agricultural products. Thus, in order to achieve sustainability of agricultural systems in the member states of the Eurasian Economic Union, one needs to conduct their detailed analysis using cutting-edge approaches and insights. Such an evaluation of agricultural systems is highly necessary since it gives an opportunity to change, improve, or support them using scientifically backed data and insights. This can be also used to provide policy makers and stakeholders with relevant and useful information. All these steps would be able to help build more sustainable and innovative agricultural systems in Russia and other countries of the Eurasian Economic Union.
However, our literature review shows that there is no single study that comprehensively addresses the issues of building and evaluating sustainable agricultural systems in the EAEU member states on the basis of advanced methods and cutting-edge approaches.

The goal of the paper is to review the existing approaches to building and evaluating agricultural systems, which can be used by the member states of the Eurasian Economic Union. The paper proceeds as follows. The next section describes materials and methods used. Then we review major approaches to building and evaluating sustainable agricultural systems and provide their examples. Lastly, we discuss both the approaches and their applicability to building and evaluating agricultural systems in the member states of the Eurasian Economic Union.

2. Materials and methods

In order to define approaches to evaluating agricultural sustainability of Russia and other countries of the Eurasian Economic Union, we conduct a review of secondary scholarly literature having three perspectives in mind. First of all, our goal is to list main approaches being used for the evaluation of how sustainable the agricultural production systems of Russia and the EAEU counties are. Second, given the importance of environmental issues, we have to focus on the approaches that allow to understand the impact a specific agricultural practice has on the sustainability of rural environment. And lastly, since agricultural systems are very much interconnected, it is highly necessary to find appropriate approaches to exploring their various dimensions, such as environmental, economic, and social ones.

3. Results and Discussion

As our analysis clearly shows, there numerous ways to evaluate how well agricultural systems develop in terms of their sustainability and innovative potential. We conditionally identify the total of four major approaches: (1) a balance between energy and matter in sustainability and innovations; (2) water and soil consumption in agricultural production; (3) potential environmental impacts; (4) energy dimension in sustainable agricultural systems. We would like to give a concise overview of each approach and then discuss how they can be used for analyzing issues of sustainability in agricultural systems of the member states of the Eurasian Economic Union.

The first group of research, which is vividly represented by the Vienna school of social metabolism (for reference, please see [7, 8, 9, 10]), primarily considers a balance existing between production inputs and the outputs being created. According to [7], “The core axioms of the shared paradigm are that human social and natural systems interact, coevolve over time and have substantial impacts upon one another, with causality working in both directions.” Focusing on material and energetic aspects, this approach studies the limits of sustainability in agriculture. It is advisable to use such an approach when studying historical developments of sustainability in the whole area of agriculture or its individual subdivisions (farming, planting, breeding, etc.). In practical terms, the approach is comfortable to use due to its reliance on convenient statistical data and estimation models. Inside the social metabolism approach, there is also a group of scholars that attempt to calculate ecological limits as an indicator showing the impact of social metabolism on agriculture [11, 12]. For instance, Haberl at al. rely on the index “Human appropriation of net primary products” (HANPP), which is a measure of human impacts on the flow of trophic energy in ecosystems, in order to evaluate the increasing use of biophysical resources, including land and biomass [11]. Figure 1 demonstrate the complexity of the concept being used.
Fig. 1. Definition of HANPP explained using global estimates for the year 2000 (by Haberl et al., 2014). For more information please visit [11].

Another group of research studies the water and soil consumption in agricultural production through the prism of sustainability. In particular, [13] introduces the concept of “virtual water” which is understood as “the quantity of water used in the production process of a product.” In other words, this is an indicator used to evaluate water consumption and its sustainability: how much water the agricultural sector of the economy needs in order to sustain its development. Soil consumption is another highly important area of research in agricultural sustainability. For instance, there are models being used to calculate alternations of time and soil employed in agricultural production [14, 15].

The third body of research is concerned with the issues of potential environmental impacts that take place at different stages of the life cycle of an agricultural product [16, 17]. Such an analysis allows to identify the impact of both all stages together and individual stages. Also, within this approach and methods used, it is possible to quantify how much energy and natural products are employed in order to create an agricultural product in each part of the whole process. According to M. Levy, “a life cycle analysis consists of three parts: (1) an inventory of the impacts (raw materials acquisition, manufacture, processing, formulation, distribution and transportation, use, reuse, maintenance, recycling, and waste disposal) <…>; (2) an impact analysis that characterizes and assesses the effects of chemical releases on human health and the environment, and (3) an improvement analysis to evaluate and implement modifications in the production process based on findings of the inventory and impact analysis” [16]. Thus, the life cycle analysis and assessment might be useful for evaluating how sustainable the production of a certain agricultural good is, or whether it is necessary to apply cleaner production technologies in agriculture, etc.

Finally, the forth group of scholars analyzes the energy dimension in agricultural sustainability and provides a number of insights on internal and external processes. For some scholars (such as [18 and 19]), agricultural sustainability can be defined in relation to the quantity and quality of the energy being used and transformed by a particular system of production. Another perspective within this approach is to evaluate agrarian metabolism through energy consumption. For instance, a number of scholars focus their attention on whether an agrarian system can maintain the biomass production and ecosystem services [20, 21]. As an example of the research from this group, Tello et. al provide an energy analysis of past and present farm systems aimed to contribute to their sustainability assessment [22]. They use a model of energy flows on farms systems (Figure 2), which can be applied to study farm systems in the Eurasian Economic Union.
In summary, the conducted review of the main approaches to building and evaluating the sustainability of agricultural systems clearly demonstrates that such approaches can be applied to agricultural systems of the member states of the Eurasian Economic Union. The first group of approached, focusing on a balance existing between production inputs and outputs being created, can effectively analyze changes in industrial agriculture and food production. The second approach, which studies the water and soil consumption, can be used to analyze the level of agricultural sustainability from the perspective of natural resources management and its effectiveness. Also, the approach has a broad array of research tools and allows to investigate diverse aspects of agricultural systems, including the volume of water and land being used in agricultural production, as well as quantity of time dedicated to food production in the member states of the Eurasian Economic Union. Lastly, the fourth group of approaches deals with energy in the agricultural sector. This issue of the highest importance for Russia and Kazakhstan, because these countries have very energy intensive economies, which also affects the non-efficient energy use in the agricultural sector, preventing it from better policies and practices aimed at achieving greater sustainability.

Fig. 2. Proposed model of energy flows on farm systems as seen from a farm-operator standpoint with an agroecosystem boundary. Source: [22].

4. Conclusions
The agricultural sector of the member states of the Eurasian Economic Union faces significant challenges, including those devoted to its sustainable development. Since there are no complete studies devoted to the agricultural sector of the EAEU countries, we conducted a review of the main approaches devoted to the sustainability of agricultural systems, namely (1) a balance between energy and matter in sustainability and innovations; (2) water and soil consumption in agricultural production; (3) potential environmental impacts; (4) energy dimension in sustainable agricultural systems. It is recommended to use these approaches for building and evaluating sustainable agricultural systems in Russia and other EAUE countries.
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