

## Climate-smart Green Business Innovations for Restorative Environmental Management in Agriculture 4.0 in Russia and Central Asia

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**Abstract:** The research aims to determine the contribution of climate-smart innovations in green business to developing restorative environmental management in Agriculture 4.0 in Russia and Central Asia. Using correlational analysis, the authors defined the connection between indicators of restoration-oriented natural resource management and the activity of implementing climate-smart innovations in green business in Agriculture 4.0. The research sample includes seven countries from Central Asia (as classified by UNESCO). The research period is 2022. The authors conclude that restorative environmental management is being implemented in Russia and Central Asia. However, its potential is not fully realized due to insufficient support from climate-smart innovations in green business in Agriculture 4.0. The theoretical significance of the research is explained by the fact that they have, for the first time, revealed the unique experience of Central Asia (including Russia) and identified and explained its specificity in restorative environmental management in Agriculture 4.0. The empirical value of these conclusions lies in the fact that they make it possible to identify the most promising area of restorative environmental management in Agriculture 4.0 in Russia and Central Asia, which is represented by climate reversal. Additionally, the results of this research highlight the weaknesses in restorative environmental management in Agriculture 4.0 in Russia and Central Asia: insufficient climate resilience in agriculture and slow soil recovery. The practical significance of the author's recommendations lies in their potential to enhance the efficiency

of state investment policy in the agricultural sector, as well as the effectiveness of corporate management of climate-smart innovations in green business in Agriculture 4.0 in Russia and Central Asia. The social significance of these recommendations lies in their support for sustainable development in Agriculture 4.0 in Russia and Central Asia, ensuring progress in restorative environmental management in this region of the world.

**Keywords:** climate-smart innovation, green business, regenerative environmental management, Agriculture 4.0, Central Asia

**JEL codes:** O32, Q16, Q54

Industrial revolutions have had a profound impact on the environment and brought fundamental changes in the practice of environmentally responsible environmental management. Primary industrialization during the first three industrial revolutions led to critical environmental pollution and large-scale depletion of natural resources. At that time, industry came to the fore in the practice of ecologically responsible environmental management, the task of which was to reduce the environmental damage of industrial production. This made it possible to reduce the environmental costs of industrial growth.

The Fourth Industrial Revolution promoted a secondary industrialization based on Industry 4.0, covering all sectors of the economy. This has opened up new opportunities for caring for the environment. Agriculture (namely Agriculture 4.0) has come to the forefront of the contemporary practice of ecologically responsible environmental management. Its task is to ensure regenerative environmental management. The essence of regenerative environmental management is related to improving the environment and reversing climate change through climate-smart green business innovations in Agriculture 4.0.

Thus, under the conditions of the Fourth Industrial Revolution, Agriculture 4.0 fulfills the urgent mission of neutralizing the environmental damage caused by the previous industrial revolutions. In this respect, the experience of restorative environmental management in Agriculture 4.0 in Russia and Central Asia is remarkable. It deserves a separate in-depth study because this region, first, is actively participating in the Fourth Industrial Revolution and shows rapid industrial growth.

Second, it is characterized by high environmental costs of the economy. Third, it actively develops the agricultural economy and demonstrates outstanding success in restorative environmental management in Agriculture 4.0. Therefore, this research aims to determine the contribution of climate-smart green business innovations to developing restorative environmental management in Russia and Central Asia.

### **Literature Review**

The theoretical basis of this research is the theory of restorative environmental management, the scientific foundations of which are laid in the works of Borisova et al. (2015), Butorin and Bogoviz (2019), Ostrovskaya et al. (2017), and Turginbayeva and Domalatov (2019). In line with this theory, drawing on international experience, the existing literature identifies the following three key manifestations of restorative environmental management in Agriculture 4.0:

- Enhancing climate resilience in agriculture (Karbekova et al., 2022; Karbekova & Samieva, 2022);
- Reversing climate change (slowing the rate of temperature increase) (Daribekova et al., 2023);
- Soil remediation (combating land degradation) (Bogoviz et al., 2019).

Climate-smart green business innovations are at the heart of the noted achievements of Agriculture 4.0 in restorative environmental management (Altukhov et al., 2019; Bogoviz et al., 2018). The literature review has shown that, although the concept of Agriculture 4.0 is quite seriously developed and widely described in the available literature, the existing publications do not sufficiently reflect the experience of restorative environmental management in Agriculture 4.0 in Russia and Central Asia.

This gap in the literature raises the following research question (RQ): “How do climate-smart green business innovations contribute to restorative environmental management in Agriculture 4.0 in Russia and Central Asia?”

To find an answer to this RQ, this research empirically analyzes the experience of regenerative environmental management in Agriculture 4.0 in Russia and Central Asia based on climate-smart green business innovations.

### Materials and Methods

For this research, the authors formulated and used the following food security statistics indicator framework based on Economist Impact (2023):

- “Sustainable agriculture” as an indicator of climate resilient agriculture;
- “Temperature rise” as an indicator of the success of reversing climate change (rate of temperature rise);
- “Land degradation” as an indicator of the success of soil remediation (combating land degradation).

The authors used correlation analysis to determine the relationship of these indicators with “Early-warming measures / climate-smart agriculture” as an indicator of the activity of implementation of climate-smart green business innovations in Agriculture 4.0. The sample includes all Central Asian countries (in the UNESCO country classification), for which statistical records are kept in the materials of Economist Impact (2023) (Table 1).

**Table 1**

Environmental management statistics in Agriculture 4.0 in Russia and Central Asia in 2022, scores 1–100

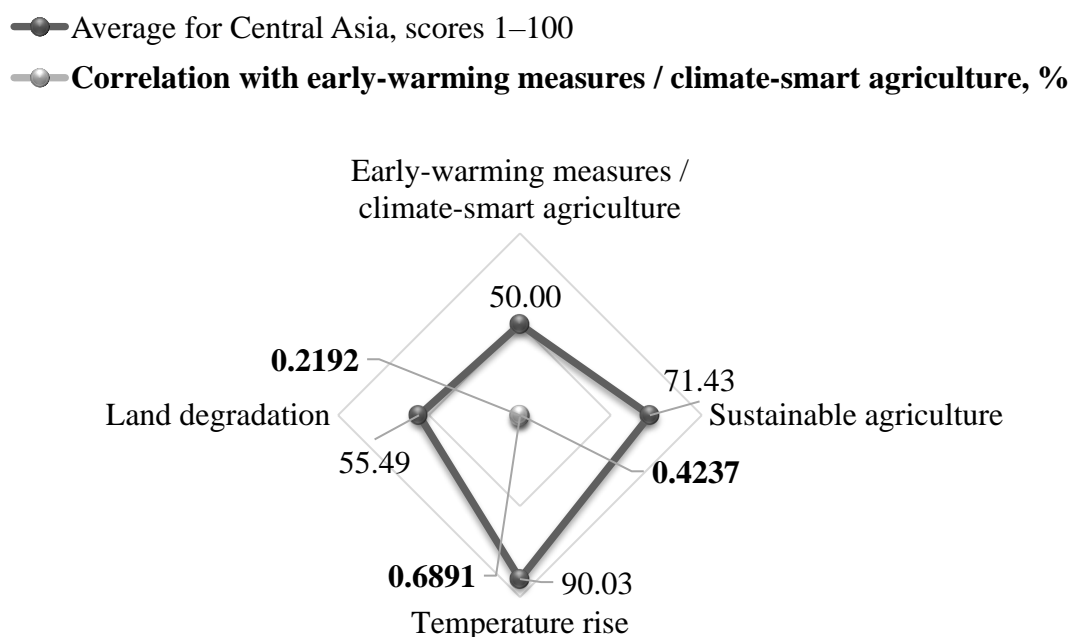
Country	Early-warming measures / climate-smart agriculture	Sustainable agriculture	Temperature rise	Land degradation
China	50.00	100.0	89.4	56.7
India	0.00	100.0	85.9	51.7
Kazakhstan	100.0	100.0	95.2	41.7

Pakistan	0.00	0.0	85.0	93.3
Russia	100.0	50.0	89.2	91.7
Tajikistan	0.00	50.0	91.6	0.0
Uzbekistan	100.0	100.0	93.9	53.3

Source: Compiled by the authors based on the research materials

## Results

To determine the adoption rate of climate-smart green business innovations and their contribution to restorative environmental management in Agriculture 4.0 in Russia and Central Asia, the authors calculated arithmetic averages and performed correlation analysis of the data from Table 1. The results are summarized in Figure 1.



**Figure 1**

Activity of climate-smart green business innovations and their contribution to restorative environmental management in Agriculture 4.0 in Russia and Central Asia

Source: Calculated and constructed by the authors

The results from Figure 1 suggest the following conclusions. First, Russia and Central Asian countries have a high level of climate-resilient agriculture (on average, 71.43 points). Nevertheless, the contribution of climate-smart green business innovations to its achievement is low (correlation: 0.4237). Therefore, a targeted application of climate-smart green business innovations to climate-resilient agriculture is recommended to reinforce the success of restorative environmental management in Agriculture 4.0 in Russia and Central Asia.

Second, Russia and Central Asian countries have a very high success rate in reversing climate change (on average, 90.03 points), which is largely due to the implementation of climate-smart innovations in green business practices (correlation: 0.6891). In this regard, the

following recommendations are offered to multiply the achieved success of restorative environmental management in Agriculture 4.0 in Russia and Central Asia:

- To automate the monitoring of temperature rise rate with smart innovations in green business practices in Agriculture 4.0;
- To link the investment attractiveness of innovative projects in Agriculture 4.0 to the fight against global warming through green stocks, bonds, loans, subsidies, and integration processes.

Third, Russia and Central Asian countries have moderate soil restoration success (on average, 55.49 points). However, the contribution of climate-smart green business innovations to its achievement is very small (correlation: 0.2192). In this regard, the following recommendations are offered to strengthen the success of restorative environmental management in Russia and Central Asia:

- To incorporate soil quality analysis into automated phytomonitoring programs in green business practices in Agriculture 4.0;
- To strengthen investment support for combating land degradation through smart innovations in green business practices in Agriculture 4.0.

Comprehensive implementation of the proposed author’s recommendations will make it possible to unlock the fullest potential of restorative environmental management in Russia and Central Asia with reliance on climate-smart green business innovations.

## Discussion

The research contributes to the literature through the development of scientific provisions of the theory of restorative environmental management, clarifying the cause-and-effect relationships of the implementation of climate-smart green business innovations in Agriculture 4.0. The specifics of the application of these innovations for regenerative environmental management in Agriculture 4.0 in the Central Asian region of the world are first revealed in this research. The results obtained are summarized in Table 2 and compared with the available literature.

**Table 2**

Comparison of the findings with available literature

Existing literature based on international experience		This research: Results for Russia and Central Asia	
		Development level, scores 1–100	Linking to climate-smart innovation
Key manifestations of restorative environmental	Enhancing climate resilience in agriculture (Karbekova et al., 2022; Karbekova & Samieva, 2022)	71.43 (strong)	42.37% (moderate)
	Reversing climate change (slowing the rate of	90,03 (very strong)	68.91% (strong)

	temperature increase) (Daribekova et al., 2023)		
	Soil rehabilitation (combating land degradation) (Bogoviz et al., 2019)	55.49 (moderate)	21.92% (weak)

Source: Developed and compiled by the authors

As is shown in Table 2, in contrast to Karbekova et al. (2022) and Karbekova and Samieva (2022), this research found that although climate resilience of agriculture in Russia and Central Asia is high (estimated at 71.43 in 2022), it is insufficiently supported by climate-smart green business innovations in Agriculture 4.0 (only 42.37%).

In support of Daribekova et al. (2023), it is proven that climate-smart green business innovations in Agriculture 4.0 provide strong support (by 68.91%) to reverse climate change, due to which the fight against temperature rise is very successful (scored 90.03).

In contrast to Bogoviz et al. (2019), the research revealed that the fight against land degradation in Russia and Central Asia is insufficiently successful (rated at 55.49 points) and insufficiently supported by climate-smart green business innovations in Agriculture 4.0 (only 21.92%).

## Conclusion

The obtained results make it possible to conclude that Russia and Central Asia implement restorative environmental management. However, its potential is not fully realized due to insufficient support from climate-smart green business innovations in Agriculture 4.0. The theoretical significance of the results is explained by the fact that they reveal the unique experience of Central Asia (including Russia) and identify and explain its specificity of restorative environmental management in Agriculture 4.0.

The empirical value of these findings is that they identify the most promising area of restoration in Agriculture 4.0 in Russia and Central Asia, which is reverse climate change. The results of this research also reveal weaknesses of regenerative nature management in Agriculture 4.0 in Russia and Central Asia: insufficient climate resilience of agriculture and slow rate of soil regeneration.

The practical significance of the author's recommendations is that they will increase the effectiveness of public investment policy in the agro-industrial complex and improve the efficiency of corporate management of climate-smart green business innovations in Russia and Central Asia. The social significance of the author's recommendations lies in the fact that they support sustainable development in Russia and Central Asia and ensure the progress of restorative nature management in this region.

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