

UDC 333.73:630*6

DOI: 10.31548/forest/1.2025.82

Monitoring economic risks associated with forest landscape degradation

Dzhyldyz Albanbaeva*

Master

Kyrgyz State University named after I. Arabaev
720026, 51A Razzakov Str., Bishkek, Kyrgyz Republic
<https://orcid.org/0000-0003-3558-7107>

Zhibek Amerkulova

Senior Lecturer

Kyrgyz State University named after I. Arabaev
720026, 51A Razzakov Str., Bishkek, Kyrgyz Republic
<https://orcid.org/0009-0006-5416-167X>

Aigul Chaldanbaeva

Doctor of Pedagogical Sciences, Professor

Kyrgyz State University named after I. Arabaev
720026, 51A Razzakov Str., Bishkek, Kyrgyz Republic
<https://orcid.org/0009-0003-8107-2697>

Raushanbek Zainiev

PhD in Economics

Kyrgyz State University named after I. Arabaev
720026, 51A Razzakov Str., Bishkek, Kyrgyz Republic
<https://orcid.org/0009-0001-3721-8172>

Rustambek Asanov

PhD in Economics

Kyrgyz State University named after I. Arabaev
720026, 51A Razzakov Str., Bishkek, Kyrgyz Republic
<https://orcid.org/0009-0005-0166-9229>

Abstract. The study aimed to assess the economic risks caused by the degradation of forest landscapes and their impact on the forestry sector's economy and regional development. The analysis examined the impact of deforestation, soil erosion, biodiversity loss and climate change on forestry

Suggested Citation:

Albanbaeva, D., Amerkulova, Zh., Chaldanbaeva, A., Zainiev, R., & Asanov, R. (2025). Monitoring economic risks associated with forest landscape degradation. *Ukrainian Journal of Forest and Wood Science*, 16(1), 82-107. doi: 10.31548/forest/1.2025.82.

*Corresponding author



sustainability, the labour market, investment attractiveness and financial flows in the regions. A comprehensive approach was used, including statistical analysis of data, comparative assessment of changes in the forest industry, and forecasting of possible economic consequences under different scenarios. The study found that between 2015 and 2024, global forest cover loss reached 10 million hectares annually, leading to a reduction in timber stocks and a 15-25% increase in prices in the most affected regions. The decline in forest area has had a direct impact on employment in the forestry industry, causing a 20-30% reduction in jobs in the sector in Southeast Asia and Latin America, where logging is an important source of income. The results show that the reduction in tax revenues from the forestry industry and the shrinking of local budgets have led to limited funding for social programmes and infrastructure projects in rural areas. The analysis also showed that illegal deforestation remains a serious problem, as up to 30% of the global timber market may be of illegal origin, undermining the economic stability of the industry and complicating international regulation. The loss of biodiversity and soil erosion has led to an increase in the cost of ecological restoration of forest areas, which in some countries has exceeded USD 5 billion. Comprehensive measures to reduce economic risks are proposed, including the introduction of strict regulatory mechanisms, the development of FSC certification, stimulating investment in forest restoration, and the introduction of digital monitoring technologies, including satellite surveillance and the use of drones. The results of the study can contribute to the development of strategies for forest management, environmental control, reduction of economic risks, implementation of monitoring technologies and assessment of the impact of forest degradation on regional development

Keywords: environment; sustainable development; ecosystem; erosion; biodiversity

Introduction

The degradation of forest landscapes is one of the most acute environmental and economic problems of our time, affecting the sustainable development of society, ecosystem balance and economic security of regions. Forest ecosystems perform key functions in conserving biodiversity, regulating climate, maintaining water balance and providing natural resources for the economy. However, large-scale deforestation, soil erosion, climate change and anthropogenic pressure pose significant economic risks, which manifest themselves in the reduction of forest resources, loss of jobs, reduced investment attractiveness and increased socio-economic instability.

According to the Food and Agriculture Organisation of the United Nations (n.d.), between 2015 and 2024, the average annual loss of forest

area was about 10 million hectares, which led to an increase in the cost of timber, a reduction in production capacity in the forest industry and a decrease in local community income. Illegal deforestation, which accounts for up to 30% of the global timber market, significantly increases financial risks for state budgets, reduces the competitiveness of legal enterprises and exacerbates the problem of the shadow economy in the sector. The consequences of forest degradation are particularly noticeable for countries whose economies are heavily dependent on the forest sector, in particular for countries in Southeast Asia, Latin America and Eastern Europe (Moroz, 2024). The loss of forest areas in these regions has led to a 20-30% reduction in employment in the logging industry, which has led to an outflow of labour to other sectors and

increased social instability. In addition, the loss of biodiversity and destruction of soil cover require additional costs for environmental restoration, which in some countries exceed billions of dollars (Soloviy, 2016).

The problem of forest landscape degradation and its economic consequences is the subject of numerous scientific studies. The loss of forest resources causes significant financial losses, reduced employment, and a decline in the investment attractiveness of regions. Assessment of economic risks in this area is relevant, but not sufficiently researched. F. Sourokov *et al.* (2024) noted that economic methods for assessing forest degradation are used to a limited extent, which makes it difficult to develop effective policies to prevent losses. Sustainable management of forest resources is a key tool for their conservation. According to the study by E. Khazieva *et al.* (2022), overgrowth of pastures with shrubs is one of the main signs of landscape degradation. The use of geoinformation technologies allowed the authors to identify the main factors of this process, including changes in land use and climate fluctuations. The emphasis is placed on the need for economic mechanisms to mitigate the negative effects.

Based on the results of E. Duulatov *et al.* (2021), intensive soil erosion leads to a significant reduction in productive forest areas. Modelling using the Revised Universal Soil Loss Equation (RUSLE) methodology allowed the authors to estimate the loss of fertile soil, which complicates forest management and creates economic risks for the logging sector. The environmental consequences of forest degradation are assessed in the work by G. Donbaeva *et al.* (2024). The decline in the populations of animals and plants dependent on forest ecosystems not only increases environmental instability, but also threatens economic sectors such as ecotourism and agriculture.

The reduction in the area of floodplain forests in the Naryn Valley leads to a decrease in the regulatory role of forests in water conservation, as confirmed by N. Degembaeva *et al.* (2022). The study demonstrates the need to strengthen the policy of preserving floodplain ecosystems as a factor in maintaining the stability of the region's water resources. Z. Yu *et al.* (2024), in their work, focused on assessing the risks of land degradation on the Elk Plateau, where significant soil erosion poses a serious threat to agriculture and forestry. The work of A. Ibraimova *et al.* (2023) proves that forest degradation has a direct impact on the well-being of the population that depends on natural resources. In the Chui Oblast of Kyrgyzstan, traditional agricultural and forestry enterprises are losing productivity, forcing local residents to change their activities and look for new economic strategies.

Significant experience in addressing land degradation has been gained in the European Union. As noted by Y.O. Mynko (2024), the integration of modern land management methods and environmental and economic measures can effectively reduce the negative impact of anthropogenic factors. The issue of forest degradation as a result of military operations is considered by A.Y. Herman (2024). War contributes to the destruction of ecosystems, which necessitates costly environmental restoration programmes. The approaches proposed by the author may be useful for the territories affected by military operations. The processes of adaptation to environmental challenges through the introduction of "green" economic strategies are considered by O.S. Chmyr & T.K. Kvasha (2013). The analysis of sustainable development indicators demonstrates the need for multi-level management that takes into account both environmental and socio-economic aspects.

Thus, current research confirms that forest landscape degradation has a multifaceted

impact on the economy, environment and social processes. The use of the latest technologies, implementation of regulatory measures, promotion of sustainable forest management and development of international forest conservation programmes are key strategies to overcome the effects of degradation and ensure economic stability of the regions. Therefore, this study provides a comprehensive analysis of the economic risks caused by the degradation of forest landscapes, identifying their impact on the forest sector, employment, regional development and investment attractiveness. Particular attention is paid to the mechanisms for minimising negative economic consequences through the introduction of sustainable forest management, environmental regulation and modern forest monitoring technologies.

Materials and Methods

The main sources of data were the reports of the Food and Agriculture Organization of the United Nations (n.d.), the World Wide Fund for Nature (WWF), and the World Bank (2024), which contain up-to-date information on the dynamics of forest area loss, the economic impact of forest degradation, and the level of employment in the forest industry (Soloviy, 2016).

The methodological basis of the study included several key approaches that allowed for a comprehensive assessment of the economic risks of forest degradation. Firstly, a statistical analysis of data on the scale of deforestation in 2015-2024 was conducted based on official statistics (Food and Agriculture Organization of the United Nations, n.d.; Soloviy, 2016). Data on deforestation rates in South America (Brazil, Paraguay), Asia (Indonesia), Africa (Democratic Republic of Congo, Nigeria, Ghana), Europe (Ukraine, Romania, Finland, Sweden), and North America were used, as these regions demonstrate different forest management models and have a significant impact on global

deforestation processes. In South America, deforestation is driven by agricultural expansion, in Asia by palm oil production, and in Africa by illegal logging and agricultural development. The choice of European countries allows us to compare the consequences of illegal logging (Ukraine, Romania) and the effectiveness of sustainable forest management (Finland, Sweden). We also examine trends in employment in the logging sector and the dynamics of timber prices in these regions.

Economic forecasting methods were used to assess the economic consequences of forest degradation. Three possible scenarios for the development of the forestry sector were modelled: a pessimistic scenario that assumes uncontrolled deforestation, a baseline scenario that reflects current trends, and an optimistic scenario that assumes the introduction of effective mechanisms for monitoring and restoring forests. Economic modelling allowed us to estimate possible changes in tax revenues, investment activity, and the overall impact of the decline in forest resources on the gross domestic product (GDP) of the regions.

Geoinformation analysis played an important role in the study, as it made it possible to visualise the degradation of forest landscapes. For this purpose, satellite images and map data were used to identify the regions with the most intense deforestation. Particular attention was paid to the analysis of illegal logging, which remains one of the main causes of economic instability in the forest sector.

The comparative analysis examined the effectiveness of various forest management strategies, such as the Forest Stewardship Council International (n.d.) certification system, environmental taxation, and the development of alternative sources of income, including ecotourism and recreational use of forests. International experience in combating illegal logging was assessed, including an analysis of

carbon credit mechanisms, the Regulation (EU) No. 995/2010 of the European Parliament and of the Council “Laying down the obligations of operators who place timber and timber products on the market Text with EEA relevance” (2010) and the Soy Moratorium (2024).

Modern methods of assessing the ecological state of forest ecosystems were used to monitor biodiversity. The use of automated camera traps provided data on changes in wildlife populations, and deoxyribonucleic acid (DNA) analysis of soil samples made it possible to assess changes in the microflora of forest soils. The classical Shannon and Simpson indices were used to quantify biodiversity, which made it possible to assess the impact of forest degradation on ecological balance.

Scenario analysis allowed us to assess the possible consequences of changes in forestry policy. The impact of regulatory measures on regional economies, employment levels, and the

prospects for the development of green technologies that could reduce the economy’s dependence on timber harvesting was considered.

Results

The impact of deforestation on the economy of the forest sector

The degradation of forest landscapes caused by deforestation, soil erosion and biodiversity loss have a significant impact on the forestry sector’s economy and regional development. According to the Food and Agriculture Organization of the United Nations (n.d.), in the period from 2015 to 2020, global forest cover loss was approximately 10 million hectares annually, and this trend continued to grow in the following years. This leads to a decrease in available timber reserves, which in turn leads to higher prices for timber. Figure 1 illustrates the dynamics of forest cover loss over the period 2015-2024.

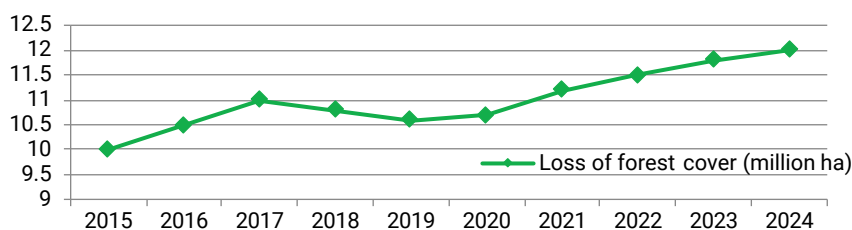


Figure 1. Dynamics of forest cover loss (2015-2024)

Source: compiled by the authors based on source Food and Agriculture Organization of the United Nations (n.d.)

The decline in forest resources directly affects employment in the forest industry. According to the World Bank (2024), the reduction in forest areas and timber harvesting leads to a decrease in demand for labour in this sector. This is especially noticeable in regions where the forest industry is the main source of employment. Between 2010 and 2020, South America lost approximately 2.6 million hectares of forest annually, which negatively impacted employment in the forestry sector.

More than 90 per cent of people living below the poverty line depend on forests for food, firewood, and livelihoods.

Using satellite images from NASA and European Space Agency (2023), combined with GIS analysis, the most critical deforestation areas were identified for the period 2015-2024 (Global Forest Watch, n.d.). According to the analysis, the largest losses of forest cover were observed in the Amazon (about 1.2 million hectares annually, Indonesia (900 thousand hectares), and

Central Africa (650 thousand hectares). Cartographic models visualised the dynamics of changes in forest cover, which showed the unevenness of the deforestation process. In particular, in Europe, a significant reduction in forest area was recorded in the Carpathian region (Ukraine, Romania), where about 400 thousand hectares of forest were lost between 2015 and 2024 due to active logging and insufficient control over illegal logging (Soloviy, 2016; Miniaylo et al., 2020).

An assessment of economic losses showed that the reduction in forest areas directly affected the timber market and employment in the industry. In Southeast Asia, the reduction of forest resources has led to a 20-30% increase in the cost of timber, which has led to a reduction in production capacity in the woodworking industry (Food and Agriculture Organization of the United Nations, n.d.). In Latin America, losses from illegal logging are estimated at USD 5-7 billion annually, and in Africa at USD 3-4 billion (World Bank, 2024). In countries with strict forestry control mechanisms in place (e.g., under the European Timber Regulation (EUTR)), the situation has stabilised. In particular, in Finland and Sweden, illegal logging does not exceed 5% of the total volume of timber harvesting, while in Brazil and Indonesia this figure reaches 30-40% (EU rules against..., n.d.).

A comparative analysis of international initiatives, such as the Amazon Soy Moratorium and the EUTR, has shown that their implementation helps to reduce deforestation. For example, after the introduction of the

Amazon Moratorium in 2006, deforestation rates in Brazil decreased by 84% in certified areas (Soloviy, 2016). In the European Union (EU), the share of illegal timber in imports decreased by 15% in 2023 after the EUTR requirements were tightened (EU rules against..., n.d.). However, in countries where control mechanisms remain weak (e.g., Nigeria, Ghana, and Paraguay), illegal logging continues to grow, undermining the economic stability of the industry and increasing financial risks (Food and Agriculture Organization of the United Nations, n.d.).

Reduced logging has a negative impact on local budgets, which leads to reduced funding for social programmes. In Canada, where the forestry industry generated USD 34 billion in 2013, the decline in logging has led to a reduction in funding for education and healthcare in rural communities (World Bank, 2024). In Ukraine, the decline in timber exports (USD 507 million in 2004) affected budget revenues, which affected the financing of schools and hospitals (World Bank, 2024). In Latin American countries (Brazil, Chile), the annual loss of 2.6 million hectares of forest has reduced community incomes, forcing governments to cut spending on healthcare, education, and infrastructure (Green Climate Fund..., 2021). According to the WWF, deforestation and forest degradation in tropical regions have a direct impact on the health and well-being of local communities (Soloviy, 2016). Figure 2 shows a visual comparison of GDP losses in different regions of the world due to forest degradation.

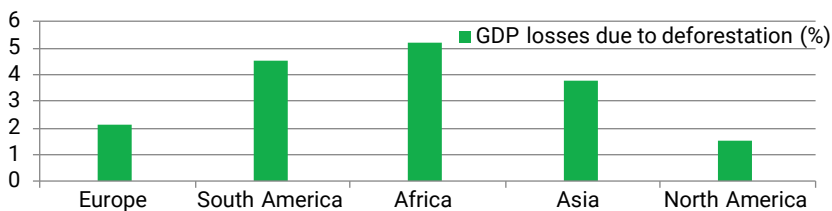


Figure 2. The impact of deforestation on regional GDP

Source: compiled by the authors based on I. Soloviy (2016)

Thus, deforestation has a complex negative impact on regional development, reducing budget revenues, reducing employment and slowing economic growth. This confirms the need to develop effective forest management strategies that combine economic and environmental interests.

A comparative analysis of the Forest Stewardship Council (FSC) certification policy has shown that its implementation helps to reduce illegal logging, increase transparency of the timber market and attract investment in the sustainable development of the forest sector. In the EU, more than 50% of commercial timber is certified according to FSC standards, which ensures stable market conditions and promotes the growth of forest products exports (Food and Agriculture Organization of the United Nations, n.d.). At the same time, in countries with a low level of certification, such as Ukraine, Romania, and Indonesia, illegal logging remains a serious problem that negatively affects financial flows and investment attractiveness of the industry (Soloviy, 2016). An analysis of economic indicators has shown that countries with a developed FSC certification system (Finland, Sweden, Canada) have a stable level of employment in the forest industry, while in regions with a low level of certification (Brazil, Paraguay, Ghana), the number of jobs in the industry has decreased by 15-25% due to illegal logging and a shrinking resource base (World Bank, 2024).

Instability in the forestry sector caused by the degradation of forest resources reduces its investment attractiveness. The depletion of forests leads to a reduction in available timber reserves, making long-term investments risky. According to the Food and Agriculture Organization of the United Nations (n.d.), about 10 million hectares of forest disappear every year worldwide, which negatively affects the availability of raw materials for the forest industry. In regions with high deforestation rates, such

as the Amazon, Central Africa, and Southeast Asia, there is a gradual withdrawal of investors who fear a shortage of timber in the future (Flatpacked forests..., n.d.).

Climate change, including rising average temperatures, changes in precipitation and more frequent natural disasters (fires, floods), contribute to the degradation of forest landscapes, which in turn affects the economic stability of the regions. Forest fires, floods, and droughts cause significant economic losses. For example, in 2021, large-scale fires in the United States destroyed more than 2.2 million hectares of forest, resulting in billions of dollars in losses and a number of companies' refusal to invest in the region (National Integracy Fire Center, 2025).

Another important factor that reduces the investment attractiveness of the industry is the spread of illegal logging. Illegal deforestation creates an unstable business environment and can also lead to sanctions and trade restrictions from international markets. According to the WWF, up to 30% of timber in global circulation may be of illegal origin, which undermines confidence in the industry and makes it less attractive to international investors (Soloviy, 2016). Large corporations avoid investing in regions where government control over logging is weak, fearing reputational risks and legal complications.

Reduced investment in the forestry industry leads to a general slowdown in its development, especially in the area of technological modernisation. Projects to introduce zero-waste production, automate timber harvesting, and create new logistics centres are being halted due to a lack of funding. For example, in Southeast Asia, more than 15% of woodworking plants closed in 2015-2024 due to the depletion of forest resources and a lack of stable supplies of raw materials. In Africa, low levels of investment in forest infrastructure hinder local economic development and job creation (World Bank, 2024).

Lack of funding also hinders the development of environmental technologies in forestry. Investors are reluctant to invest in the research and development of biotechnology for forest restoration, satellite deforestation monitoring systems, and other innovative solutions. In 2021, global investments in green technologies in the forestry sector decreased by 15%, which slowed down the implementation of many sustainable forest management projects (World Bank, 2024). This could lead to further deterioration of forests and an even greater reduction in investment in the future.

In order to overcome investment risks, international financial institutions and environmental organisations are developing mechanisms to support the sustainable development of the forest industry. The World Bank (2024) and the Green Climate Fund (GCF) have allocated more than USD 500 million to finance environmental initiatives in the forest industry aimed at reducing deforestation, restoring degraded forests, and developing alternative sources of income for local communities (Green Climate Fund Board..., 2021). In addition, the European Investment Bank (EIB) (n.d.) also provides loans and grants to support sustainable forest management programmes, particularly in developing countries (Indonesia, Brazil). In 2023, the international LEAF Coalition initiative raised USD 1.5 billion from governments and the private sector to protect tropical forests and support local communities dependent on forestry (LEAF Coalition commitments..., 2022). In addition, the introduction of international environmental standards, such as Forest Stewardship Council International (n.d.) and Programme for the Endorsement of Forest Certification (PEFC) (n.d.) certification, helps to increase the transparency of the logging business, combat illegal logging, and attract responsible investors. Many governments in the European Union, Canada,

and the United States are tightening requirements for timber imports, giving preference to products that meet these certification standards. This encourages companies to switch to environmentally responsible forest management and ensures the long-term financial stability of the forestry sector.

Factors causing instability in the forestry sector include variability in regulatory policies, increased illegal logging, and changes in demand for timber. This reduces the investment attractiveness of the industry, as companies assess the increased risks of investing in regions with unstable forest management. The high level of risks associated with resource depletion, natural disasters and illegal logging makes investors look for more reliable industries to invest in. This, in turn, slows down the development of the forestry industry, reduces investment in technology and leads to further environmental degradation. To stabilise the situation, it is necessary to strengthen national and international control over logging, encourage environmentally responsible business and create financial mechanisms to compensate for investment risks.

Violations of environmental regulations and illegal logging can have serious financial consequences for forestry companies. Governments in many countries, including the United States, Canada, Germany, France, the United Kingdom, Brazil, Indonesia and Australia, are introducing strict regulatory mechanisms to combat illegal logging and ecosystem degradation. For example, in the European Union, Regulation (EU) No. 2023/1115 of the European Parliament and of the Council “On the Making Available on the Union Market and the Export from the Union of Certain Commodities and Products Associated with Deforestation and Forest Degradation and repealing Regulation (EU) No. 995/2010” (2023), banning the import of timber grown in deforested

areas. Such measures impose additional costs on companies operating in the forestry sector, reducing its investment attractiveness.

One of the most famous examples of international regulation is the Soy Moratorium (2024), which was introduced in 2006 to combat illegal deforestation in Brazil. Under this initiative, major agribusiness companies, including Archer Daniels Midland (ADM), Cargill and Bunge, refused to purchase soybeans grown on land that had been cleared by deforestation after July 2008 (ADM Statement on..., 2019; Cargill in the Amazon..., 2019; Amazon soy moratorium, n.d.). ADM, one of the world's largest food corporations, has stated that it does not buy soy from deforested areas of the Amazon and does not make investments in these areas. Similar policies are followed by Cargill and Bunge, which control a significant share of the global soybean market. The refusal of these companies to purchase agricultural products associated with illegal deforestation has contributed to a significant reduction in deforestation in the region. In particular, during the first years of the moratorium, deforestation related to soy production decreased by 84%, and the share of soy grown on land cleared after 2008 fell below 1% of total production in the Amazon (Soy Moratorium, 2024).

In addition to Brazil, similar mechanisms are used in other countries. For example, the EUTR, which prohibits trade in illegally harvested timber (Regulation (EU) No. 995/2010 of the European Parliament and of the Council, 2010). Companies that cannot prove the legality of their products face severe fines and the risk of losing partners. In 2021, France and Germany tightened controls on timber imports, which affected the market for suppliers from countries where illegal logging is common (EU rules against..., n.d.). High regulatory risks and fines are also relevant for

Indonesia. In 2021, the country tightened control over timber exports by introducing new measures to combat illegal logging, including the requirement for companies to confirm the legality of their products through the Timber Legality Verification System (SVLK) (Wicaksono, 2021). This has significantly reduced the level of illegal timber trade. As a result, Indonesia has achieved a 70% reduction in illegal logging compared to previous years (Ma'ruf, 2021).

Fines and regulatory restrictions affect not only direct participants in the forest industry, but also international investors. Large financial institutions, such as the World Bank (2024) and the International Monetary Fund (IMF) (n.d.), often require compliance with environmental standards before allocating funds for infrastructure projects. For example, in 2022, the European Investment Bank (2020) refused to finance large-scale logging projects in Southeast Asia due to high environmental risks and insufficient control over illegal logging.

Thus, deforestation has a complex negative impact on the economy of the forestry sector, causing a decrease in the resource base, loss of jobs, lower incomes of local communities, reduced investment, and increased regulatory risks. Companies and countries that fail to implement effective deforestation control mechanisms face severe fines, restricted access to international markets, and loss of investor confidence. This underscores the need to strengthen environmental responsibility and develop more sustainable approaches to forest management.

Effective control over forest resources is a key factor in the fight against illegal logging and forest degradation. Modern monitoring methods allow timely detection of violations, assessment of the scale of losses, and forecasting of possible economic and environmental consequences (Table 1).

Table 1. Methods for monitoring deforestation

Monitoring method	Description	Advantages
Satellite monitoring	Use of satellite images (NASA, ESA) for global monitoring of forest cover changes.	Global coverage, the ability to analyse changes in real time.
Drone technology	Use of drones to detect illegal logging and monitor the state of forest ecosystems.	High accuracy, ability to work in hard-to-reach areas.
GIS analytics	Modelling the effects of deforestation, analysing economic losses and predicting changes in the landscape.	Enables informed decision-making for sustainable forest management.

Source: compiled by the authors based on V. Myroniuk *et al.* (2024)

Thus, modern methods of monitoring deforestation play a crucial role in controlling logging, preventing illegal activities and developing sustainable forest management strategies. The use of satellite technologies, drones and GIS-analytics allows for a timely response to threats, minimising the economic and environmental risks associated with the degradation of forest ecosystems.

The impact of soil erosion in forested areas on the regional economy

Soil erosion in forested regions causes significant economic losses, affecting various sectors of the economy. Firstly, the decline in forest productivity due to erosion leads to a loss of potential for forest regeneration. Eroded soils lose a significant amount of humus, which reduces their fertility and complicates reforestation processes. For example, in the US Midwest, erosion rates average 12.5 tonnes of soil per hectare per year, reaching 250 tonnes in the most problematic cases. This leads to the loss of topsoil, which is rich in organic matter, which negatively affects land productivity. Globally, soil degradation also leads to significant losses of humus. Every year, about 23.7 million tonnes of humus are lost due to erosion, which negatively affects soil bioproductivity (Soil erosion, 2017). The loss of soil fertility leads to a reduction in the productivity of forest plantations, which directly affects the economic stability of regions dependent on the forest industry.

Second, soil erosion leads to increased infrastructure costs due to damage to roads, dams, and buildings caused by landslides. The development of ravines and siltation of water bodies reduce the area of arable land and require additional investment in the restoration and protection of infrastructure. According to research by the University of Central Asia (n.d.) of Environmental Studies, annual nutrient losses due to erosion in Kazakhstan and Uzbekistan are up to 700,000 tonnes of nitrogen compounds, 320,000 tonnes of phosphate fertilisers and 250,000 tonnes of potassium salts. This is equivalent to the loss of the ability to grow more than 900,000 tonnes of grain crops annually, which significantly affects the region's food security.

Third, erosion worsens the water regime, reducing the quality of water resources. For example, siltation of reservoirs due to erosion processes globally reduces the water capacity of reservoirs by 1%-2% annually, which significantly affects water supply and increases the cost of water treatment. This phenomenon is particularly acute in China, India and sub-Saharan Africa (Nigeria and Kenya). In China, particularly in the Huang He River basin, soil erosion has caused sediment to accumulate in reservoirs, reducing their capacity and increasing the risk of a water crisis. In India, the siltation of the Ganges and Brahmaputra rivers is limiting water supplies for agriculture and the energy sector, forcing the government to invest heavily in dredging. In the Sahelian region

of Africa, intensive erosion has caused degradation of water bodies, making it difficult for industrial and agricultural facilities to access water, which negatively affects economic development (Soloviy, 2016).

Soil erosion causes significant losses to agriculture, especially through wind erosion, which damages spring sprouts of crops such as sugar beet, sunflower, and corn. Wind erosion results in the loss of up to 24 billion tonnes of topsoil globally each year, which has a significant impact on yields. In arid regions such as Central Asia (Kazakhstan, Turkmenistan), soil blowing can destroy up to 25% of crops, forcing farmers to spend additional money on

reseeding and protecting their fields (Food and Agriculture Organization of the United Nations, n.d.).

Thus, soil erosion in forested regions has a complex negative impact on the economy, requiring the implementation of effective measures to prevent and minimise its consequences. Soil erosion monitoring in forest regions is an important tool for assessing its effects and developing strategies to combat land degradation. Modern technologies make it possible to track changes in soil cover, analyse the level of siltation of water bodies and predict further changes in the landscape. Table 2 shows the main methods of erosion monitoring.

Table 2. Methods monitoring soil erosion

Monitoring method	Description	Advantages
Radar images of satellites	Recording changes in land cover using satellite technology.	Allows tracking erosion over large areas in real time.
Hydrological analysis	Assessment of the level of siltation of rivers and other water bodies to determine the impact of erosion.	It helps to determine the degree of water pollution and flooding risks.
Modelling of landscape changes	Predicting future changes in relief and assessing possible economic consequences.	It helps to develop strategies to combat erosion and restore degraded land.

Source: compiled by the authors based on European Space Agency (2023)

The use of these methods allows identifying erosion risks in a timely manner and taking appropriate measures to minimise them. The introduction of satellite monitoring, hydrological analysis and digital modelling of landscape changes helps to preserve forest ecosystems and protect natural resources.

The impact of biodiversity changes on the economics of the forest sector

Biodiversity loss has long-term economic consequences for regions where forestry plays an important role. The loss of species diversity disrupts the ecological balance, leading to a decrease in the productivity of forest ecosystems, reduced economic opportunities and increased

costs of forest management. The decline in ecosystem services has a significant impact on economic processes, as forests perform a natural function of climate regulation, air and water purification, soil conservation and nutrient cycling. For example, in the tropical Amazon region, the loss of forest area has reduced the region's ability to retain moisture, leading to more frequent droughts and a negative impact on agriculture (de Sousa *et al.*, 2016). The decline in these services leads to an increase in public spending on ecosystem restoration and climate change mitigation measures.

Losses for the pharmaceutical and food industries are associated with the disappearance of rare plant species with high economic

value. According to the World Health Organization (2013), about 80% of the world's population uses medicinal plants to treat various diseases, and many of these plants grow in forests. The disappearance of rare species, such as the African yohimbe or the South American lapacho, leads to a reduction in potential resources for the production of new medicines. In addition, forest degradation reduces the diversity of wild fruits, nuts and honey plants, which is detrimental to the food industry.

The decline in tourist attraction is another significant economic impact of biodiversity loss. Forest ecosystems attract millions of tourists who visit national parks, nature reserves and recreational areas. For example, in 2023, the global ecotourism market was estimated to be worth USD 191.3 billion, and its growth is directly dependent on the preservation of the natural environment. In countries where forests are degrading, such as Brazil and Indonesia, due to the disappearance of species, there is an outflow of tourists, which leads to economic losses for local communities and tourism-related businesses (Ecotourism Market Size..., 2024).

Reducing the resilience of forest ecosystems makes them more vulnerable to diseases and pests, which leads to additional costs for pest control and forest fires. In 2020, the Czech Republic, Germany, and Austria suffered the largest losses due to bark beetles. In the Czech Republic, a large-scale epidemic led to an oversupply of timber, which reduced its value and forestry companies' revenues. In Germany, the drying out of spruce forests led to a sharp increase in emergency logging, a glut of timber on the market, and financial losses for companies. In Austria, significant damage to forests, especially in the Alps, led to a decline in production in the woodworking industry and job losses. In general, the bark beetle epidemics in these countries have led to lower timber prices, higher costs of sanitary felling, and economic losses

for the forestry sector (Food and Agriculture Organisation of the United Nations, n.d.). This has led to significant economic losses in the forestry sector and the need to allocate additional funds for sanitary felling and forest restoration. Thus, biodiversity loss leads to significant economic losses affecting various industries, from forestry and pharmaceuticals to tourism and agriculture. Biodiversity loss and climate change pose significant economic risks, especially in sectors such as agriculture and infrastructure. Climate change is leading to an increase in average annual temperatures and uneven distribution of precipitation, which negatively affects yields. For example, in the United States, particularly in North Dakota, farmers are facing the need to adapt crop rotations and production systems due to changing climate conditions. This requires additional investment in new technologies and practices, which increases production costs (Hughes, 2024).

Extreme weather events, such as floods and heat waves, cause damage to infrastructure, resulting in significant costs to rebuild. In the United States, for example, floods and extreme heat accelerate the deterioration of bridges, many of which were built decades ago and were not designed to withstand modern climate stresses. This poses a safety hazard and requires significant financial resources for repair and modernisation (Hughes, 2024). In general, the combination of biodiversity loss and climate change increases economic risks, in particular through reduced agricultural productivity and increased costs for infrastructure maintenance and restoration. This requires the implementation of effective forest management strategies and biodiversity conservation as a key factor in economic stability. To effectively monitor the state of biodiversity, modern methods are used to assess changes in wildlife populations, soil microflora, and species composition of forest ecosystems (Table 3).

Table 3. General characteristics of test areas

Monitoring method	Description	Advantages
Automatic camera traps	Use of cameras with motion sensors to monitor wildlife populations in the natural environment.	Provides accurate data on species abundance and behaviour without human intervention.
DNA analysis from soil samples	Determining changes in the microflora and composition of soil organisms by analysing soil samples.	It helps to identify species, including rare and endangered species, without the need for direct observation.
Indices biodiversity	Quantification of changes in the species composition of flora and fauna using special indices (e.g., Shannon index, Simpson index).	Provides a comprehensive analysis of biodiversity dynamics and helps to predict environmental changes.

Source: compiled by the authors based on A.F. O'Connell *et al.* (2011)

These methods help to identify threats to biodiversity, analyse environmental trends and develop strategies for the conservation of natural ecosystems. Automated camera traps provide continuous monitoring of animal populations, helping to combat poaching and evaluate the effectiveness of conservation measures.

Economic consequences of forest degradation for regional development

The degradation of forest landscapes has serious economic implications for regional development, as it affects employment, financial flows, the investment climate and demographic processes. The loss of forests not only reduces economic activity in the logging sector, but also affects related industries such as construction, woodworking, agriculture, and tourism. Reduced budget revenues are one of the most visible consequences of forest degradation. Logging companies and woodworking enterprises generate a significant share of tax revenues for local budgets. For example, in Canada, the forestry industry provides more than USD 12 billion in tax payments annually, but due to the reduction in forest area and restrictions on logging, this figure may decrease (Natural Resources Canada & Canadian Forest Service, 2020). A similar situation is observed in Southeast Asian countries, where illegal logging leads to the shadow economy and a reduction in official

budget revenues (Food and Agriculture Organization of the United Nations, n.d.).

Successful and problematic reforestation projects in different countries demonstrate the importance of a comprehensive approach and consideration of local conditions.

In Indonesia, Eden Reforestation Projects launched a large-scale mangrove restoration initiative in 2017 on the island of Biak in Papua province. During the first year, more than 1.7 million trees were planted, and as of November 2020, more than 22 million trees were planted in 10 project locations. This success highlights the importance of collaboration between international organisations and local communities to achieve sustainable results in forest restoration (Eden Reforestation Projects plants..., 2020).

In Brazil, in December 2024, a plan was announced to restore 40 million hectares of degraded rangeland through commercial reforestation, including eucalyptus plantations. While this may contribute to economic development and carbon sequestration, critics have raised concerns about the impact of eucalyptus monocultures on biodiversity and water resources. This example demonstrates the difficulty of balancing economic interests with environmental sustainability in forest restoration projects (Hillsdon, 2024).

In countries heavily affected by deforestation, such as Indonesia and Brazil, governments

are forced to spend billions of dollars on greening and protecting natural landscapes. Indonesia has introduced a moratorium on deforestation of old-growth forests and peatlands, and is reviewing plantation licences. Deforestation rates have decreased, but illegal logging remains a problem (Soloviy, 2016). Brazil plans to restore 40 million hectares of grassland through eucalyptus plantations, which is controversial due to possible negative impacts on biodiversity and water resources (Hillsdon, 2024).

Demographic changes are a consequence of the decline in economic activity in regions affected by forest degradation. Job losses in the forestry industry, wood processing and related sectors lead to population migration. In Latin America, deforestation combined with climate change is creating conditions that are forcing people from forested regions to seek employment in urban areas. For example, in Brazil, the loss of jobs in the forestry industry led to the migration of about 15% of the population from rural Amazonian regions in 2015-2020 (World Bank, 2024).

Declining land and property values are another long-term consequence of forest degradation. Areas that have lost forests become less attractive to investors as they lose their environmental and recreational benefits. In the United States and Canada, the market value of deforested land can fall by 30-50%, especially if it has become prone to erosion or has lost its economic value. In countries where forested areas are of tourist value, such as Switzerland or Finland, landscape degradation can reduce the flow of tourists and, consequently, the region's income (Food and Agriculture Organization of the United Nations, n.d.). Thus, the economic consequences of forest landscape degradation go far beyond the forest sector. They affect tax revenues, necessitate additional environmental expenditures, cause demographic changes, and lead to a decline in land and property values.

This calls for an integrated approach to natural resource management, including sustainable forest management, investment in ecosystem restoration and the creation of alternative economic opportunities for regions dependent on the forest sector.

The degradation of forest landscapes is the result of not only environmental but also socio-economic factors that largely determine the extent of deforestation and the rate of depletion of forest resources (Shuplat *et al.*, 2022). One of the key factors is corruption in the forestry sector, which facilitates illegal logging and export of products without proper control. The absence of effective monitoring allows business entities to circumvent restrictions, manipulate reporting and exploit forest resources beyond the established environmental standards. This creates a shadow timber market, which undermines the economic stability of the forestry sector and complicates its regulation at the state level (Key corruption risks..., 2025).

Economic pressure caused by the growing demand for wood in the construction, industrial, and energy sectors has a significant impact on deforestation. Infrastructure development, production of paper, furniture, and biofuels stimulate an increase in timber harvesting, which poses risks to forest ecosystems. This is especially true in countries where forestry is a strategic sector of the economy and legislative regulation remains weak. In Ukraine, the partial lifting of the moratorium on timber exports has led to increased timber harvesting, which has exacerbated the problem of deforestation and increased economic risks for the timber processing industry (Yaroshchuk, 2018; Turchyn, 2024).

Social factors also play an important role in forest degradation. In regions where forestry is the main source of employment, the population is dependent on timber harvesting, making it difficult to implement restrictions and environmental restoration programmes.

Low awareness of the long-term consequences of deforestation and the lack of alternative sources of income force local communities to maintain intensive use of forest resources. In such circumstances, insufficient funding for environmental programmes and the lack of effective government support mechanisms only exacerbates the problem. In view of the above, a comprehensive approach to regulating the industry is needed to reduce socio-economic pressure on forest resources. This includes strengthening control over logging, eliminating corruption schemes, creating economic incentives for the development of alternative materials and technologies, and supporting local communities through sustainable development and ecotourism programmes. Only a systematic approach will reduce the negative impact of anthropogenic factors and ensure a balance between economic interests and the preservation of forest ecosystems.

Ways to reduce economic risks associated with forest degradation

Reducing economic risks caused by forest landscape degradation requires a comprehensive approach that includes a sustainable approach to forest management, effective economic mechanisms and innovative technological solutions. One of the key ways to minimise economic risks is Forest Stewardship Council International (n.d.) certification, which guarantees that timber harvesting meets environmental and social standards. The introduction of this certification allows controlling logging, ensuring the rational use of resources and reducing illegal logging. In EU countries, where more than 50% of commercial timber is certified by FSC, this approach helps to increase investment in the sustainable development of the forestry sector.

Another method is agroforestry, which involves planting trees to combat soil erosion. Combining agriculture with forest plantations

not only protects soil but also improves yields. For example, in China, a large-scale greening programme called the Great Green Wall has helped to stop the expansion of deserts and increase the productivity of agricultural land (Hillsdon, 2024). In addition, the development of renewable sources of income, such as ecotourism and recreational areas, contributes to economic growth without harming forests. In Sweden and Canada, forest parks and protected areas generate millions of dollars in revenue each year, supporting local communities and promoting conservation. In Sweden, national parks and nature reserves generate significant ecotourism revenues, funded by the state and the private sector. Investments are directed to the development of infrastructure, eco-camps, and tourist routes (Swedish Environmental Protection..., n.d.). In Government of British Columbia (n.d), two funds of CAD 60 million each have been created to support ecotourism and forest conservation. The projects are funded by the government and private donors, which ensures sustainable development and protection of forest ecosystems. An effective way to regulate deforestation is through environmental taxation, which involves imposing taxes on logging and timber use. In a number of countries, such as Finland and Norway, the introduction of environmental taxes has helped to reduce deforestation and stimulate the use of recycled raw materials (Yegorova, 2015).

Another important mechanism is the financing of forest restoration through government and international subsidies. For example, in Germany, government support for the Forest Ecosystems programme allowed for the planting of more than 30 million trees in 2014-2024, which significantly improved forest health and helped reduce soil erosion (Walcott *et al.*, 2022). At the international level, the GCF is a key donor supporting climate initiatives, including reforestation projects. In 2023, the GCF approved

USD 2.1 billion in funding for 34 new projects, expanding its portfolio to USD 13.5 billion (Green Climate Fund Board..., 2021).

Another promising area is carbon credit mechanisms, which involve the sale of certificates for forest conservation. This mechanism allows companies to offset their CO₂ emissions by investing in reforestation projects. For example, Brazil and Indonesia have raised hundreds of millions of dollars through the carbon credit market, which has helped reduce deforestation in these countries (World Bank, 2024).

Innovative technologies also play a key role in forest conservation. The use of drones for monitoring allows for real-time tracking of deforestation, detection of illegal logging, and assessment of the state of forest ecosystems. In Costa Rica, where drones are used to monitor logging, the level of illegal logging has decreased by 35% (World Bank, 2024). Another innovation is the introduction of artificial intelligence for risk prediction, which allows analysing satellite data and identifying areas at risk of deforestation. In the United States, such a system is used to assess the impact of climate change on forests, which allows for timely

development of adaptation strategies (National Integracy Fire Center, 2025).

Reducing dependence on wood is also possible through the development of alternative materials, such as biodegradable polymers, recycled composites, and bamboo. For example, Japan is actively using innovative materials based on mushroom mycelium and agricultural waste to replace wood in construction and packaging (Alaneme *et al.*, 2023). The introduction of a sustainable approach to forest management, financial mechanisms to stimulate forest conservation, and innovative technologies are key ways to minimise economic risks associated with forest landscape degradation. Effective monitoring, the development of environmental entrepreneurship, and international cooperation will help preserve forest resources and ensure the economic stability of regions that depend on the forest sector. To assess possible ways of developing the forestry sector, it is advisable to consider three main scenarios: pessimistic, basic and optimistic. They demonstrate different approaches to forest management and their possible economic consequences (Table 4).

Table 4. Forecast scenarios for the forestry sector

Scenario	Main characteristics	Consequences	Examples of countries
Pessimistic	Lack of effective control, increased illegal logging, weak environmental policy, low level of investment in reforestation.	Reduced forest resources, loss of biodiversity, soil erosion, reduced productivity of the forest industry, economic losses and reduced employment.	Liberia, Democratic Republic of Congo, Bolivia – high rates of deforestation, weak control, lack of sustainable forest management programmes.
Basic	Maintaining the current forest management policy without significant reforms, partial reforestation, limited control over deforestation.	Moderate reduction in forest area, increase in timber prices, risks for the timber industry, partial compensation for losses through restoration programmes.	Ukraine, Brazil, Indonesia – environmental legislation is in place, but control remains insufficient, and partial reforestation is underway.
Optimistic	Introduction of strict controls, digital forest monitoring, expansion of FSC certification, development of ecotourism and alternative sectors.	Stabilisation of forest resources, sustainable economic growth, creation of new jobs, reduction of regional dependence on logging, improvement of the environmental situation.	Finland, Sweden, Germany – developed sustainable forest management systems, FSC certification, digital monitoring of forest resources.

Source: compiled by the authors

The presented scenarios allow assessing the long-term consequences of different management strategies. It is evident that a passive approach to management (pessimistic scenario) causes significant environmental and economic risks, while the baseline scenario only partially compensates for the negative impacts. The optimistic scenario, which envisages the implementation of strict control measures, the development of sustainable forest management models and support for local communities, is the most promising option for ensuring economic stability and conservation of natural resources.

Discussion

The results of the study demonstrated a significant impact of forest landscape degradation on the economic stability of regions, which is consistent with the findings of other studies. The work of K. Navare *et al.* (2021) emphasised the importance of integrating circular economy principles for biological cycles, which helps to reduce economic losses caused by deforestation. The use of regulatory mechanisms, such as FSC certification, is confirmed by the above guidelines for stabilising economic losses in the forest sector. The study by H. Kassa *et al.* (2022) demonstrated that the restoration of forest landscapes in Ethiopia through the implementation of large-scale programmes helped to reduce soil erosion and economic risks. Successful examples of regional greening programmes confirm the effectiveness of such initiatives, such as those justified in the study.

The analysis presented by S. Eshetu *et al.* (2024) indicates the effectiveness of monitoring erosion processes and the introduction of the latest technologies for landscape restoration. The data obtained on economic losses due to soil erosion are in line with the results of the study, which showed significant losses in agriculture due to wind erosion. The monitoring of

land degradation in Central Asia, highlighted by L. Jiang *et al.* (2022), in demonstrated the effectiveness of using geographic information technologies to track changes in landscapes. The use of such technologies supports the conclusions about the importance of GIS monitoring for assessing the economic impact of forest degradation.

The results confirm the importance of monitoring forest landscape degradation for the economic stability of regions. The study by H. Bo *et al.* (2023) focuses on the classification of agricultural land productivity degradation, which makes it possible to assess the impact on the economy and identify areas for intervention. The use of integrated monitoring approaches, such as land use change analysis, allows not only to record the level of degradation but also to identify the main causes of this process (Skydan *et al.*, 2021). This approach facilitates the development of targeted strategies aimed at reducing economic losses by adapting land use to changing environmental conditions. This confirms the expediency of a systematic approach to monitoring, which allows predicting the long-term effects of degradation and taking timely measures to mitigate them.

The practice of tropical forest restoration described by Y. Indrajaya *et al.* (2022), demonstrates a significant positive effect from the implementation of restoration programmes. The use of modern technologies and a scientifically based approach to forest restoration contributes to increasing the resilience of ecosystems to the impact of erosion processes. Reducing erosion as a result of such measures is closely linked to reducing economic risks arising from soil loss, reduced yields and increased costs of restoration (Pichura *et al.*, 2023). In addition, such programmes support the socio-economic development of regions by providing additional sources of income for local communities and creating new opportunities for attracting

investment in sustainable forestry. The effectiveness of such initiatives confirms the need for their further implementation and scaling up.

The results of T. Fremout *et al.* (2021) show the importance of a properly selected tree species composition to ensure the sustainability of forest landscapes in changing climatic conditions. The use of biodiversity as a basis for restoration measures shows high efficiency in terms of long-term economic benefits. In the work of R.K. Mishra & R. Agarwal (2024), the authors substantiated a sustainable approach to the management of degraded areas, which includes a combination of environmental and economic instruments. The application of such approaches provides comprehensive support for restoration processes. The study by W. Shao *et al.* (2024) proposes an improved model for assessing land degradation, which allows for a more accurate determination of the scale of the problem and its impact on the economy. The use of integrated models helps to improve the efficiency of decision-making on the management of degraded areas.

The results of the analysis confirmed the significant impact of forest landscape degradation on environmental sustainability and economic development of regions, which is consistent with the findings of S. Shah & D. Race (2024). The study emphasises the importance of Reducing Emissions from Deforestation and Forest Degradation (REDD+) programmes as an effective tool to combat deforestation. These programmes help to reduce greenhouse gas emissions by implementing measures for forest conservation, restoration and sustainable management of forest resources. The application of such mechanisms in regions with high deforestation rates provides a comprehensive impact on the environmental and economic situation, reducing the risks of ecosystem degradation. The study also points out the importance of involving local

communities and international support, which allows for effective implementation of programmes and improves their effectiveness. The effectiveness of REDD+ confirms the need for further development of such initiatives to maintain environmental sustainability and reduce economic risks associated with forest landscape degradation.

The study by Z. Du *et al.* (2024) found that the dynamics of land use change in the steppe regions of Eurasia directly affects the extent of land degradation. These results confirm the conclusions about the need for a systematic approach to landscape management to reduce negative economic consequences. The analysis of U. Khujanazarov *et al.* (2024) demonstrated the effectiveness of monitoring the dynamic state of the vegetation cover of pastures in the Kashkadarya basin. The results confirm the feasibility of using integrated monitoring approaches to ensure sustainable landscape management, similar to those proposed in the data presented here.

M.R. Saoum & S.K. Sarkar (2024) drew attention to changes in mangrove forests and their impact on the environment. The estimation of economic losses due to the degradation of mangrove ecosystems correlates with the conclusions about the economic consequences of forest landscape degradation in coastal regions. Y.H. Khachoo *et al.* (2024) emphasised the economic consequences of changes in land use and land cover, which also includes a reduction in carbon stocks. The use of Google Earth Engine for the analysis confirms the effectiveness of the latest technologies in studying such changes, which is consistent with the results obtained. S. Kumi *et al.* (2024) identified barriers and opportunities in restoring degraded forest landscapes in Ghana. The analysis confirmed that the successful implementation of restoration programmes requires taking into account socio-economic factors, which coincides with the

conclusions about the need for an integrated approach to solving degradation problems.

The study by S. Bayraktar *et al.* (2024) examined the directions of land degradation within the Istanbul metropolitan area, covering four decades. The results indicate a significant impact of urbanisation and land use changes on the state of land resources. The assessment of the dynamics of degradation underlines the importance of long-term monitoring, which allows not only to identify the main factors of degradation, but also to predict its consequences for the economic development of regions (Adamenko *et al.*, 2023). This confirms the need to integrate monitoring into spatial planning processes to reduce the negative impact of degradation on ecosystem services and the economy.

The evaluation of the research results emphasises the importance of integrated approaches to managing degraded landscapes. Taking into account environmental, economic and social aspects provides a comprehensive understanding of the scale of the problem and allows for the development of targeted strategies to reduce economic risks. This approach contributes to the effective restoration of forest and land resources, which is of particular importance for regions with different natural conditions and the degree of anthropogenic impact. The use of modern technologies and monitoring models helps to improve the efficiency of management decision-making and ensure the resilience of landscapes to negative factors.

Conclusions

The study showed that the degradation of forest landscapes has a complex impact on the economy of regions where the forest sector plays a key role. It was found that the annual loss of forest cover in the world reaches 10 million hectares, which leads to a decrease in the resource base of wood, an increase in its cost and a reduction in the production capacity of the woodworking

industry. In Southeast Asia and Latin America, this has resulted in a 15-25% reduction in employment in the forestry sector and a decrease in tax revenues to local budgets.

Estimates of economic losses have shown that illegal logging causes annual losses of USD 5-7 billion in Latin America and USD 3-4 billion in Africa. At the same time, in countries with developed FSC certification mechanisms, illegal logging does not exceed 5% of total logging, which ensures the stability of the industry and attracts investment. An analysis of international regulatory measures (EUTR, Amazon Soy Moratorium) has shown that strengthening control over forest management helps to reduce deforestation and increase the market sustainability of forest products.

Erosion processes in forested regions have been found to worsen soil fertility, making reforestation more difficult. For example, in Kazakhstan and Uzbekistan, annual nutrient losses due to erosion lead to a decrease in agricultural land productivity, which poses a threat to food security. In addition, siltation of reservoirs increases water and energy costs by 1-2% annually.

The decline in biodiversity in forest ecosystems reduces their resistance to pests and diseases, causing losses to wood processing companies. For example, in the Czech Republic and Germany, large-scale bark beetle epidemics have led to an oversupply of timber, which has reduced its value and reduced the profits of forestry companies. In addition, the decline in biodiversity has a negative impact on the tourist attractiveness of the regions, which affects the income of local communities.

To mitigate the economic risks caused by forest degradation, it is necessary to strengthen control over illegal logging, expand the FSC certification system and develop alternative revenue streams such as ecotourism. Encouraging investment in forest monitoring technologies, including satellite imagery, drones

and GIS analysis, is also important. A promising area is the development of carbon credits, which would allow for the attraction of funding for forest conservation.

Further research should focus on assessing the effectiveness of innovative forest management methods and analysing the impact of climate change on reforestation dynamics. In addition, it is necessary to expand the empirical base on the economic consequences of forest

degradation in Central Asia, which will allow for more accurate risk forecasting and the development of adaptive strategies for managing forest landscapes.

Acknowledgements

None.

Conflict of Interest

None.

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Моніторинг економічних ризиків, пов'язаних з деградацією лісових ландшафтів

Джилдиз Албанбаєва

Магістр

Киргизький державний університет імені І. Арабаєва
720026, вул. Раззакова, 51А, м. Бішкек, Киргизька Республіка
<https://orcid.org/0000-0003-3558-7107>

Жибек Амеркулова

Старший викладач

Киргизький державний університет імені І. Арабаєва
720026, вул. Раззакова, 51А, м. Бішкек, Киргизька Республіка
<https://orcid.org/0009-0006-5416-167X>

Айгуль Чалданбаєва

Доктор педагогічних наук, професор

Киргизький державний університет імені І. Арабаєва
720026, вул. Раззакова, 51А, м. Бішкек, Киргизька Республіка
<https://orcid.org/0009-0003-8107-2697>

Раушанбек Зайнієв

Кандидат економічних наук

Киргизький державний університет імені І. Арабаєва
720026, вул. Раззакова, 51А, м. Бішкек, Киргизька Республіка
<https://orcid.org/0009-0001-3721-8172>

Рустамбек Асанов

Кандидат економічних наук

Киргизький державний університет імені І. Арабаєва
720026, вул. Раззакова, 51А, м. Бішкек, Киргизька Республіка
<https://orcid.org/0009-0005-0166-9229>

Анотація. Метою дослідження було оцінити економічні ризики, спричинені деградацією лісових ландшафтів, та їх вплив на економіку лісового сектору і регіональний розвиток. В ході аналізу було проаналізовано вплив вирубки лісів, ерозії ґрунтів, втрати біорізноманіття та зміни клімату на стійкість лісового господарства, ринок праці, інвестиційну привабливість та фінансові потоки в регіонах. Використано комплексний підхід, що включає статистичний аналіз даних, порівняльну оцінку змін у лісовій галузі та прогнозування можливих економічних наслідків за різними сценаріями розвитку подій. Дослідження показало, що в період з 2015 по 2024 рік глобальна втрата лісового покриву сягала 10 мільйонів гектарів щорічно, що призводило до скорочення запасів деревини та зростання цін на неї на 15-25 % у найбільш постраждалих регіонах. Зменшення площі лісів безпосередньо вплинуло на зайнятість у лісовій галузі, спричинивши скорочення робочих місць у секторі на 20-30 % у Південно-Східній Азії та Латинській Америці, де лісозаготівля є важливим джерелом доходу. Результати показують, що скорочення податкових надходжень від лісової галузі та зменшення місцевих бюджетів призвели до обмеження фінансування соціальних програм та інфраструктурних проектів у сільській місцевості. Аналіз також показав, що нелегальна

вирубка лісів залишається серйозною проблемою, оскільки до 30 % світового ринку деревини може мати нелегальне походження, що підриває економічну стабільність галузі та ускладнює міжнародне регулювання. Втрата біорізноманіття та ерозія ґрунтів призвели до збільшення витрат на екологічне відновлення лісових територій, які в деяких країнах перевищили 5 мільярдів доларів США. Запропоновано комплексні заходи для зниження економічних ризиків, серед яких запровадження жорстких регуляторних механізмів, розвиток FSC-сертифікації, стимулювання інвестицій у відновлення лісів, впровадження цифрових технологій моніторингу, зокрема супутникового спостереження та використання дронів. Результати дослідження можуть сприяти розробці стратегій управління лісовим господарством, екологічного контролю, зниження економічних ризиків, впровадження технологій моніторингу та оцінки впливу деградації лісів на регіональний розвиток

Ключові слова: довкілля; сталий розвиток; екосистема; ерозія; біорізноманіття