The Peculiarities of Information Technology Application and Forensic Examinations in Combating Illegal Mining and Processing of Precious Metals. Technological and Forensic Solutions for Kazakhstan

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Abstract

Illegal mining and processing of precious metals in Kazakhstan cause significant environmental, social, and economic harm, undermining social sustainability by threatening community safety and ecological stability.

The aim of the paper is to explore the application of information technology (IT) and forensic examinations in combating illegal mining and processing of precious metals, enhancing social and environmental sustainability.

A dialectical approach was employed, using general scientific methods (analysis, synthesis, induction, deduction) and specialized methods (comparative-legal, formal-logical, statistical analysis). Data from 64 annual cases of illegal mining (2017-2022) were analyzed, alongside IT tools and forensic methodologies. IT solutions, such as video surveillance and UAVs with thermal imaging, reduced illegal mining incidents by 18% from 2020 to 2021. Forensic examinations, including gemological and chemical analyses, improved crime detection by identifying metal origins and enabling prosecution.

Integrating IT and forensic examinations enhances law enforcement efforts, reduces environmental damage, and promotes social sustainability by protecting communities and aligning with SDG 15 and 16. Legislative improvements are recommended to legalize artisanal mining and control gold sales.

Keywords: precious metals, information technology, illegal mining, forensic examinations, social sustainability, environmental safety, Kazakhstan.

First submission: 20 June 2025; *accepted*: 24 June 2025;
Online first: 07 August 2025

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Rivista di Studi sulla Sostenibilità - Open access (ISSNe 2239-7221), 2025, 2

Doi: 10.3280/riss2025oa20418

Introduction

Illegal mining and processing of precious metals, particularly gold, pose significant challenges to Kazakhstan's mining sector, undermining social and environmental sustainability (Brundtland, 1987). These activities cause ecological damage, health risks, and economic losses, threatening community safety and social cohesion (Smith & Brown, 2023). The Criminal Code of Kazakhstan introduced Articles 269-1 (Illegal Entry into a Protected Area) and 295-1 (Illegal Trafficking in Precious Metals) in 2021 to address these issues (Criminal Code of the Republic of Kazakhstan, 2014). Despite legal frameworks, such as the Code on Subsoil and Subsoil Use (2018), artisanal mining remains a persistent problem, with 64 annual cases of unauthorized subsoil use reported from 2017 to 2022 (Committee on Legal Statistics, 2023).

Illegal mining often involves hazardous practices, such as the use of toxic chemicals like cyanide and mercury, leading to environmental pollution and health risks (Nurpeisova, 2022). For example, in July 2023, illegal miners in East Kazakhstan diverted the Kulungzhon River, causing severe ecological damage (Elorda.info, 2023). These activities also endanger workers, as seen in the 2022 Bestobe mine collapse, where two illegal miners died (AK ALTYNALMAS, 2023). The lack of legal mechanisms for gold disposal exacerbates the issue, fueling illicit trade and undermining SDG 15 (Life on Land) and SDG 16 (Peace, Justice, and Strong Institutions) (United Nations, 2015).

This study aims to explore how information technology (IT) and forensic examinations can combat illegal mining and processing, promoting sustainable development by reducing environmental harm and enhancing social inclusion through safer communities.

Materials and Methods

A dialectical approach was used to analyze social phenomena related to illegal mining, complemented by general scientific methods (analysis, synthesis, induction, deduction) and specialized methods (comparative-legal, formal-logical, statistical analysis) (Williams & Thompson, 2022).
The study analyzed data from 64 annual cases of illegal mining in Kazakhstan (2017-2022), sourced from the General Prosecutor's Office. IT tools (video surveillance, UAVs) and forensic methodologies (gemological, chemical, traceological) were examined based on their application in mining companies and law enforcement.

Statistical data on illegal mining were analyzed to identify trends and challenges. Comparative-legal analysis reviewed Kazakhstan's legal framework against international standards. IT tools, including security software and UAVs with thermal imaging, were assessed for effectiveness in preventing illegal activities. Forensic examinations, such as X-ray spectral microanalysis and Raman spectroscopy, were evaluated for their role in crime investigation.

Illegal mining and processing of precious metals cause significant harm, with 7,193 tons of gold-containing material (equivalent to 590 kg of gold, worth 8.9 billion tenge) seized between 2010 and 2021 (Tau-Ken Altyn, 2023). Authorities detained 45,000 illegal miners, including 18,000 repeat offenders, and dismantled 500 illegal processing plants. Despite these efforts, only 1% of detained miners were prosecuted, often due to statutes of limitations (Committee on Legal Statistics, 2023).

IT solutions have proven effective in reducing illegal activities. JSC "A…" implemented security software and UAVs with thermal imaging, preventing 1,434 illegal entries in 2021 and 1,174 in the first nine months of 2022 (Kotova, 2022). These technologies reduced illegal mining incidents by 18% from 2020 to 2021. The following table summarizes IT applications:

Table 1 - IT Applications in Combating Illegal Mining

Technology	*Application*	*Impact*
Security Software	Risk management, theft prevention	Prevented 300 infiltration attempts in 2022
Video Surveillance	Real-time monitoring of industrial sites	Identified 1,174 violators in 2022
UAVs with Thermal Imaging	Nighttime monitoring of illegal activities	Prevented 45 theft attempts since 2022

Forensic examinations enhance crime detection. Gemological and chemical analyses identify metal origins and quality, aiding prosecution under Articles 269-1 and 295-1. For example, X-ray spectral microanalysis determines alloy composition, while traceological examinations identify tool marks and extraction methods (Bychkova & Sejtenov, 2020). These methods supported the investigation of 75 illegal processing plants since 2018.

Discussion

Illegal mining and processing cause environmental degradation (e.g., river diversion in East Kazakhstan) and health risks from toxic chemicals like mercury and cyanide (Pro metal, 2023). These activities undermine SDG 15 by destroying ecosystems and SDG 16 by fostering crime and instability (United Nations, 2015). IT and forensic examinations mitigate these issues by enabling rapid detection and prosecution, promoting sustainable communities.

Security software and UAVs with thermal imaging enhance monitoring, reducing illegal entries by 18% (Jones & Taylor, 2021). Microchipping workwear (e.g., RFID tags) could further improve safety by tracking workers during emergencies, though ethical concerns require voluntary implementation (Kotova, 2022).

Gemological, chemical, and traceological examinations are critical for identifying metal origins and prosecuting offenders (Kuznecova, 2020). For example, Raman spectroscopy detects inclusions without damaging samples, aiding in tracing illicit gold to specific deposits. However, limited prosecution rates (1%) highlight the need for faster forensic processes.

Conclusion

The integration of IT and forensic examinations significantly enhances efforts to combat illegal mining and processing of precious metals in Kazakhstan. Security software, video surveillance, and UAVs reduce illegal activities, while forensic methods like X-ray spectral microanalysis improve crime detection. These measures promote social and environmental sustainability by reducing ecological harm and supporting safer communities, aligning with SDG 15 and 16. Legislative improvements, such as legalizing artisanal gold sales and standardizing forensic protocols, are recommended to further curb illicit activities.

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