DOI 10.61718

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ISBN 978-617-7886-61-6
DOI: 10.61718/mon202511

ГУМАНІТАРНІ ПРІОРИТЕТИ В УМОВАХ СОЦІАЛЬНО-ПОЛІТИЧНИХ ТРАНСФОРМАЦІЙ УКРАЇНИ

Монографія

Харків • СГ НТМ «Новий курс» • 2025

УДК 001:1
Г93

Гуманітарні пріоритети в умовах соціально-політичних трансформацій України: моногр. – Харків: СГ НТМ «Новий курс», 2025. – 179 с.

ISBN 978-617-7886-61-6
DOI: 10.61718/mon202511

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Рекомендовано до друку Вченою радою наукової установи Соціально-гуманітарна науково-творча майстерня «Новий курс» *(протокол № 11мн-2025 від 28.11.2025)*

Видавець СГ НТМ «Новий курс» – діяльність у науковій, видавничій, освітній, творчій, Інформаційній сфері з 1989 року. Свідоцтво про внесення суб'єкта видавничої справи до Державного реєстру видавців, виготовлювачів і розповсюджувачів видавничої продукції ДК № 8013 від 22.11.2023. Зареєстровано у Global Register of Publishers.
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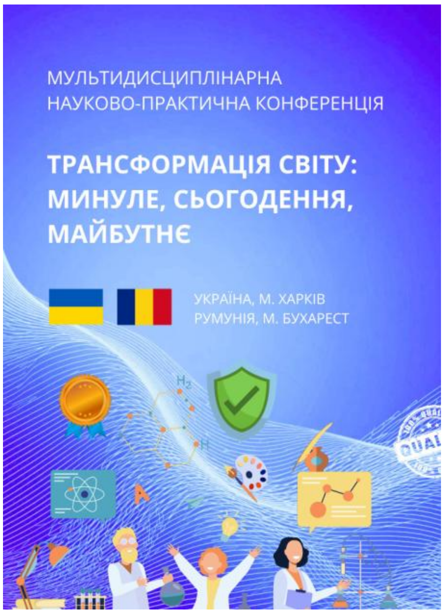
Монографія присвячена актуальним питанням розвитку сучасного суспільства. Монографія буде корисною науковцям, викладачам, здобувачам освіти, а також широкому колу осіб, які цікавляться питаннями розвитку сучасної науки та практики. Монографія оприлюднюється за результатами проведення науково-практичної конференції «Трансформація світу: минуле, сьогодення, майбутнє». За результатами проведення конференції та оприлюднення рукописів автори отримують електронні сертифікати. Сертифікати оприлюднюються на сайті видавця (згідно Порядку підвищення кваліфікації педагогічних і науково-педагогічних працівників, затвердженого постановою Кабінету Міністрів України від 21 серпня 2019 р. № 800).



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ПРО КОНФЕРЕНЦІЮ

За результатами проведення конференції та оприлюднення рукописів, учасники отримують електронний сертифікат (90 годин – 3 ECTS credits). Сертифікати оприлюднюються на сайті видавця (згідно Порядку підвищення кваліфікації педагогічних і науково-педагогічних працівників, затвердженого постановою Кабінету Міністрів України від 21 серпня 2019 р. № 800). За результатами проведення конференції оприлюднюється монографія. Розміщення публікації автора у виданні є підтвердженням участі автора у конференції. Публікація у виданні є науковою працею, яка опублікована у вітчизняному науковому виданні.

правову невизначеність, а з іншого – стають рушійною силою еволюції права, стимулюючи розвиток законодавства і вдосконалення механізмів правозастосування.

Їхній дестабілізаційний вплив проявляється у порушенні єдності правової системи, утрудненні реалізації норм, зниженні рівня довіри до права та правосуддя. Водночас саме через подолання таких суперечностей і заповнення прогалин формується гнучкість і адаптивність правової системи, що дозволяє їй відповідати на нові соціальні виклики.

Вирішення проблем колізій і прогалин потребує системного підходу, який поєднує правотворчу, правозастосовну та доктринальну діяльність. Важливу роль у цьому відіграють механізми гармонізації законодавства, судове тлумачення, кодифікація правових актів, а також розвиток єдиної судової практики.

Таким чином, юридичні колізії та прогалини в праві слід розглядати не лише як недоліки нормативної системи, а як природні чинники її розвитку. Їхнє усвідомлення і раціональне подолання сприяють зміцненню правової стабільності, узгодженості законодавства та підвищенню ефективності правового регулювання. Саме через баланс між дестабілізацією та розвитком формується жива, динамічна й стійка правова система, здатна відповідати на потреби сучасного суспільства.

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3.3. Using digital products in combating environmental violations

Introduction. Digitalisation has become a key factor in modernising environmental policy, supervision, and law enforcement worldwide. In the context of increasing anthropogenic load, climate change, and technological development, it is the digital solutions that determine the effectiveness of state environmental control, enabling a shift from selective inspections to continuous, preventive monitoring. The use of satellite technologies, unmanned systems, sensor networks and analytical data platforms forms a multi-level surveillance ecosystem that ensures timely detection of violations and creates new opportunities for environmental forensics and evidence in legal proceedings.

On the other hand, the expansion of digital infrastructure creates new challenges related to energy consumption, cyber risks, personal data protection and admissibility of digital evidence. The scientific literature increasingly emphasises the need for a balanced approach - combining innovative monitoring technologies with the principles of "green IT" and proper data management. Therefore, the effective use of digital tools in the environmental sphere requires the simultaneous development of regulatory frameworks, digital forensics procedures, and transparent protocols for interaction among state institutions, scientific institutions, and the public.

Ukraine, as a highly industrialised state facing significant environmental challenges, especially during military operations, needs to introduce a holistic digital environmental control system. Given the complex conditions of monitoring, the destruction of infrastructure, and the risks of data loss, digital technologies should serve as the basis not only for recording violations but also for prompt response, prevention, and accountability. It is the implementation of multi-access monitoring - "satellite → drone → in-city" – that both creates the basis for objective proof of environmental violations and raises the effectiveness of environmental justice.

We find it necessary to conduct a comprehensive analysis of current trends in digitalisation in environmental safety, to determine the functional potential of digital products for the prevention and investigation of environmental offences, and to formulate proposals to improve regulatory and legal support for digital environmental control in Ukraine. The implementation of this task requires a combination of technical, legal and social approaches that would ensure not only technological efficiency, but also procedural legitimacy, ethics and public trust in digital tools in the field of environmental protection.

Literature review. Research by contemporary authors indicates that the digitalisation of environmental monitoring is a crucial tool for transitioning from reactive to preventive control of environmental conditions. However, the issues of legal legitimacy and standardisation of digital evidence remain insufficiently studied. That is why in our study, we focus on a comprehensive analysis of the use of digital products in the prevention and investigation of environmental offences. The scientific problem is to determine how digital technologies can be integrated into law enforcement practice for environmental security in Ukraine while adhering to the principles of reliability, admissibility, and the ethics of digital evidence.

Results.

Digitalisation in the field of environmental security: current trends and challenges.

The digitalisation of environmental protection activities has become systemic, integrating remote sensing of Earth, unmanned systems, sensor networks, and analytical data platforms into a single loop for early risk detection and response. This approach significantly enhances the state's ability to counter environmental violations and bolster environmental security.

At the same time, digital infrastructure has its own environmental footprint, particularly through the energy consumption of data centres and the generation of electronic waste. Experts highlight the need to develop "green IT" policies that minimise adverse side effects, ensuring a balance between the benefits of digital surveillance and environmental safety [1, p. 5-6; 2, p. 7-9].

The theoretical basis for the digital transformation of environmental activities lies in the distinction between "greening ICT" and "ICT for ecology".The first vector aims to minimise the negative impact of the technologies themselves; the second aims to use digital tools to monitor, warn, and enforce environmental regulations in real time. This assigns control to a risk-oriented framework [1, pp. 6-12]. In this context, the effectiveness of a digital ecosystem should be assessed not by the number of installed sensors or technical devices, but by the ability of analytical tools to ensure data consistency across different systems, promptly support decision-making, and provide a reliable evidence base for management and law enforcement.

The term "in city" denotes direct data collection or measurements at the scene, i.e., in natural conditions without removing the object from its environment. This approach allows highly accurate results on the parameters of air, water, soil, or biota, thereby significantly increasing the reliability of analytical conclusions. The triad "satellite → drone → in city" incorporates the principle of multi-access monitoring, which combines remote sensing data (satellite and aerial photography) with the results of local field measurements, creating a multi-level system of verification and confirmation of environmental information. Such a hierarchy of observations allows for optimising inspection costs, increasing response speed, and improving the accuracy of recording short-term environmental incidents [3, p. 18].

Multi-level monitoring using satellites, UAVs and ground sensors is consolidated into multilayer datasets for environmental forensics, which allow the localisation of illegal dumps, unauthorised discharges and land-use changes, with a reproducible evidence base for inspections and courts [4, p. II]. Practice shows that the hierarchy "satellite → drone → and in-city" optimises inspection costs and increases the probability of fixing short-term incidents.

The use of artificial intelligence and deep learning technologies enables much faster detection of deviations or suspicious changes in large volumes of images and sensor data, thereby reducing the time between the occurrence of an environmental event and the management response. At the same time, to ensure the results of such systems remain legally and scientifically sound, it is necessary to verify their accuracy, the clarity of the principles of algorithmic operation, and the transparency of decision-making procedures. Therefore, there are compelling arguments that interpretable models and independent audits of algorithms should be prioritised in regulatory contexts to ensure the reproducibility of conclusions in judicial practice [5, p. 4-6].

The importance of digital technologies in combating environmental crimes lies in moving from post-facto investigations to preventive risk identification and targeted inspections, thereby increasing the chances of holding offenders accountable. Real-time data on water and air quality, waste movement, and energy consumption enable adaptive inspections and rapid verification of citizen complaints, increasing the accountability of control bodies [2, p. 10-13].

The integration of multispectral and thermal infrared analysis, time-series of coverage, and bioindicators significantly increases the likelihood of forming a law-enforcement chain: "source – path – target". This allows targeting inspection activities to the so-called "hot zones", in particular those with an increased probability of illegal emissions or landscape changes – for example, in frontline regions or industrial zones of Ukraine.

National context of digital forensics requires the introduction of standardised metadata (including timestamp, sensor type, georeferencing, level of uncertainty) and a clearly defined digital chain of custody (chain of custody). Without proper metadata and storage procedures, high-precision observations risk losing their procedural validity and being inadmissible as evidence in court.

Given the situation in Ukraine with its specific challenges, such as complex territorial issues, high level of industrialisation, an area of active military influence, and rapid changes in the landscape and ecological environment, it is important to establish a regulatory framework that determines metadata standards, criteria for the admissibility of digital surveillance, and mechanisms for their integration into law enforcement and judicial processes. Only in this way can digital monitoring technologies be transformed into practical law enforcement tools, rather than remaining a purely technical means.

Environmental DNA (eDNA) refers to genetic material that organisms leave behind in the environment – in water, soil, air or sediment. Research on this material allows the identification of species present in a particular ecosystem without the need for direct observation or sampling of living organisms. In particular, fish leave behind cell particles in the aquatic environment, animals – epithelial cells or fur, plants – pollen and tissue fragments.

eDNA research enables the assessment of biodiversity, the condition of ecosystems, the identification of rare and invasive species, and sources of anthropogenic impact. Methodologically, eDNA is valuable because it provides reliable data without the need for direct sampling of organisms, reducing potential stress on natural ecosystems, and allowing monitoring in hard-to-reach or protected areas.

The use of eDNA allows for effective monitoring of biodiversity and the identification of sources of anthropogenic impacts without invasive sampling, which is especially important for the protection of rare and protected species in Ukraine. At the same time, the use of eDNA requires strict standardisation of procedures, contamination control, and mandatory cross-checking of data with traditional observation methods (field surveys, remote sensing) to ensure the admissibility of results in judicial and administrative procedures.

Scholars emphasise that eDNA should be institutionalised as part of a mixed-evidence set, ensuring clear standards for operating procedures, validation protocols, and integration with other data sources, rather than being used as a stand-alone attribution tool [5, p 4-6].

In the context of Ukraine and its unique environmental challenges, which include high levels of human-induced stress, pollution of water bodies, and risks to protected species, the use of environmental DNA (eDNA) in environmental monitoring and forensics can significantly enhance the effectiveness of demonstrating violations of environmental legislation.

Institutionally, it is important to establish a "digital chain of custody" for environmental evidence, including data versioning, cryptographic hashes, access logs, and independent auditing coordinated among environmental inspectorates, police, and courts. This approach reduces the risk of admissibility challenges to evidence and speeds up the process [2, pp. 14-16; 1, pp. 15-16]. Establishing minimum metadata requirements and chain-of-custody principles (Chain of Custody, CoC) in secondary legislation unifies practices for storing and presenting digital data, increasing legal predictability and ensuring the integrity, transparency, and evidentiary value of information in judicial and administrative procedures.

The risks of technocratic or authoritarian intensification of digital surveillance arise in the absence of stakeholder participation, assessment of algorithmic biases, and transparency. The introduction of "ethical default safeguards" (privacy-by-design, explainability-by-design) into the technical specifications of state surveillance systems minimises the legitimacy deficit [5, pp. 6-9].

Citizen surveillance platforms can enhance preventive measures and democratise control, but require validation protocols, noise filtering, and privacy protections. When these platforms are integrated with official sensor networks, they become more sensitive to local incidents. Crowdsourcing should be embedded in formal data offices with transparent rules for accepting messages and providing clear feedback.

Information integration challenges involving platform interoperability, quality control, verification and calibration, and asymmetries in access to sensors and computing resources require open data standards, agreed classifiers, and sustainable funding for cyber protection of critical digital infrastructure. It is advisable to implement "minimum required" data profiles and modular application programming interfaces (APIs) to reduce technical shortcomings (e.g., eliminating unnecessary data in the system, thereby keeping the system effective and easily scalable). It will ensure coordination among agencies.

Regulatory frameworks should simultaneously encourage the use of ICT to minimise environmental risks and limit the impacts of digital infrastructure by implementing energy efficiency standards, e-waste management, and transparency in equipment supply chains. We believe that the concept of "digital minimalism for maximum environmental impact" should be considered based on relevant data and proven practical cases. Such an approach reduces the burden on the infrastructure and increases the public legitimacy of the decisions made.

For Ukraine, the priority tasks are harmonising national environmental data registers with European open standards, ensuring compatibility between field measurements and satellite products, and improving the energy efficiency of digital surveillance services. Public analytical monitoring panels and certified digital evidence procedures strengthen trust, raise the effectiveness of control, and preserve procedural guarantees. There is no doubt that the institutionalisation of digital CoC and interdepartmental data exchange protocols is a critical condition for the transition from surveillance to effective enforcement.

The strategic effectiveness of digitalising environmental security can be achieved through a synthesis of technological, legal, and social elements: digital tools are practical only when supported by transparent procedures, ethical safeguards, and public trust. In such a configuration, digital products shift from passive surveillance to active prevention, evidencing, and fair enforcement in the environmental sphere.

Digital products in the field of environmental control and their functional purpose.

Digital products are gradually shaping the transition from reactive to proactive, continuous environmental monitoring, where integrated surveillance, analytics, and forensics provide a complete cycle of "observation – analysis – evidence – response” [6, pp. 4011-4013]. Such an ecosystem enables early detection of environmental risks and targeted inspections by integrating strategic satellite imagery, operational drone data, the temporal granularity of IoT sensors, and verified public participation in data collection. This ensures shifting environmental activities to a data-driven, preventive management model, in which decisions are made on the basis of continuously updated digital evidence.

The following digital products in the field of environmental control should be highlighted: remote monitoring platforms; IoT networks and sensor systems; analytical platforms and artificial intelligence systems; environmental forensics and digital evidence products; traceability and blockchain technologies; crowdsourcing mobile platforms; operational and strategic digital products.

Satellite systems provide strategic monitoring capabilities: they allow for the dating of changes in land use, localisation of "hot spots", identification of unauthorised waste landfills, and detection of thermal anomalies that may indicate violations of environmental legislation [4, pp. I-II]. The data collected established priorities for drone photography and field inspections, creating a risk map for procedural adherence.

Unmanned aerial vehicles provide tactical detail and operational surveillance: photogrammetry and structure-from-motion models allow for the accurate recording of erosion processes, unauthorised logging, flooding, and changes in coastlines over hours to days [6, p. 4011-4014]. Field cases demonstrate the effectiveness of regular UAV missions for verifying environmental process models and conducting targeted inspections.

The “satellite → UAV → in-city" structure minimises monitoring costs, eliminates duplication of efforts, and ensures continuity of the evidentiary chain from observation to trial.

IoT networks for water, air, soil, and industrial areas create a “nervous system” for real-time environmental monitoring. They support early warning systems and detect anomalies that remain invisible during periodic sampling [7, pp. 2-5]. When sensors indicate a sharp spike in pollutants and satellite or drone imagery simultaneously shows noticeable changes in the terrain, this provides further confirmation that the incident is real. In other words, if the "spikes" in sensor data coincide with visible traces in the images, the confidence in such a detection increases significantly.

It is advisable to design “minimally sufficient” sensor arrays with power supply redundancy, calibration, and automatic verification. Excessive sensor density without proper procedures leads to the generation of pseudo-signals and the overloading of analytical systems.

Analytical platforms using artificial intelligence algorithms integrate satellite data, UAV imagery, sensor streams, and citizen reports to build risk models and predict hot spots before an incident occurs. Reviews emphasise the need for model interpretability, regular revalidation on field datasets, and robustness to distributional shifts [8, p. 8].

In regulatory scenarios, it is advisable to implement *MLOps practices* – journaling access, model versioning, and data control, which enhance the procedural legitimacy of digital findings and ensure transparency of interdepartmental audits.

Environmental forensics combines archival imagery, satellite data, UAVs, and in-city measurements to reconstruct the source-path-target chain and localise pollution sources [4, p. III]. Using the multiparameter/multisensor framework fusion (MUM³) allows for the reduction of the errors of individual methods and ensures the reproducibility of conclusions in complex cases.

Metadata (time, sensor, georeferencing, uncertainty) and digital chain of custody (chain of custody) are essential to give forensic products evidentiary value; without them, even the most accurate surveys lose their legal weight.

Blockchain-based traceability systems record the movement of resources and recyclables from origin to end user, preventing counterfeiting and illegal exports, especially when combined with IoT tags and smart contracts [9, p. 1215]. The integration of blockchain technologies into environmental policy creates a new level of trust in control, enabled by the immutability of records and automated verification of the chain of events.

Community monitoring platforms expand the geographical reach and frequency of event recording, creating a kind of "social sensor" for local environmental incidents. Recent studies demonstrate the effectiveness of mixed approaches that combine official monitoring systems with citizen-provided data verification [10]. Community monitoring platforms should operate with transparent moderation, protecting personal data and supporting whistleblowers, as without this, their evidentiary power and user trust are reduced.

In the structural dimension, it is necessary to distinguish between operational response products (monitoring, notification, initial fixation) and strategic management products (analytics, forecasting, risk assessment). It is their interaction that ensures the continuity of environmental safety and the transition from fragmented control to systemic management. The practice of using autonomous UAVs in mountainous areas and involving citizens in water monitoring confirms the role of raising inspection efficiency and the quality of incident screening [11, pp. 4012–4015; 12; 13].

The use of digital products depends on their potential to generate evidence and support management decisions, rather than solely on technical parameters. Modular platforms with clear APIs, standardised metadata, and an organised digital chain of custody ensure the reproducibility and legality of digital evidence. The most effective is a hybrid model, in which government platforms guarantee procedural legitimacy and public ones increase the accuracy and sensitivity of local monitoring. The use of interpretable AI models and rigorous standard operating procedures (SOPs) for IoT forensics lays a foundation for transforming digital data into robust forensic evidence and reliable management signals in the environmental control system.

Innovative tools for proving environmental offences: experience and prospects.

Modern practice in environmental control indicates the rapid introduction of digital technologies for monitoring, recording, and analysing environmental offences. The use of unmanned aerial vehicles, satellite surveillance systems, and the Internet of Things (IoT) ensures not only faster data acquisition but also greater reliability. Such tools allow recording the facts of water, soil, and atmospheric air pollution in real time, thereby increasing the evidentiary value of information in criminal proceedings [5, p. 3–5].

It is worth emphasising that digital technologies are becoming a key element in forming an objective picture of environmental crime. They not only allow observation of environmental changes but also automatically identify sources of pollution. Scholars rightly point out that the use of remote sensing of Earth and artificial intelligence algorithms allows for expanding the boundaries of evidence, particularly when documenting hidden environmental crimes [1, pp. 24-27].

Big data and artificial intelligence are increasingly utilized in forensic investigations of environmental crimes. Based on collected environmental data, analytical models are developed to predict the risk of noncompliance with environmental legislation. In combination with geographic information systems (GIS), they lay the groundwork for forensic reconstructions of events and the creation of evidence maps of territory contamination.

In domestic practice, these approaches are just beginning to develop, but global experience demonstrates their high efficiency. For example, the European Environment Agency actively uses the integrated data platform Copernicus to detect violations of environmental legislation, which indicates the prospects for their adaptation in Ukrainian conditions [2, p. 12-14].

From the perspective of criminal proceedings, digital data acquires the value of full-fledged evidence if it meets the requirements of reliability, authenticity and integrity of the chain of custody. In this context, the creation of regulatory mechanisms for the certification of digital data and procedures for their legal consolidation is relevant.

A promising direction is the introduction of a national system of digital chain of evidence (Digital Chain of Custody, D-CoC), which would provide an algorithm for capturing, storing, and using digital evidence in environmental crime cases. This can ensure the appropriate level of procedural legitimacy of electronic data and improve the quality of judicial proceedings.

Despite the apparent advantages, implementing digital technologies in the practice of combating environmental offences faces several challenges. They include insufficient unification of data-collection standards, the absence of a clear accreditation system for digital tools, and limited interaction between government agencies. To overcome these challenges, it is advisable to create an integrated information and analytical platform that follows the principles of openness, interoperability, and cybersecurity. Its operation should be accompanied by the enactment of a special law that determines the status of digital environmental evidence and the procedure for its use in judicial practice.

The future of environmental crime prevention is directly linked to the development of digital ecosystems of trust that combine technological tools, legal norms, and social responsibility to ensure transparency, reliability, and the efficiency of the evidentiary process.

In this context, it is essential to develop international cooperation - to integrate Ukrainian digital systems with European environmental registers, as well as to expand participation in joint projects with the EU and the United Nations Development Program. Such an approach will not only enhance the effectiveness of national environmental policy but also contribute to the creation of a single digital legal space in environmental security.

Institutional and legal conditions for the implementation of digital products in the practice of combating environmental crimes.

The effective use of digital technologies in the fight against environmental crime requires not only technical equipment but also the establishment of a systemic institutional and legal environment. Without legal certainty regarding procedures, competencies and standards, digital tools remain only demonstration pilots, unable to ensure sustainable evidence-based practice.

A comprehensive regulatory framework should ensure legality, procedural admissibility, inter-agency interoperability and data protection. It is rooted in unified metadata standards, web services, environmental damage registries, a national spatial data infrastructure and regulated procedures for the acceptance and storage of digital evidence. This approach ensures a single evidentiary logic "from sensor to courtroom" [14].

The key international legal reference is the INSPIRE Directive, which establishes a framework for integrating and interoperating environmental data across the EU. It defines requirements for metadata, data specifications, network services, and sharing rules, ensuring cross-border interaction between government and scientific institutions. In the field of environmental control, INSPIRE enables the integration of government monitoring systems with data from Copernicus satellite missions, creating a common information space for the prevention of violations [15; 16].

The Environmental specification plays a crucial role in monitoring facilities (EMF), which oversees the structure and attributes of observation points. This regulation enabling combining data from sensor networks, remote sensing, and laboratory research in evidentiary procedures [17].

The European approach to environmental enforcement is centred around the concept of "smart" enforcement, which means smart supervision that integrates preventive measures, risk-based inspections, analytical tools, and open complaint-handling mechanisms. This approach increases the effectiveness of inspection activities and reduces the need for exclusively punitive measures.

IMPEL Network (EU Network for the Implementation and Enforcement of Environmental Law) plays a key role in standardising and harmonising approaches to environmental surveillance and inspection among the Member States of the European Union. By integrating digital methods for surveillance and verification of compliance with environmental legislation, IMPEL ensures not only technical but also procedural harmonisation of inspection practices, thereby increasing transparency, reproducibility, and judicial applicability of the resulting data [18].

Adapting IMPEL approaches to the Ukrainian context has the potential to significantly enhance the coherence and effectiveness of state environmental supervision. In particular, the application of unified standards for digital monitoring and validation of observations will allow for the unification of interaction procedures between environmental inspection agencies, law enforcement agencies, and judicial authorities, minimising the risk of challenging inspection results. In addition, the integration of Ukrainian digital platforms with European registers through IMPEL opens up opportunities for participation in joint projects, for data exchange, and for increasing the technical competence of inspectors, which, in turn, enhances overall environmental safety and the predictability of management decisions in environmental protection.

The implementation of IMPEL elements will also contribute to the development of a "hybrid" monitoring model, in which state systems ensure the legitimacy of procedures and public digital platforms enhance the detail and timeliness of local observation. Thus, the integration of European practices and digital technologies becomes a key factor in the formation of an effective, transparent and evidence-based environmental control mechanism in Ukraine.

The Environmental Liability Directive (ELD) plays an important role in ensuring the evidentiary function of digital technologies. It obliges operators to implement preventive and remedial measures and to maintain public registers of environmental damage. The combination of ELD registers with INSPIRE standards increases the transparency, reliability and procedural weight of digital data, creating a basis for reproducible, verifiable evidence [19; 20]. The practice of Ireland and other EU countries demonstrated that open data on environmental damage reduced the number of repeated violations and strengthened public trust in law enforcement [20].

For Ukraine, one of the key directions is adaptation to European standards through the development of a national geospatial data infrastructure and the harmonisation of metadata profiles and network services with INSPIRE. The UN-GGIM (2023) report notes significant progress in the field of geospatial data in Ukraine after the adoption of the law on the National Geospatial Data Infrastructure, but points to the need to strengthen the management model, public-private partnerships, and increase personnel's digital competence [21].

EU4Environment instruments, including Copernicus thematic layers, as well as waste and landscape change data, can serve as the basis for risk-based environmental surveillance [22].

To ensure the evidentiary legitimacy of digital data, standardisation of transfer models and protocols is necessary. The use of INSPIRE-compatible discover, view, and download services ensures authenticity, quality control, and data consistency with European systems. It is advisable to establish mandatory metadata profiles for environmental sets in Ukraine's secondary legislation to simplify interdepartmental exchange and international integration.

The recognition of digital data as evidence in criminal proceedings requires the introduction of standardised chains of custody (Chain of Custody, CoC). These mechanisms should include hashing, timestamping, version control and access logging. UNESCO recommendations emphasise the importance of the principles of authenticity and integrity for the procedural admissibility of electronic evidence [23, pp. 18–22]. Combining digital evidence management systems (DEMS) with national SDI and blockchain access registries will increase the legitimacy of digital materials and reduce the risks of their challenge.

Technological transformation cannot be effective without training specialists. Inspectors, investigators, prosecutors, and judges must master the technical and procedural aspects of handling digital evidence. It is recommended to incorporate training modules on INSPIRE/EMF, DEMS/CoC, and digital environmental forensics into educational programs for government employees and judges.

Digital platforms for public participation in environmental crime detection should follow the principles of the Aarhus Convention. It is important to implement clear protocols for validating reports to ensure the reliability and legitimacy of crowdsourced data in law enforcement. The optimal model for data acceptance is a two-stage process: first, a public report is recorded as a screening report, and after verification, it is entered into the official incident register [19].

Institutional integration of INSPIRE-compliant data, innovative approaches to enforcement, and standardised chains of custody form a digital trust contour in environmental law enforcement. For Ukraine, the key tasks are regulatory consolidation of metadata profiles, the creation of interdepartmental procedures (SOPs), the implementation of open data services, and consistent personnel training. This synergy can turn digital observations into procedurally usable evidence and increase the effectiveness of the fight against environmental crimes.

Conclusion. The analysis shows that the digitalisation of environmental monitoring and control is a key direction for increasing the effectiveness of state environmental policy and law enforcement practice. Modern digital products – from satellite observation systems to big data analytics platforms – form the basis of a new model of environmental management, in which the prevention of violations is grounded in the continuous collection, verification, and lawful use of digital evidence. The transition to such a model requires integrating technical standards with legal procedures, ensuring data compatibility, protecting personal information, and preserving the evidentiary value of digital traces.

The effectiveness of digital environmental monitoring depends directly on the level of coordination among state, scientific, and public platforms. A hybrid monitoring model, in which state systems guarantee procedural legitimacy and public ones increase the sensitivity of local observation, is optimal for the Ukrainian context. This combination enhances data reliability, enables rapid response to environmental incidents, and lays the foundation for building trust in digital tools among society.

Institutional implementation of international standards, in particular IMPEL approaches and the INSPIRE Directive, opens up opportunities to harmonise the Ukrainian environmental supervision system with European practice. This will not only increase transparency in management decisions but also help establish a common data space that ensures reproducibility, legality, and cross-border cooperation in environmental protection.

Therefore, further development of the digital ecosystem of environmental control in Ukraine should be based on interoperability, open APIs, standardised metadata, and adherence to the principles of "green IT". The formation of a system of digital environmental forensics integrated into state supervision processes will serve as a basis for increasing the effectiveness of environmental law enforcement, ensuring the evidentiary value of digital data in judicial practice, and establishing European approaches to natural resource management and environmental protection.

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