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DIGITAL MATURITY OF PUBLIC ADMINISTRATION IN ENVIRONMENTAL PROTECTION AND NATURAL RESOURCE MANAGEMENT: A METHODOLOGICAL APPROACH TO ASSESSMENT

Abstract

The article substantiates a methodological approach to assessing the digital maturity of public administration in environmental protection and natural resource management. Digital maturity is interpreted not as the number of electronic services but as the institutional capacity to use data, interoperable registers, geospatial technologies, analytical models and digital participation channels throughout the environmental policy cycle. A seven-dimensional model is proposed, covering institutional and strategic governance; data and interoperability; digital-by-design processes; platform integration; openness and participation; predictive analytics; and cyber resilience with human oversight. Five maturity levels and an aggregation method with a bottleneck rule are introduced to prevent strong components from concealing critical weaknesses. An information and analytical mechanism is developed that links environmental data sources, interoperability, analytics, managerial decisions, public interaction and ex post evaluation. Directions for applying the methodology in Ukraine are defined with regard to the EcoSystem platform, geospatial data infrastructure, the pollutant release and transfer register, digital environmental-impact assessment and environmental-monitoring reform.

Keywords: digital transformation; public administration; environmental protection; digital maturity; environmental data; interoperability; digital twin; public participation.

Problem statement

Digitalisation of Ukraine's environmental sphere already extends beyond individual electronic services. The Unified Environmental Platform “EcoSystem” has a statutory basis, the national geospatial data infrastructure is developing, the National Pollutant Release and Transfer Register has been created, environmental-impact assessment procedures are being digitalised, and reform of the state environmental-monitoring system provides for modern information support for administrative decisions [1–5]. In 2025, the EcoSystem platform integrated 38 environmental registers and 25 administrative services [6]. Yet the number of digital components does not show whether decisions have become better substantiated, more coordinated or more proactive.

The central problem is the gap between technical digitalisation and administrative transformation. A registry may be technologically modern but isolated from monitoring data. An online service may accelerate document submission without changing the risk-oriented logic of control. Open data may be formally published but unsuitable for machine reuse. This problem is especially important in environmental policy because natural processes are interconnected while administrative competences are distributed across agencies and levels of government. A tool is therefore required to measure not the number of IT solutions but the maturity of the complete cycle “data – analysis – decision – participation – outcome”.

Analysis of recent research and publications

The OECD Digital Government Policy Framework assesses digital government through six dimensions: digital by design, data-driven public sector, government as a platform, open by default, user-driven and proactiveness [7]. The Digital Government Outlook 2026 strengthens this logic by emphasising a shift from isolated digital projects to the systemic embedding of data and technologies in regulation, services and policy [8]. Research on sustainable and environmental governance shows that

digitalisation can improve governance performance, but its effect depends on institutional conditions, participation and data quality [14–16].

A separate strand of research concerns digital twins, which can integrate monitoring data, scenario modelling and communication with governance participants. At the same time, such systems alter information and control relationships and therefore require transparency, human oversight and democratic legitimacy [17; 18]. Existing studies identify important elements of digital environmental governance, but a comprehensive method for assessing its digital maturity in the Ukrainian institutional and European-integration context remains insufficiently developed.

Purpose of the article

The purpose of the article is to develop a methodological approach to assessing the digital maturity of public administration in environmental protection and natural resource management, to construct a system of maturity dimensions and levels, and to substantiate an information-analytical mechanism for transition from fragmented digitalisation to data-driven and predictive-adaptive environmental governance.

Presentation of the main material of the study

Digital maturity as institutional capacity

Digital maturity of public administration in environmental protection and natural resource management is proposed as an integrated characteristic of the institutional capacity of public authorities and related information systems to ensure digital-by-design, data-driven, interoperable, open, proactive, secure and accountable environmental policymaking and implementation. This definition separates digital transformation from the simple conversion of a document or procedure into electronic form.

The structure of digital maturity should be built around seven dimensions. Institutional and strategic governance captures the existence of objectives, process owners, data owners, coordination mechanisms and evaluation arrangements. Data and interoperability cover metadata, identifiers, quality standards, APIs and spatial

compatibility. Digital-by-design processes characterise end-to-end electronic procedures, reuse of data already held by the state and minimisation of manual operations. Platform integration reflects the capacity of different public bodies to work with common standards and repeatedly use shared information resources.

Openness and participation concern real access to environmental information, digital consultation, feedback and traceability of how public input affects decisions. Predictive and analytical capacity includes GIS, risk scoring, scenario modelling, machine learning and digital twins. Resilience and human oversight cover cybersecurity, redundancy, recovery, algorithmic audit and the human-in-the-loop principle for decisions with significant legal or environmental consequences. This structure is consistent with general OECD digital-government principles while also incorporating requirements concerning access to environmental information, INSPIRE and public-sector interoperability [7–13].

Maturity assessment and the bottleneck rule

Each dimension can be decomposed into four to eight indicators and assessed on a scale from 0 to 4: 0 – the practice is absent; 1 – local and episodic; 2 – formalised but incomplete; 3 – systematically applied in most relevant processes; 4 – integrated, measurable and continuously improved. Scores should be supported by documents, technical specifications, exchange logs, data-quality statistics, audits and performance indicators.

A normalised dimension score can be calculated as $D_j = (25 / n_j) \times \Sigma s_{jk}$ and therefore ranges from 0 to 100. For integrated comparison, the geometric mean of the seven dimensions may be used. Nevertheless, the principal result should remain the maturity profile rather than a single index. A bottleneck rule is therefore added: the overall maturity level should not exceed the level of the weakest dimension by more than one stage. This prevents advanced e-services from concealing critical weaknesses in data quality, interoperability, cybersecurity or accountability.

Table 1. Dimensions of digital maturity in environmental public administration

Dimension	What is assessed	Indicator of maturity
Institutional governance	objectives, responsibility, process and data owners, coordination	digital change is linked to an administrative outcome
Data and interoperability	quality, metadata, APIs, identifiers, geospatial data	data are reused without unnecessary duplication
Digital by design	end-to-end procedures, once-only principle, automated checks	the process is designed as digital rather than digitised after the fact
Platform integration	shared services and standards across public bodies	information systems operate as a coordinated environment
Openness and participation	open data, consultation and feedback	users can see data, status and the effect of participation
Analytics and prediction	GIS, risk analysis, AI, scenarios, digital twins	the system provides early warning and supports choice among decisions
Resilience and human oversight	cybersecurity, redundancy, audit, human-in-the-loop controls	critical functions remain available and decisions remain traceable

Source: developed by the author.

Information and analytical mechanism

Digital-maturity assessment should be connected to an information and analytical mechanism. Its logic includes six sequential layers: data sources;

interoperability; analytics; administrative decision; public interaction; and outcome evaluation.

Table 2. Levels of digital maturity

Level	Score	Characteristics	Governance logic
0. Fragmented	0–19	local solutions without stable exchange	post-factum reaction
1. Digitised	20–39	electronic documents and isolated services	electronic copy of a paper procedure
2. Integrated	40–59	coordinated registers, APIs and basic interagency cooperation	shared data for several processes
3. Data-driven	60–79	data systematically influence planning and control	risk-oriented evidence-based governance
4. Predictive-adaptive	80–100	early warning, scenarios, digital twins and feedback	proactive policy adjustment

Source: developed by the author.

Data originate from monitoring networks, registers, environmental-impact assessment, the pollutant release and transfer register, geospatial resources, remote sensing and verified citizen reports. The interoperability layer unifies identifiers, metadata, units of measurement and quality rules. The analytical layer transforms data into risk signals, forecasts and scenarios.

The critical issue is the link between analytics and the legal competence of the responsible authority. Each signal should have defined response thresholds, a responsible official or organisational unit, permissible alternatives and a method for documenting the final decision. An algorithm may recommend priorities or forecast developments, but it should not dissolve public accountability. Public interaction completes the external layer: citizens and businesses should have access not only to a service but also to relevant information and procedural feedback. Ex post evaluation closes the cycle by showing whether the digital instrument changed an actual outcome rather than merely increasing the number of electronic operations.

Application of the methodology in Ukraine

Practical application in Ukraine should begin with a map of data and decisions. EcoSystem already performs a platform function [1; 6]; the law on national geospatial data infrastructure creates a basis for spatial compatibility [2]; the pollutant release and transfer register creates a standardised pollution dataset [3]; digital environmental-impact assessment provides a registry and participation layer [4]; and monitoring reform directs the system towards modern information support [5]. The next step is not the mechanical merger of these systems but definition of shared identifiers, flows, data owners and rules for reuse.

European integration adds a requirement for compatibility with the principles of access to environmental information, INSPIRE, GreenData4All and public interoperability [9–13]. New Ukrainian systems should be designed as components of a future common information space, with machine-readable formats, metadata, APIs, clear access rules and opportunities for cross-border reuse. For digital twins, a use-case approach is preferable: starting from a specific problem, user and administrative decision and only then defining the required dataset and model, rather than proceeding in the opposite direction [17; 18].

The performance of digital transformation should be measured at four levels: data quality, process efficiency, service quality and outcome. Outcome indicators may

include shorter response times, more accurate prioritisation of risks, reduced duplication of reporting, a larger share of decisions with a traceable evidence base and better access to environmental information. An environmental effect can be attributed to a digital intervention only when a plausible causal link is demonstrated, because environmental conditions depend on many external factors.

Investment priorities should follow the principle "governance gap before technology". The problem is identified first – duplicated data collection, delayed response, incompatible geospatial data or missing feedback. The expected result is then specified, and only after that should an IT solution be selected. This converts digital transformation from a portfolio of technology procurements into a portfolio of institutional change.

Limitations and directions for further testing

The limitations of the proposed approach arise from the expert nature of some assessments and the need to test empirically the boundaries between maturity levels. Further validation should be conducted across different functional processes, for example environmental-impact assessment, water monitoring and waste management, with checks of inter-rater consistency and sensitivity of the maturity profile to indicator selection. The methodology does not replace evaluation of environmental policy itself; it measures the ability of the digital environment to support evidence-based, coordinated and accountable governance.

Conclusions

Digital maturity of environmental public administration should be assessed as institutional capacity rather than technological saturation. The proposed seven-dimensional model combines governance, data, processes, platform integration, participation, analytics and resilience, making it possible to identify specific weak links in the complete data-to-decision cycle.

A five-level maturity scale and an aggregation method supplemented by a bottleneck rule are proposed. The rule limits the compensatory effect of a composite

index and prevents a high level of individual digital services from concealing critical problems in interoperability, security or accountability.

Table 3. Roadmap for increasing digital maturity

Stage	Key action	Result	Transition criterion
1. Diagnosis	map processes, systems, data and responsibility	baseline maturity profile	critical processes have defined owners and data sources
2. Standardisation	metadata, reference data and quality rules	managed data catalogue	key datasets have provenance and quality rules
3. Integration	APIs and links between registers, GIS and monitoring	end-to-end information environment	repeated manual data entry decreases
4. Analytics	risk scoring, scenarios and pilot digital twins	proactive decision support	time from signal to response decreases
5. Adaptability	ex post evaluation and regular adjustment	feedback between data, decisions and outcomes	decisions change on the basis of measured outcomes

Source: developed by the author.

An information and analytical mechanism is developed that links environmental data sources, interoperability, analytics, competent administrative decisions, public interaction and ex post evaluation. This creates a basis for transition from the electronic reproduction of procedures to data-driven and predictive-adaptive governance.

For Ukraine, the methodology can build on already established components such as EcoSystem, geospatial infrastructure, the pollutant release and transfer register,

digital environmental-impact assessment and environmental-monitoring reform. The next priority should be data standardisation, interagency integration, risk analytics and measurement of actual outcomes rather than simply increasing the number of information systems.

Further research should focus on empirical validation of indicators, testing of thresholds between maturity levels and the development of comparative profiles for different functional subsystems and territorial levels of environmental governance.

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