



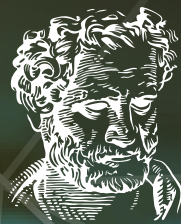
ICPCDGR2026

International Hybrid Conference on Crisis and
Disaster Governance, Planning and Resilience

INTERNATIONAL HYBRID CONFERENCE ON CRISIS AND DISASTER GOVERNANCE, PLANNING AND RESILIENCE:

INTEGRATING RISK AND SECURITY WITHIN
INTERNATIONAL POSTGRADUATE EDUCATION

PROCEEDINGS OF ICPCDGR2026 Book of Abstracts



ΔΗΜΟΚΡΙΤΕΙΟ
ΠΑΝΕΠΙΣΤΗΜΙΟ
ΘΡΑΚΗΣ

DEMOCRITUS
UNIVERSITY
OF THRACE

EDITOR

Associate Professor Michail Chalaris

**International Hybrid Conference
Kavala, 6-9 May 2026**

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This publication was produced within the framework of the project “Internationalisation of HEIs’ Educational Services (Sub-project 3)”, implemented under SUB2 “Universities of Excellence” (OPS TA 5180665), within the National Recovery and Resilience Plan “Greece 2.0”, and funded by the European Union – NextGenerationEU and national resources.



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EDUCATION**

BOOK OF ABSTRACTS

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**WELCOME ADDRESS BY THE ASSOCIATE PROFESSOR,
CHEMISTRY DEPARTMENT, DEMOCRITUS UNIVERSITY OF THRACE,
MR. MICHAEL CHALARIS**

Your Excellencies, Honourable representatives of the Greek State, Distinguished representatives of the Region, the Municipality and public authorities, Esteemed colleagues from Democritus University of Thrace and York University, Dear members of the Scientific and Organizing Committees, Dear keynote speakers, invited lecturers, researchers, practitioners, postgraduate students, Ladies and gentlemen,

*It is with great pleasure, deep gratitude and a strong sense of responsibility that I welcome you today to the official opening ceremony of the **International Hybrid Conference on Crisis and Disaster Governance, Planning and Resilience: Integrating Risk and Security within International Postgraduate Education — ICPCDGR 2026**.*

*As Conference Chair, and also as Scientific Coordinator of the project that supports and frames this international initiative, I feel truly honoured to welcome you to **Kavala**, a historic and vibrant coastal city of Northern Greece, a city open to the Aegean Sea, to the Balkans, to the Eastern Mediterranean, and today, through this conference, to the world.*

This conference is not only an academic event. It is a meeting point of ideas, institutions, disciplines, and people. It is a space where science meets public policy, where education meets operational experience, and where international cooperation becomes a practical tool for resilience.

*ICPCDGR 2026 is organized by the **Democritus University of Thrace**, in strategic academic cooperation with **York University, Canada**, within the framework of **Greece 2.0 — the Recovery and Resilience Facility** and the **Universities of Excellence Initiative**.*

This framework supports the internationalisation of higher education, the digital transformation of academic programmes, and the development of advanced postgraduate competences with real social, institutional and professional relevance.

For us, this is not a formal reference. It is the essence of the conference.

The world today does not need universities that speak only to themselves.

It needs universities that listen to society, cooperate internationally, support public institutions, train new leaders, and produce knowledge that can be used when uncertainty becomes crisis.

And this is precisely why we are here.

We live in an era of complex, systemic and interconnected risks. Climate-driven disasters, wildfires, floods, earthquakes, hybrid threats, cybersecurity risks, public-health emergencies, infrastructure vulnerability, energy transition pressures, geopolitical instability and social fragility are no longer separate challenges. They interact. They reinforce one another. They test the limits of governance, preparedness and coordination.

In such an environment, crisis and disaster management cannot be approached as a narrow technical field.

It requires science, technology, leadership, law, psychology, communication, operational planning, education, ethics and trust. It requires the ability to connect prevention with preparedness, preparedness with response, response with recovery, and recovery with long-term resilience.

*This is the core message of ICPCDGR 2026: **resilience is not built during the crisis; it is built before the crisis, through knowledge, cooperation, planning and institutional responsibility.***

*Our conference brings together more than **400 participants**, attending physically and online, from **16 countries across the world**.*

This international participation is, for us, a strong sign that the themes of risk, security, governance and resilience are no longer peripheral.

They are central to the future of public administration, higher education, civil protection, critical infrastructure, health security, environmental management and democratic governance.

During the coming days, we will have the opportunity to listen to distinguished scholars, experienced practitioners, institutional representatives, young researchers and postgraduate students.

We will discuss risk governance and strategic planning, crisis and emergency management, homeland security and public safety, cybersecurity and critical infrastructure protection, public health security, humanitarian response, artificial intelligence and emerging technologies, leadership under uncertainty, psychological resilience, legal and ethical frameworks, climate risk and disaster preparedness.

This thematic diversity is not accidental. It reflects the very nature of contemporary crises.

No single discipline can fully understand them. No single institution can manage them alone. No single country can face them in isolation.

*That is why this conference places particular emphasis on **interdisciplinary postgraduate education**.*

The next generation of professionals must be trained not only to know, but to coordinate; not only to analyse, but to decide; not only to respond, but to prevent; not only to manage emergencies, but to design resilient systems.

In this sense, ICPDGR 2026 is also an investment in people.

It is an investment in students, researchers, public servants, civil protection officers, engineers, scientists, health professionals, local government officials and decision-makers who will be called upon to work in environments of uncertainty and pressure.

As universities, we have a duty to prepare them. As public institutions, we have a duty to support them. As societies, we have a duty to trust science, planning and cooperation.

I would also like to underline a dimension of this conference that is very important to us: its connection with society.

The last day of the conference will include three workshops in Greek, open to the public, addressing highly relevant issues for citizens, local authorities and workers.

*The first workshop, **“How violence and harassment in the workplace affect people, companies, and society,”** will open an essential discussion on dignity, safety, health and organizational resilience in the workplace.*

*The second workshop, **“Climate Risks: Governance and Preparedness in Greece – Coordination as a Foundation for Building Resilience,”** will focus on climate-related risks, governance and the critical role of coordination.*

*The third workshop, **“Municipal Networks in Civil Protection: the Case of DYOPP,”** will highlight the importance of cooperation among municipalities and local authorities in civil protection.*

*These workshops are not simply parallel activities. They are a conscious contribution of the **Department of Chemistry of Democritus University of Thrace** to the citizens and workers of Kavala, to the wider Region of Eastern Macedonia and Thrace, and to all Greek citizens who believe that a resilient country begins with informed, prepared and empowered communities.*

Because resilience is not an abstract term. It is the safety of our cities. It is the preparedness of our municipalities. It is the protection of workers. It is the continuity of critical services. It is the trust between citizens and institutions. It is the capacity of a country to stand, to learn, to adapt and to move forward.

Ladies and gentlemen, This conference would not have been possible without the work of many people.

I would like to express my sincere thanks to the Organizing Committee, the Scientific Committee, the reviewers, the invited speakers, the STUDENT CONFERENCE AMBASSADORS, the technical support teams, our collaborators from York University, and all colleagues from Democritus University of Thrace who worked with dedication and professionalism.

I would also like to thank all authors and participants for their trust.

Your presence, your research, your experience and your active contribution give meaning to this initiative.

To our international guests, I warmly welcome you to Greece and to Kavala.

I hope that, beyond the scientific programme, you will find time to experience the beauty, hospitality, culture and history of this remarkable city. Kavala is not only the place where we meet; it is part of the identity of this conference — a place of dialogue, openness and connection.

To our online participants, I also extend a warm welcome. The hybrid nature of this conference allows us to expand access, strengthen international participation and create a broader community of knowledge and practice.

Dear friends, the challenges before us are serious. But the message of this conference is not fear. It is responsibility. It is cooperation. It is confidence in knowledge, institutions and people.

ICPCDGR 2026 invites us to think beyond disciplinary borders, beyond institutional silos, beyond national limits. It invites us to build bridges: between Greece and Canada, between Europe and the wider world, between research and policy, between education and practice, between security and resilience.

Let this conference be a starting point for new collaborations, new research, new educational pathways and new governance models.

Let Kavala become, during these days, a living laboratory of dialogue for a safer, more prepared and more resilient future.

*Because this is the promise of ICPCDGR 2026: **Where Governance Meets Security. Where Education Builds Resilience. Where Strategy Shapes the Future.***

With these thoughts, I warmly welcome you all and wish you a productive, inspiring and successful conference.

Thank you very much.

**WELCOME ADDRESS BY THE PROFESSOR, DEPARTMENT OF CIVIL
ENGINEERING, SCHOOL OF ENGINEERING, DEMOCRITUS UNIVERSITY OF
THRACE, MR. KONSTANTINOS CHALIORIS**

Distinguished guests, Representatives of academic institutions, public authorities and international organizations, Dear colleagues, dear students, Ladies and gentlemen,

*It is with great pleasure and a strong sense of institutional responsibility that I welcome you to the **International Hybrid Conference on Crisis and Disaster Governance, Planning and Resilience: Integrating Risk and Security within International Postgraduate Education – ICPCDGR 2026**.*

Today, here in Kavala, Democritus University of Thrace has the honour of hosting a conference that speaks directly to some of the most urgent challenges of our time: climate-driven disasters, complex crises, critical infrastructure vulnerabilities, hybrid threats, public health emergencies, security risks, and the growing need for societies that are not only prepared to respond, but capable of anticipating, adapting and recovering.

This conference is not simply an academic event. It is a meeting point between knowledge and responsibility; between research and practice; between universities, public institutions, professionals and young scientists who will be called upon to lead in an increasingly uncertain world.

For Democritus University of Thrace, this moment has a special meaning.

Our University is in a period of transformation. We are an institution with deep roots in the region of Eastern Macedonia and Thrace, but also with a clear and growing international outlook. We are located at a strategic crossroads — between Europe and Asia, the Balkans, the Mediterranean and the wider international environment. This geography is not just a location on the map. It is part of our identity. It defines our role as a university that connects people, disciplines, cultures and ideas.

In recent years, Democritus University of Thrace has been steadily strengthening its profile as an emerging, dynamic and outward-looking university. We are expanding our academic footprint, investing in interdisciplinary education, strengthening applied research, modernizing our structures and building partnerships that connect our region with the world.

Our strategic choice is clear: we do not want to be a university that simply follows developments. We want to be a university that participates in shaping them.

And this is exactly where ICPCDGR 2026 fits into our broader institutional strategy.

The themes of this conference — crisis governance, disaster planning, resilience, risk and security — are no longer narrow technical fields. They are central pillars of modern public policy, sustainable development, institutional preparedness and social cohesion. They require engineers and social scientists, chemists and economists, emergency managers and security experts, policymakers and educators to work together.

They require precisely the kind of interdisciplinary and international approach that Democritus University of Thrace is determined to promote.

*This conference is also directly linked to our strategic commitment to internationalization. Through the framework of the **Greece 2.0 Recovery and Resilience Facility** and the **Universities of Excellence initiative**, Democritus University of Thrace has chosen to invest in **five funded postgraduate programmes** with strong international orientation. These programmes are not isolated academic projects. They are bridges: bridges between Greek higher education and leading international partners; bridges between research and professional practice; bridges between regional needs and global challenges.*

*Our cooperation with **York University, Canada**, in the context of this conference and the wider academic initiative, is a powerful example of what meaningful internationalization can achieve. It is not*

internationalization for visibility alone. It is internationalization with purpose: to design better curricula, to create new learning opportunities, to support joint research, and to prepare graduates who can think critically, act responsibly and operate effectively in complex crisis environments.

In this sense, ICPCDGR 2026 is both a conference and a statement.

It states that postgraduate education must evolve. It must become more international, more interdisciplinary, more connected to real-world challenges. It must prepare professionals not only to understand risk, but to govern it; not only to respond to crises, but to prevent and manage them; not only to study resilience, but to help build it in communities, institutions and systems.

Ladies and gentlemen,

The world today needs universities that are open, collaborative and socially responsible. It needs universities that can produce knowledge, but also mobilize knowledge. It needs universities that can serve their regions while speaking to the world.

This is the path that Democritus University of Thrace has chosen.

From Kavala, from Komotini, from Xanthi, from Alexandroupolis, from Drama, from Orestiada and from Didymoteicho, our University is building a model of higher education that is decentralized, inclusive, applied and internationally connected. We believe that strong universities do not only exist in metropolitan centres. Strong universities can also emerge from regions with history, diversity, resilience and strategic vision.

And perhaps this is one of the strongest messages of this conference: resilience is not built only in capitals, ministries or central institutions. It is built in regions, in cities, in universities, in laboratories, in classrooms, in municipalities, in professional communities and in networks of cooperation.

Before closing, allow me to express my sincere thanks to all those who made this conference possible.

*I warmly thank **York University** for its valuable cooperation and academic partnership. I thank the members of the Scientific and Organizing Committees, the participating Departments, the administrative staff, the researchers, the volunteers and all contributors who worked with dedication and professionalism.*

I would also like to offer special thanks to the Scientific Coordinator of both the Conference and the project, Assoc. Professor Michail Chalaris. His role reminds us of something very important: in the field of crisis and disaster governance, coordination is not a procedural detail. It is the difference between intention and implementation, between planning and impact, between an idea and a living international academic initiative.

Dear colleagues and friends, I welcome you all to Democritus University of Thrace and to the city of Kavala. I wish you a productive, inspiring and forward-looking conference.

May ICPCDGR 2026 become not only a successful scientific event, but also the beginning of new collaborations, new educational pathways and new contributions to safer, more resilient and better-prepared societies.

Thank you very much.

WELCOME ADDRESS BY THE MINISTER OF EDUCATION, RELIGIOUS AFFAIRS AND SPORTS, MRS. SOFIA ZACHARAKI

*Honourable President of the Conference,
Distinguished representatives of the academic and scientific community,
Ladies and Gentlemen,*

*It is with great pleasure that I address the **International Hybrid Conference on Crisis and Disaster Governance, Planning and Resilience (ICPCDGR 2026)**. This important international initiative highlights the crucial role of knowledge, research, cooperation and innovation in crisis and disaster governance, disaster management, strategic resilience planning, and the development of contemporary policies for security and prevention.*

At a time when our societies are called upon to respond to increasingly complex and multidimensional challenges — including the climate crisis, natural disasters, health threats, geopolitical developments, and emerging risks arising from rapid technological and social transformation — the need for effective crisis governance and for strengthening the resilience of institutions and societies is more urgent than ever.

Scientific knowledge, interdisciplinary cooperation and the exchange of good practices are invaluable tools for prevention, preparedness and the effective management of risk. Of particular importance is the link between university research, public policy and applied practice, so that scientific evidence and research findings may be translated into meaningful policy interventions for the benefit of society and citizens.

I would like to warmly congratulate Democritus University of Thrace, the Department of Chemistry, as well as all collaborating institutions, the members of the Organising and Scientific Committees, and the participating scholars from Greece and abroad, for the organisation of this timely and highly relevant conference. Its international dimension, together with the emphasis placed on education, research and cooperation across institutions and scientific fields, are key elements that further enhance its value and impact.

It is particularly encouraging that initiatives such as this build bridges of dialogue and cooperation among the academic community, public administration, operational agencies and civil society, with the shared objective of strengthening prevention, preparedness and sustainable development in an ever-changing international environment.

I wish every success to the proceedings of the Conference. I am confident that the discussions, conclusions and proposals that will emerge will make a meaningful contribution to the advancement of scientific knowledge and to the formulation of effective policies and strategies for a safer, more resilient and sustainable future.

Thank you very much.

PROGRAM

WEDNESDAY, May 6th, 2026

9.00-9.30 **REGISTRATION**

Chairs Sessions I & II: Tolkou A., Alonistioti N., Badica C.

SESSION I

9.30-9.45 **ADAPTIVE MULTI-SIGNAL KICK DETECTION: THE EWIM FRAMEWORK**

F. N. Zachopoulos, N. C. Kokkinos

9.45-9.55 **LARGE LANGUAGE MODEL PIPELINES FOR CRISIS INTELLIGENCE:
AUTOMATED HELP REQUEST CLASSIFIER**

L.D.R.E. De Silva

9.55-10.05 **IMAGE BASED RECOGNITION OF LUPUS RASHES USING SWIN
TRANSFORMER**

I. Gogineni, P. S. K. Palagani, S. N. Banavathu

10.05-10.15 **IOT ENABLED DATA MONITORING AND VISUALIZATION SYSTEM USING
RASPBERRY PI PICO W WITH MQTT PROTOCOL**

M. Wyavahare, S. Sangole, P. Murkute, V. Sangvikar

SESSION II

10.15-10.30 **AI-ENABLED BIOENGINEERING SYSTEMS FOR EARLY WARNING AND
DECISION SUPPORT IN PUBLIC HEALTH CRISES**

N. Vordos, T. Markopoulos, M. Maragakis

10.30-10.40 **MULTI-CLOUD SECURITY ASSESSMENT FOR AI-AUGMENTED ENTERPRISE
ENVIRONMENTS**

M. Vedom

10.40-10.50 **RAINFALL PREDICTION USING FUSED SATELLITE IMAGERY AND COMPUTER
VISION-BASED FEATURE EXTRACTION**

M. Rane, S. Sangole, P. Murkute, V. Sangvikar

10.50-11.00 **SMART ML-BASED ANOMALY DETECTION IN SMART GRIDS**

A. Barbadekar, A. Pawar, A. Pardeshi, A. Narkhede

Chairs Sessions III & IV: Karagkouni A., Markopoulos Th., Mocioi I.-A.

SESSION III

11.00-11.15 **NATIONAL RESILIENCE AND REDUNDANCY PLAN FOR GREECE'S
HORIZONTAL RESEARCH E INFRASTRUCTURES: GOVERNANCE LESSONS
FROM THE DUTCH MODEL AND THE 2023 GRNET CYBERATTACK**

M. Maragakis, N. Vordos, K. Tarchanidis

11.15-11.25 **AI- BASED CARRER PATH RECOMMENDATION SYSTEM**

D. K. Kohli, P. Thakur, R. Dwivedi, A. S. Chauhan

- 11.25-11.35** **NEAR MISSES AND THE VIOLENT EDGE OF POLICY BACKLASH IN DISASTER RISK AND ENVIRONMENTAL GOVERNANCE**
O. C. Oghenechovwen
- 11.35-11.45** **ENHANCING SAFETY ASSESSMENT IN POWER GENERATION THROUGH DETERMINISTIC METHODS, STATISTICAL ANALYSIS, AND AI INTEGRATION**
A. P. Marhavidas, T. Malkopoulos

SESSION IV

- 11.45-12.00** **DRONES FOR EMERGENCY SEARCH AND RESCUE OPERATIONS**
A. Asgary
- 12.00-12.10** **YIELD MANAGEMENT AND DEMAND ELASTICITIES IN CRISIS-RESPONSIVE AIR TRANSPORT MARKETS: EVIDENCE FROM THE ATHENS–MILAN MARKET**
A. A. Konstantaros, D. Dimitriou
- 12.10-12.20** **DYNAMIC PRICING AND DEMAND ELASTICITY UNDER MARKET DISRUPTIONS: A COMPARATIVE STUDY OF ATHENS–BRUSSELS AND ATHENS–LONDON HEATHROW ROUTES**
A. Lazakis, G. Vasileiou, D. Dimitriou
- 12.20-12.30** **DYNAMIC PRICING AND DEMAND BEHAVIOR IN THE ATHENS–AMSTERDAM AIR TRAVEL MARKET: A DATA-DRIVEN ANALYSIS**
I. Sakkalis, D. Dimitriou

12:30 -13:00 COFFEE BREAK

Chairs Sessions V & VI: Dimitriou D., Pan, Chih-Long, Rapaport C.

SESSION V

- 13.00-13.15** **USE OF THE LOSS DISTRIBUTION APPROACH IN WIND FARM SETTING EMERGENCY PREPAREDNESS FROM EXTREME WEATHER**
I. Benekos, V. Kappatos, M. Boile
- 13.15-13.25** **KEY FACTOR COMBINATIONS DRIVING GREEN INFRASTRUCTURE IMPLEMENTATION FOR SUSTAINABLE URBAN STORMWATER OUTCOMES**
T. Mudiwa
- 13.25-13.35** **RE-EXAMINING COMMUNITY RESILIENCE: A REVIEW OF COMMUNITY INITIATIVES TO DEVELOP RESILIENCE**
E. Bogdan, N. Yiu
- 13.35-13.45** **DURABILITY OF INFRASTRUCTURES IN GREECE**
V. Lekidis

SESSION VI

- 13.45-14.00** **INTEGRATING A STIGMA-FOCUSED AGENDA INTO EMERGENCY MANAGEMENT PRACTICE: LESSONS FROM COVID-19 RESPONSE IN TORONTO, CANADA**
Aaida Mamuji

14.00-14.10	CLIMATE-NEUTRAL AND SMART CITIES: INTEGRATING RESILIENCE AND RISK GOVERNANCE IN URBAN SYSTEMS E. Samourkasidou, A. Thysiadou, M. Chalaris, P. Xofis
14.10-14.20	ENHANCING URBAN COASTAL RESILIENCE UNDER CLIMATE CHANGE: A MEDITERRANEAN CASE STUDY APPROACH E. Samourkasidou, A. Thysiadou, M. Chalaris, A. Panagiotidou
14.20-14.30	URBAN RESILIENCE TO NA-TECH DISASTERS IN A LANDSCAPE OF CASCADING RISKS E. Samourkasidou, A. Thysiadou, M. Chalaris, A. Panagiotidou

14:30 -15:00 BREAK

Chairs Sessions VII, VIII & IX: Xofis P., Dribetas E, Poposka V.

SESSION VII

15.00-15.15	CRISIS MANAGEMENT: CANADIAN CASE OF DISASTER RESPONSE SYSTEM N. Agrawal
15.15-15.25	OPERATIONALIZING YIELD MANAGEMENT AND ELASTICITY THEORY FOR CRISIS-RESILIENT AIRPORT SYSTEMS: THE CASE OF FRANKFURT AIRPORT O. Gkotzai, D. Dimitriou
15.25-15.35	CIRCULAR ECONOMY AS A RESILIENCE STRATEGY IN TRANSPORT INFRASTRUCTURE: THE CASE OF HEATHROW AIRPORT M. Chalemi, A. Karagkouni
15.35-15.45	QUALITY-DRIVEN RESILIENCE IN GLOBAL LOGISTICS: STRATEGIC INTEGRATION OF TQM, ISO STANDARDS, AND DIGITAL GOVERNANCE IN DHL GROUP M. Zantanidou, A. Goulas, E. Papadopoulou, C. Sakellaris, A. Moutzouri

SESSION VIII

15.45-16.00	INNOVATION IN SUPPLY CHAIN TRANSPORT UPON PREPAREDNESS AND CONTINUITY D. Dimitriou
16.00-16.10	SUPPLY CHAIN RESILIENCE AND HUMANITARIAN LOGISTICS: CONCEPTUAL STRATEGIC FRAMEWORK FOR CRISIS RESPONSE AND RECOVERY D. Dimitriou, M. Sartzetaki, A. Karagkouni, V. Benteniotis
16.10-16.20	EVALUATING SDG IMPLEMENTATION AND FIRM RESILIENCE WITHIN CIRCULAR ECONOMY: A DATA-DRIVEN PERFORMANCE INDEX I. Kolari, M. Sartzetaki, D. Dimitriou
16.20-16.30	IDENTIFYING CRITICAL AND VULNERABLE FREIGHT ROUTES IN ROADWAY NETWORKS: A GAME THEORY FRAMEWORK AND APPLICATION IN THE STATE OF FLORIDA M. D. Golias, E. I. Kaisar, I. P. Ioannou
16.30-16.45	INNOVATION IN FREIGHT TRANSPORT TOWARDS EMERGENCIES E. Kaiser

- 16.45-16.55** **RESILIENCE AND RECOVERY OF POINTS OF INTEREST FOLLOWING HURRICANE HELENE: A TEMPORAL ANALYSIS**
A. G. Sefidmazgi, K. Gulati, V. Pandey
- 16.55-17.05** **CONSTRUCTION TECHNOLOGY, SEISMIC BEHAVIOR, AND CULTURAL MONUMENTS: EXPERIENTIAL EDUCATION FOR HERITAGE AWARENESS**
A. K. Thomoglou, T. A. Pringopoulos, M. E. Voutetaki, A. A. Thysiadou
- 17.05-17.15** **SUSTAINABILITY ASSESSMENT OF MINE VENTILATION SYSTEMS: ESG RISK AND INFRASTRUCTURE RESILIENCE INSIGHTS FROM MULTI-SITE CASE STUDIES**
V. Alexiou, N. Kontogianni, E. Polyzou, M. Chalaris, I. Yakoumis

SESSION IX

- 17.15-17.30** **HOW ALGORITHMS ASSIST EXTREMIST GROUPS IN SPREADING THEIR MALICIOUS CONTENT**
S. Bamiatzis

CEREMONIAL OPENING & WELCOME ADDRESSES

- 18:00–18:30** Welcome Coffee (Venue Foyer)
18:30–19:30 Official Welcome Addresses & Opening Greetings
19:30–20:00 Inaugural Plenary Lecture
- Beyond Resilience: Ethical Leadership in an Era of Continuous Crisis**
Christina Alexandropoulou, F.ISRM, CFPS, M.IPSA
Private Sector Chair (Greece-Overseas), OSAC | Board Member, IFMA |
Chapter Chair, ISRM
20:00–22:00 Welcome Reception & Standing Cocktail

THURSDAY, May 7th, 2026

9.00-9.30 REGISTRATION

Chairs Sessions X & XI: Nannou Ch., Nastos P., Mavrikou S.

SESSION X

- 9.30-9.45** **DESIGNING EDUCATOR FORMATION FOR DISRUPTION: A POST-GRADUATE CURRICULUM ARCHITECTURE AT THE INTERSECTION OF RESILIENCE, DRR, AND SUSTAINABILITY**
M. Roussi
- 9.45-9.55** **A POSITIVE PSYCHOLOGY INTERVENTION FOR BUILDING WORKFORCE RESILIENCE AND WELLBEING IN GREEK HEALTHCARE AND EDUCATION SYSTEMS**
C. I. Schoina, I. V. Papathanasiou, T. Paralikas, K. Tsaras
- 9.55-10.05** **FROM GLOBAL FRAMEWORKS TO SCHOOL PRACTICE: POLICY TRANSLATION IN CRISIS, DRR, AND RESILIENCE EDUCATION**
M. Roussi
- 10.05-10.15** **PSYCHOLOGICAL DISTRESS, RESILIENCE, AND WORK ENGAGEMENT IN FRONTLINE NURSING PROFESSIONALS: A MEDIATION ANALYSIS**
C. I. Schoina, I. V. Papathanasiou, T. Paralikas, K. Tsaras

SESSION XI

- 10.15-10.30** **FROM POSTGRADUATE LEARNING TO EDUCATIONAL INTERVENTION: THE LIVING LAB PRACTICUM AS AN IMPLEMENTATION BRIDGE**
M. Roussi
- 10.30-10.40** **ADAPTIVE RESIDUAL HYBRID FRAMEWORK FOR FOOD WASTE PREDICTION IN INSTITUTIONAL KITCHENS**
R. D. Tiwari, S. Raj, K. Rajkumar
- 10.40-10.50** **SIMULATION OF THE EFFECTS OF CHEMICAL SUBSTANCES FROM INDUSTRIAL ACCIDENTS AND TERRORIST ATTACKS ON COASTAL ECOSYSTEMS THROUGH COMPUTATIONAL APPROACHES**
E. Avagiannis, M. Chalaris, N. Stasinopoulos
- 10.50-11.00** **VALORIZATION OF OLIVE MILL BY-PRODUCTS FOR EXTRACTS RICH IN AMPHIPHILIC BIOACTIVES WITH ANTI-INFLAMMATORY AND ANTIOXIDANT HEALTH PROMOTING PROPERTIES, IN A SUSTAINABLE AND CIRCULAR ECONOMY DESIGN**
N. Varnali, E. Palamida, V. D. Prokopiou, K. Shiels, S. K. Saha, A. Ofrydopoulou, A. Tsoupras

Chairs Sessions XII & XIII: Fantidis I., Hela D., Efthimiadou E.

SESSION XII

- 11.00-11.15** **PREVENTIVE PLANNING, PREPAREDNESS & EFFECTIVE RESPONSE TO EMERGENCIES THROUGH ADVANCED TECHNOLOGIES**
V. Pipitsoulis

- 11.15-11.25** **ENVIRONMENTAL ASSESSMENT OF CLASSICAL AND SUSTAINABLE APPROACHES TO PORPHYRIN SYNTHESIS**
D. R. Bitsos, K. Karakosta, K. Ladomenou
- 11.25-11.35** **FROM AGRICULTURAL WASTE TO CLEAN ENERGY: SUSTAINABLE SYNTHESIS OF CARBON DOTS FROM OLIVE LEAVES FOR PHOTOCATALYTIC GREEN HYDROGEN PRODUCTION**
E. Kyriazi, C. Malerou, C. Kampouri, K. Ladomenou
- 11.35-11.45** **EVALUATION OF NSAID ADSORPTION ONTO MONTMORILLONITE/ GRAPHENE OXIDE IN MONO AND BINARY AQUEOUS SOLUTIONS AND ENVIRONMENTAL WASTEWATER SAMPLES**
A. D. Meretoudi, G. Z. Kyzas

SESSION XIII

- 11.45-12.00** **ECONOMIC EVALUATION OF LABORATORY RISK REDUCTION THROUGH SEM SAFETY TRAINING**
D. Gkika, G. Z. Kyzas
- 12.00-12.10** **SULFO-FUNCTIONALIZED 3D PRINTED HIGH IMPACT POLYSTYRENE MONOLITHS AS ORGANIC MICROPOLLUTANT ADSORBENTS FOR ENVIRONMENTAL REMEDIATION APPLICATIONS**
E. Tsintziras, P. Efthymiopoulos, S. Kavafaki, G. Maliaris, G. Z. Kyzas
- 12.10-12.20** **DEVELOPMENT OF A PORPHYRIN-CURCUMIN HYBRID MOLECULE AS INNOVATIVE ANTIMICROBIAL AGENT FOR PUBLIC HEALTH PROTECTION IN POST-DISASTER ENVIRONMENTS**
E. Banta, C. Stylianoudakis, P. Bantas, E. Tourtoura, K. Ladomenou
- 12.20-12.30** **HEMP WASTE DERIVED ACTIVATED CARBONS FOR THE DECONTAMINATION OF PHARMACEUTICALS FROM AQUEOUS SOLUTIONS**
S. L. Kouvalakidou, V. Petratos, G. Z. Kyzas

12:30 -13:00 COFFEE BREAK

Chairs Sessions XIV & XV: Ladomenou K., Paz Sh., Saliu A.

SESSION XIV

- 13.00-13.15** **AUTONOMOUS INTELLIGENCE ON THE FRONT LINE: INTELLIGENT AGENTS AS FORCE MULTIPLIERS IN CRISIS MANAGEMENT**
K. Kravari
- 13.15-13.25** **3D-PRINTED BEADS FOR THE ADSORPTION OF HEXAVALENT CHROMIUM**
K. Maroulas, S. Kavafaki, G. Maliaris, G. Kyzas
- 13.25-13.35** **BRIDGED RGO-GO@TERNARY LAYERED DOUBLE HYDROXIDES FOR THE REMOVAL OF ANTIPSYCHOTIC DRUG SULPIRIDE FROM WASTEWATER**
D. A. Chatzipapas, K. N. Maroulas, G. Z. Kyzas
- 13.35-13.45** **SYNTHESIS AND CHARACTERIZATION OF MODIFIED CHITOSAN-BASED ADSORBENT FOR FLUORIDE REMOVAL**
G. Tenente, K. Maroulas, G. Kyzas

SESSION XV

- 13.45-14.00** **INFORMATION VALUE FOR RISK**
A. Targoutzidis
- 14.00-14.10** **GRAPE POMACE BIOMASS AS A FUNCTIONAL INGREDIENT IN NATURAL COSMETIC EMULSIONS**
M. P. Koulou, I. Koumentakou, G. Z. Kyzas
- 14.10-14.20** **3D-PRINTED RECYCLED PET POROUS STRUCTURES WITH ENHANCED ABSORPTION CAPACITY**
D. Thanou, S. Kavafaki, I. Koumentakou, G. Z. Kyzas
- 14.20-14.30** **ANTIOXIDANT, ANTI-INFLAMMATORY AND ANTITHROMBOTIC POTENTIAL AND CHEMICAL CHARACTERIZATION OF AMPHIPHILIC AND LIPOPHILIC LIPID EXTRACTS FROM SHRIMP AND CRAYFISH**
G. Maniatakou, V. D. Prokopiou, A. Ofrydopoulou, C. Anastasiadou, A. Tsoupras

14.30 -15.30 LIGHT LUNCH

Chairs Sessions XVI, XVII & XVIII: Tsoupras A., Shosholovski L., Stamevski V.

SESSION XVI

- 15.30-15.45** **FROM DEGRADATION TO DETOXIFICATION: KINETIC PROFILING AND HRMS CHARACTERISATION OF BISPHENOL A TRANSFORMATION PRODUCTS UNDER METALLOPORPHYRIN-BASED PHOTOCATALYSIS**
C. K. Tsamtzidou, M. Chalaris, K. Ladomenou, C. Nannou
- 15.45-15.55** **EFFECTIVENESS OF HOUSEHOLD AND INDUSTRIAL WASHING AND THERMAL METHODS ON PESTICIDE RESIDUE REMOVAL FROM TOMATOES: A FOOD SAFETY AND PUBLIC HEALTH PERSPECTIVE**
I. C. Maziotis, A. S. Konstantoulis, A. Papadopoulou, C. Nannou
- 15.55-16.05** **PESTICIDE RESIDUE MONITORING IN PET FOOD: ANALYTICAL METHOD DEVELOPMENT AND IMPLICATIONS FOR FOOD CHAIN SAFETY GOVERNANCE**
A. S. Konstantoulis, M. Kalaboka, V. Boti, C. Nannou
- 16.05-16.15** **DEVELOPMENT OF MICRO AND NANOFIBERS FROM RECYCLED POLYETHYLENE TEREPHTHALATE VIA ELECTROSPINNING USED FOR EFFICIENT OIL ABSORPTION**
T. E. Traga, I. Koumentakou, G. Z. Kyzas

SESSION XVII

- 16.15-16.30** **BRIDGING FRAGMENTATION IN WILDFIRE RISK GOVERNANCE: A MULTI-LEVEL MODEL BASED ON THE CASE OF NORTH MACEDONIA**
L. Shosholovski, V. Poposka, A. Grizhev
- 16.30-16.40** **MAPPING THE INVISIBLE: CRITICAL AND RADICAL APPROACHES TO REPRESENTING CRISES, DISASTERS AND HIDDEN SPATIAL CONDITIONS**
E. Tsakiri

- 16.40-16.50** **ORIENTATION IN WILDFIRE SUPPRESSION**
S. Papageorgiou
- 16.50-17.00** **ENHANCING LABORATORY SAFETY AWARENESS IN UNDERGRADUATE CHEMISTRY EDUCATION: EVIDENCE FROM A CASE-BASED STUDY IN AN EMERGING ACADEMIC DEPARTMENT**
S. Moma, S. Anastasiou, M. Chalaris

SESSION XVIII

- 17.00-17.15** **REFRAMING LEADERSHIP AND MANAGEMENT ROLES IN CBRN CRISIS ENVIRONMENTS: A CONCEPTUAL AND OPERATIONAL PERSPECTIVE**
M. Vareli, M. Chalaris
- 17.15-17.25** **GREEN EXTRACTS DERIVED FROM GRAPE BY-PRODUCTS FOR APPLICATION IN HEALTH-PROMOTING FUNCTIONAL PRODUCTS**
S. Michailidis, A. Ofrydopoulou, A. Tsoupras
- 17.25-17.35** **CHILD PROTECTION IN CRISIS CONTEXTS: RETHINKING DATA GOVERNANCE AND GDPR IN EMERGENCY RESPONSE SYSTEMS**
G. Penekeli
- 17.35-17.45** **ANTIOXIDANT ACTIVITY AND AMPHIPHILIC BIOACTIVES IN GREEN EXTRACTS FROM FISH BY-PRODUCTS: A CIRCULAR ECONOMY APPROACH**
G. Liepouris, K. Ofrydopoulou, E. Antonopoulou, M. Koutrakis, A. Ofrydopoulou, A. Tsoupras

17.45-18.15 COFFEE BREAK

Chairs Sessions XIX & XX: Thomoglou A., W- P, Wagner, P., Sartzetaki M.

SESSION XIX

- 18.15-18.30** **CIVIL-MILITARY COOPERATION IN CRISIS AND DISASTER GOVERNANCE IN THE WESTERN BALKANS**
N. Kletnikov, B. Maksuti
- 18.30-18.40** **COMPUTATIONAL SYSTEM DYNAMICS FRAMEWORK USING STELLA FOR MODELING CHEMICAL ACCIDENTS IN AQUATIC ECOSYSTEMS**
N. Stasinopoulos, M. Chalaris, A. Tezari
- 18.40-18.50** **A MULTI-OBJECTIVE INVENTORY ROUTING FRAMEWORK FOR RURAL FREIGHT LOGISTICS**
S. Saeidi, E. Kaisar
- 18.50-19.00** **AI-INTEGRATED IONIC LIQUID-BASED SENSING FOR REAL-TIME DETECTION OF HAZARDOUS SOLVENT VAPORS IN INDUSTRIAL ENVIRONMENTS**
I. Siadimas, M. Chalaris

SESSION XX

- 19.00-19.15** **CRISIS GOVERNANCE AND LEADERSHIP UNDER PRESSURE : DECISION-MAKING DYNAMICS IN BARACK OBAMA'S ADOPTION OF THE AMERICAN RECOVERY AND REINVESTMENT ACT (ARRA) OF 2009**
P. Karagianni

19.15-19.25	TRANSITIONING GREEK PUBLIC PROCUREMENT FROM GREEN CRITERIA TO ESG INTEGRATION: A MULTI-CRITERIA EVALUATION FRAMEWORK F. I. Pagkalou, J. Filos
19.25-19.35	FINSIGHT: A HYBRID FINANCIAL-AGENT SYSTEM WITH MARKET INSIGHTS M. Wyavahare, S. Sangole, P. Murkute, V. Sangvikar
19.35-19.45	RESILIENCE ASSESSMENT TOOL FOR PORT PLANNING M. Dhanak, S. Parr, E. I. Kaiser, P. Goulianou, H. Russell, F. Kristiansson
19.45-19.55	DEVELOPMENT OF A COMPUTATIONAL FRAMEWORK FOR EARLY WARNING AND COMMUNICATION REGARDING CHEMICAL ACCIDENTS IN AQUATIC ECOSYSTEMS Nikolaos Stasinopoulos, Michail Chalaris, Anastasia Tezari
19.55-20.05	THE ANHARMONIC OSCILLATION AS A FRAMEWORK FOR UNDERSTANDING AND PREDICTING CHEMICAL ACCIDENTS IN AQUATIC ECOSYSTEMS Nikolaos Stasinopoulos, Michail Chalaris, Anastasia Tezari
20.05-20.15	DEVELOPMENT OF LIPID NANOPARTICLES LOADED WITH EXTRACTS FROM PROPOLIS AND OLIVE MILL BY-PRODUCTS. D. Vatou

FRIDAY, May 08th, 2026

9.00-9.30 REGISTRATION

9.30-10.30 **WORKSHOP I: HOW VIOLENCE AND HARASSMENT IN THE WORKPLACE AFFECT PEOPLE, COMPANIES, AND SOCIETY | Open to the public**
I. Marketos

Chair Session XXI: Vordos N., Sulejman A., Pistikou V.

SESSION XXI

10.30-10.40 **PREPARATION AND CHARACTERIZATION OF PLA/CNF BIOCOMPOSITES FOR SUSTAINABLE ADDITIVE MANUFACTURING**
K. Pelpas, S. Lili, S. Kavafaki, G. Maliaris

10.40-10.50 **FROM WASTE TO VALUE: SUSTAINABLE PROCESSING OF POMEGRANATE BY-PRODUCTS VIA GREEN EXTRACTION AND THEIR ANTITHROMBOTIC ACTIVITY**
E. Kourmazou, A. Ofrydopoulou, A. Tsoupras

10.50-11.00 **INNOVATIVE PORPHYRIN – BASED PHOTOCATALYSTS ON 3D – PRINTED STRUCTURES FOR RAPID WATER DECONTAMINATION**
C. Kampouri, E. Banta, P. Bantas, I. K. Bogdani, A. Nalmpant, G. Maliaris, K. Ladomenou

11.00-11.15 **MODERN TECHNOLOGIES FOR CIVIL PROTECTION IN LOCAL GOVERNMENT**
V. Pipitsoulis

11.15-12.30 **WORKSHOP II: CLIMATE RISKS: GOVERNANCE AND PREPAREDNESS IN GREECE – COORDINATION AS A FOUNDATION FOR BUILDING RESILIENCE | Open to the public**

It is being implemented at the initiative of the Hellenic Network of Resilient Cities (EL.D.A.P.) to strengthen the ecosystem of Greece's Adaptation Hub. The workshop aspires to serve as a meaningful bridge between international approaches and good practices, on the one hand, and the everyday realities faced by Greek municipalities and local communities, on the other.

Participants include:

- Mr. Anastasios Kagiaoglou, Mayor of Paranesti,
- Mr. Theodoros Markopoulos, Governor of the Regional Unit of Kavala,
- Mr. Manolis Chatzopoulos, General Director of Development Agency of Drama S.A.,
- Mr. Marios Papanikolaou, Department of Environment, Ministry of Agriculture, Rural Development and Environment of Cyprus.

Moderator: Mr. Andreas Stergiou, Vice-President of the Board of Directors of the Hellenic Network of Resilient Cities and Mayor of Argitheia.

12.30-13.00 COFFEE BREAK

13.00-13.45

WORKSHOP III: MUNICIPAL NETWORKS IN CIVIL PROTECTION: THE CASE OF DYOPP –NETWORK FOR THE OPERATIONAL SUPPORT AND TRAINING OF CIVIL PROTECTION VOLUNTEER GROUPS | OPEN TO THE PUBLIC

The workshop highlights the role of municipal networks in civil protection, with a focus on DYOPP – the Network for the Operational Support and Training of Civil Protection Volunteer Groups. It aims to showcase how local authorities can strengthen coordination, operational readiness, and volunteer capacity through structured cooperation, shared training, and practical support mechanisms.

Participants include:

Mr. Konstantinos Kokolakis, Special Advisor to the Municipality of Thermaikos on Civil Protection matters

Mr. Konstantinos Kougioumtzidis, Deputy Mayor for Civil Protection, Municipality of Thermi

Mr. Georgios Babaratsas, Deputy Mayor for Cleanliness, Environment & Recycling (Panorama–Pylaia District), Municipality of Pylaia–Chortiatis

Mr. Stavros Fetkos, Deputy Mayor for Urban Resilience, Civil Protection & Security, Municipality of Pavlos Melas

Moderator: Mr. Triantafyllos Bouchounas, Technical Advisor, DYOPP (Network for the Operational Support and Training of Civil Protection Volunteer Groups)

Chairs Sessions XXII & XXIII: Mittas N., Mitrou L., Stevens G.

SESSION XXII

13.45-14.00

BEYOND SKILLS: META-COMPETENCES FOR EDUCATORS IN CONTEXTS OF DISRUPTION, DRR, AND RESILIENCE

M. Roussi, E. Damaskou

14.00-14.10

UTILIZATION OF PROJECT METHOD FOR TEACHING INTERMOLECULAR AND INTRAMOLECULAR FORCES

E. Fouriki, V. Dallas, D. M. Georgiadis, K. Antonopoulos, A. Thysiadou

14.10-14.20

THE SIGNIFICANCE OF VIDEO RECORDED EDUCATIONAL EXPERIMENTS IN THE INSTRUCTION OF THE REFRACTIVE INDEX

K. Memekidi, I. A. Kontokontis, G. A. Chatzipaschalis, A. Thysiadou

14.20-14.30

INNOVATIVE TEACHING AND ASSESSMENT METHODS FOR THE TOPIC OF SINGLE DISPLACEMENT CHEMICAL REACTIONS

D. Karagkiozis, A. Loukidou, Z. Mimitou, M.-I. Panou, P. Papandreou, A. Thysiadou

14.30-15.30 LIGHT LUNCH

SESSION XXIII

15.30-15.40

GUIDING PRINCIPLES FOR IMPROVING THE ETHICAL CULTURE OF LAW STUDENTS

Delia Magherescu

- 15.40-15.50** **REGULATORY CONFLUENCE IN CRISIS GOVERNANCE: ARCHITECTING INTEROPERABLE INFORMATION SYSTEMS FOR EU CIVIL PROTECTION THROUGH THE CONVERGENT FRAMEWORK OF AI ACT, GDPR, AND NIS2 COMPLIANCE**
P. Kotonopoulos
- 15.50-16.00** **HOW DID COVID 19 ERODE THE HUMAN CAPITAL AND WHAT IS THE ROLE OF STATES IN REVERSING THE EFFECTS OF THE PANDEMIC ON NEW GENERATIONS**
C. Bitouliotis
- 16.00-16.10** **ASSESSING THE ACCESSIBILITY OF TRANSPORTATION EMERGENCY MANAGEMENT FOR PERSONS WITH DISABILITIES: A CANADIAN CASE**
S. Butler, M. Sipos, A. Aliu
- 16.10-16.20** **ETHICS IN PUBLIC HEALTH EMERGENCIES AND DISASTER MANAGEMENT**
V. Kourkouni, E. Lahana
- 16.20-16.30** **RESILIENCE OF CONCRETE WITH EXPANDED POLYSTYRENE FROM MARINE WASTE IN CHEMICALLY AGGRESSIVE ENVIRONMENTS**
A. Peraki, V. Prokopiou, and Z.S. Metaxa

Chair Session XXIV: Thysiadou A., Kletnikov N., Drosos D.

SESSION XXIV

- 16.30-16.40** **APPLYING GREEN LEAN SIX SIGMA FOR RESILIENT HOSPITAL SYSTEMS: ADVANCING PUBLIC HEALTH SECURITY IN TIMES OF CRISIS**
A. Vasileiou, E. Sfakianaki, A. Kakouris
- 16.40-16.50** **AUTONOMOUS SYSTEM FOR SUPPLY ENERGY IN A HOSPITAL UNDER ANY SITUATION OF CRISIS OR DISASTER, CASE STUDY: IERAPETRA AND ERMOUPOLI**
A. Vasileiadou, A. A. Thysiadou, J. G. Fantidis
- 16.50-17.00** **COMPARATIVE ASSESSMENT OF QUALITY OF LIFE AND PHYSICAL FUNCTION IN PATIENTS WITH NON-SPECIFIC CHRONIC LOW BACK PAIN: A COMPARISON OF SURGICAL TREATMENT AND CONSERVATIVE THERAPEUTIC EXERCISE**
P. Doukas, A. Goula, G. Pierrakos, A. Filippou
- 17.00-17.10** **TECHNO-ECONOMIC FRAMING OF A PEM-BASED HYDROGEN-TO-POWER SYSTEM FOR A GREEK NON-INTERCONNECTED ISLAND**
G. Varras, M. Chalaris
- 17.10-17.20** **DEVELOPMENT OF BIO-DERIVED NANOCOMPOSITE MATERIALS WITH ENHANCED MECHANICAL AND ABSORPTIVE PROPERTIES**
M. Nenou, I. Koumentakou, S. Kavafaki, G. Z. Kyzas
- 17.20-17.30** **SYNERGISTIC EFFECTS OF NANOBUBBLES AND CARBON NANOMATERIALS ON CEMENT HYDRATION AND MICROSTRUCTURAL EVOLUTION**
M. A. Tsaroucha, R. I. Kosheleva, Z. S. Metaxa, A. Ch. Mitropoulos

17.30-18.00 COFFEE BREAK

SESSION XXV

- 18.00-18.10** **ENHANCING WATER RESILIENCE AGAINST CLIMATE RISKS: LOW-ENERGY FORWARD OSMOSIS USING NANOBUBBLES**
G. M. Maris, A. Moutzouroglou, R. I. Kosheleva, A. Ch. Mitropoulos
- 18.10-18.20** **HYDROPYRO: AN AI-DRIVEN PLATFORM FOR INTEGRATED WILDFIRE AND FLOOD RISK PREDICTION AND ENVIRONMENTAL DECISION SUPPORT**
A. Kalafatas
- 18.20-18.30** **POROUS CHITOSAN/CARBOXYMETHYL CELLULOSE AEROGELS MODIFIED WITH ACTIVATED CARBON AND MAGNESIUM OXIDE AS ADVANCED SORBENTS FOR CR(VI) REMOVALS.**
Eginloglou, K. N. Maroulas, I. Koumentakou, G. Z. Kyzas
- 18.30-18.40** **EMERGING CONTAMINANTS ACROSS SOIL AND AGRI-FOOD MATRICES: A ONE HEALTH ANALYTICAL FRAMEWORK WITH VALIDATED METHODOLOGY AND UNCERTAINTY ASSESSMENT**
A. Papadopoulou, M. Kalampoka, C. Nannou
- 18.40-18.50** **PLANT-BASED MILK ALTERNATIVES UNDER SCRUTINY: PESTICIDE RESIDUE PROFILING AND REGULATORY GAPS IN AN EVOLVING FOOD LANDSCAPE**
N. Orologidi, C. K. Tsamtzidou, M. Kalampoka, V. Boti, E. Karageorgou, C. Nannou
- 18.50-19.00** **TOXICOLOGICAL EVALUATION OF TITANIUM DIOXIDE NANOPARTICLES (TiO₂ NPS) IN BIOLOGICAL AND ENVIRONMENTAL SYSTEMS**
N. A. Kasviki

SESSION XXVI

- 19.00-19.10** **TOXICOLOGICAL EVALUATION OF SILVER NANOPARTICLES (AGNPS) IN BIOLOGICAL AND ENVIRONMENTAL SYSTEMS**
P. Tzevelekou
- 19.10-19.20** **SYNTHESIS OF THIOLATED GRAPHENE OXIDE/CHITOSAN AEROGEL FOR ENHANCED OIL-SPILL REMEDIATION: SYNTHESIS, CHARACTERIZATION, AND ADSORPTION MECHANISMS**
M. Triamataki, I. Koumentakou, G. Kyzas
- 19.20-19.30** **FORMULATION AND CHARACTERIZATION OF COSMETIC PRODUCTS ENRICHED WITH OLIVE LEAF EXTRACTS: PHOTOPROTECTIVE, ANTIOXIDANT, AND STABILITY ASSESSMENT**
A. Giannoulaki, V. D. Prokopiou, A. Ofrydopoulou, A. Tsoupras
- 19.30-19.40** **SYNTHESIS AND STUDY OF METAL DOPED CARBON DOTS AS INNOVATIVE ANTIMICROBIAL AGENT FOR PUBLIC HEALTH PROTECTION**
I. K. Bogdani, K. Ladomenou
- 19.40-19.50** **REFRAMING THE TRAINER: PROFESSIONAL PROFILES FOR EDUCATOR FORMATION IN CONTEXTS OF DISRUPTION, DRR, AND RESILIENCE**
M. Roussi

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ADAPTIVE MULTI-SIGNAL KICK DETECTION: THE EWIM FRAMEWORK

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Keywords: Kick Detection, Early Warning System, Drilling Simulation, Well Control, Real-Time Monitoring

Kick events during drilling operations posesignificant safety risks andcan escalate into blowouts if not detected and controlled promptly. Conventional detection methods rely on isolated surface-parameter alarms and manual interpretation by the driller, which often resultin delayed responses. When the invading phase is gas and the drilling fluid is oil-based or synthetic, high gas solubility at elevated downhole pressuresand temperatures can further delaythe appearance of surface anomalies, producing ambiguous signals that complicate early identification [1]. This study presents the development and evaluation of an Early Warning Indicator Monitoring system (EWIM), a real-time decision-support tool that integrates multiple surface drilling parameters into a unified risk visualization framework.

EWIM is developed and calibrated using controlled kick simulations performed on the DS-5000 Scientific Drilling Simulator, a high-fidelity platform that replicates realistic drilling environments, including surface equipment, pit system dynamics, and measurement noise. The simulator streams live measurements at 2 Hz through its application interface, providing return flow, pit volume, standpipe pressure, casing pressure, rate of penetration, weight on bit, hook load, and mud weight. Data acquisition proceeds with range checking and one-step median filtering to suppress isolated spikes, while both raw and filtered values are logged for full replay and auditability [2].

The monitoring framework operates without additional downhole hardware, relying exclusively on routinely available surface indicators. At the start of each run, a short baseline period of steady drilling (typically sixty seconds) is used to compute the empirical mean and standard deviation for each indicator, establishing a local operating envelope that reflects the current depth, mud properties, pump schedule, and temperature regime. Each indicator is classified at every time step using a traffic-light scheme: values within one standard deviation of the baseline mean are labeled Green, values between one and two standard deviations are Yellow, and values beyond two standard deviations are Red. Simple persistence rules drawn from statistical process control suppress transient spikes while promoting sustained deviations, allowing the system to distinguish genuine kick signatures from benign operational noise [3].

The per-indicator classifications are fused into the Early Warning Indicator Matrix, a time-indexed grid where rows represent time windows and columns represent individual indicators. Operators can scan

this matrix to assess whether indicator changes are developing coherently (consistent with influx or loss) or whether only a single channel is responding (possibly indicating a benign transient such as a pump adjustment). A conservative aggregation rule is applied: if any indicator is Red, the overall status is Red, and if at least one is Yellow (with none Red), the overall status is Yellow. All parameters, thresholds, and classification histories are stored in structured logs, supporting full post-event review and scenario-to-scenario comparison [4].

Three scenarios were evaluated across five independent repeats each: rapid gas influx under water-based mud, low-intensity dissolved-gas influx under oil-based mud, and partial returns (loss to formation). In all cases, EWIM signaled earlier than a conventional single-parameter baseline. The largest improvement occurred in the dissolved-gas scenario, where individual surface signatures are muted and coordinated multi-channel assessment is essential. Aggregate nuisance alarms during steady drilling segments were reduced by approximately 40% compared to fixed-threshold methods. The results confirm that adaptive, multi-indicator monitoring based on standard surface measurements can enhance kick-detection capability and reduce alarm fatigue, offering a practical and transparent contribution to safer drilling operations [5].

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LARGE LANGUAGE MODEL PIPELINES FOR CRISIS INTELLIGENCE: AUTOMATED HELP REQUEST CLASSIFIER

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Keywords: Crisis Management, Large Language Models, Prompt Engineering, Disaster Response, Logistics Optimisation

Cyclonic Storm Ditwah, which struck Sri Lanka in late 2025, caused over 643 fatalities and approximately US \$4 billion in infrastructure damage [1]. The disaster generated an overwhelming surge of digital communications that paralysed conventional emergency coordination. Thousands of messages—ranging from urgent rescue requests to redundant news updates and malicious spam—flooded digital channels, creating a critical cognitive bottleneck for the Disaster Management Center (DMC). This paper presents “Operation Ditwah,” an end-to-end Crisis Intelligence Pipeline designed to automate the triage, analysis, and strategic optimisation of humanitarian response efforts using Large Language Models (LLMs).

The pipeline comprises five sequential Python modules. The first applies few-shot learning [5] to classify incoming messages into four intent categories—Rescue, Supply, Info, and Other—each mapped to a binary priority level (High or Low). Four labeled exemplars are embedded directly in the prompt, enabling the model to learn category boundaries without retraining and achieving reliable signal discrimination even for terse, geographically specific, or stress-written messages.

The second module conducts a Stability Experiment by subjecting Chain-of-Thought (CoT) prompts [2] to temperature stress testing across two complex multi-priority scenarios: a Kandy landslide and a Gampaha hospital ICU failure. At $T=0.0$ (“Safe Mode”), the model produces deterministic, fully repeatable priority classifications across all runs. At $T=1.0$ (“Chaos Mode”), reasoning drift and hallucination emerge—for example, the model fabricates resources not mentioned in the source text, such as describing a generator as failing immediately rather than in two hours. These findings confirm that zero-temperature settings are a prerequisite for mission-critical LLM deployment and support the case for mandatory human-in-the-loop oversight.

The third module is a Logistics Commander combining CoT priority scoring with Tree-of-Thoughts (ToT) [3] route planning to allocate a single rescue boat across three simultaneous incidents. CoT scoring assigns each incident a numerical priority based on victim vulnerability (age), urgency (rescue need), and medical need (insulin/medicine), producing an auditable justification for every decision. ToT then explores three branching strategies in parallel—Greedy (highest score first), Speed (nearest location first), and Logistics Optimisation (route topology-aware)—selecting the branch that maximises total priority score within the operational window. In simulated scenarios modelled on the Western

Province road network, the Logistics Optimisation branch resolved all three test incidents with the highest combined priority score, outperforming the Speed strategy despite a ten-minute increase in total route time.

The fourth module implements a Budget Keeper that approximates the token count of each message before full processing. Messages exceeding a 150-token threshold are flagged as spam overflows and either summarised by a dedicated prompt or rejected, preventing context window saturation and reducing API costs. The fifth module uses a Pydantic-validated [4] Crisis Event schema to extract structured events from raw news feed text, enforcing field constraints before writing to a standardised Excel report. Invalid entries are skipped, ensuring a clean operational dataset.

The central contribution of this work is the demonstration that structured prompt engineering—combining few-shot classification [5], CoT reasoning [2], and ToT logistics planning [3]—can transform an unstructured information deluge into actionable, explainable humanitarian decisions without any task-specific model fine-tuning. The Human-in-the-Loop principle is preserved throughout: the pipeline augments and accelerates human commanders rather than replacing them. Hallucination risk is mitigated directly through temperature control and Pydantic schema validation, which together prevent fabricated data from entering the operational relief database.

Future work will prioritise ways of live deployment validation with Sri Lanka’s DMC, multimodal data integration—cross-referencing text SOS calls with satellite and social media flood imagery—and formal benchmarking against crisis NLP baselines. The Operation Ditwah framework offers a replicable, cost-efficient, and ethically governed roadmap for AI-assisted disaster response in Sri Lanka and the broader South Asian region.

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AI-ENABLED BIOENGINEERING SYSTEMS FOR EARLY WARNING AND DECISION SUPPORT IN PUBLIC HEALTH CRISES

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Keywords: AI, Bioengineering, Biosensors, Decision systems

Seasonal viral outbreaks, viral epidemics and increasingly dangerous climatic events (such as prolonged heat waves or dust transport), which are often associated with significant excess morbidity and mortality, often place severe pressure on health systems and overload conventional surveillance mechanisms [1]. In most countries, public health surveillance still relies heavily on clinical case reporting, laboratory confirmation and meetings of administrative bodies, which are often delayed due to the time required for symptom recognition, healthcare seeking, specimen collection, testing and official notification. As a result, conventional civil protection surveillance systems put health services under pressure in extreme situations and opportunities for early intervention are partly missed. This time lag is particularly critical in rapidly evolving public health crises, where even a delay of a few days can significantly affect outcomes in terms of public health burden and mortality [2].

In the last decade, wearable biosensor technology, Artificial Intelligence (AI) and the computational technology that supports digital public health infrastructures have matured significantly. Wearable biosensors enable continuous, non-invasive and, above all, low-cost monitoring of biological parameters such as heart and respiratory rate, human movement, glucose levels, perspiration, etc. The use of Artificial Intelligence and especially machine learning and deep learning approaches in medical applications have shown us that they can very quickly identify abnormalities in normal patterns of functioning and, if trained properly, can prove to be a useful tool in civil protection. Finally, the evolution of communications technologies and their sub-components such as -optical fibers, databases, high-speed processors, large storage spaces and surveillance systems provide governments with the technical tools to collect, aggregate and process health-related information. Despite these advances, these three capabilities are still most often developed independently and in parallel and not as elements of a unified decision support architecture[3].

This paper proposes a unified framework that integrates the use of wearable biosensors for continuous recording of biomarkers, the use of AI for inference, and the use of digital systems in public health crises for the management of all stakeholders. The unified framework is designed primarily to be proactive in crises, not just to respond when they occur and become established. Rather than waiting for the system to accumulate confirmed clinical cases, it attempts to detect important physiological signals

at an earlier stage, convert them into alerts, and communicate them to the relevant operational and institutional actors.

The architecture of the proposed system consists of four main layers. The first is the biosensor layer, which is based on low-cost wearable devices capable of recording basic biomarkers, including heart and respiratory rates, skin temperature, heart rate variability, and signals related to human movement. This layer provides data that is essential for real-time health monitoring (both individual and public). The second level is the level at which machine learning models analyze multivariate biomarkers to detect abnormalities consistent with changes related to the health of the general population. The third level is the screening and alerting level, which translates individual-level detections into outcomes, aggregating them into population-level indicators. These indicators can be evaluated by the relevant scientists to determine whether events may ultimately lead to a generalized crisis. The fourth level is the governance level, which covers the requirements for explanation, integration into clinical and emergency situations, data protection, interoperability and accountability.

Recent literature already provides significant evidence on the potential of wearable biosensors, smartwatch-derived physiological data, and artificial intelligence methods in epidemiological surveillance and health monitoring [4]. However, what remains understudied is the systematic integration of these elements into a single architecture that starts with the acquisition of biomarkers and culminates in timely, interpretable, and actionable alerts for decision-making at multiple levels. This gap is not just technical but also organizational and political. To make such systems operational, they need to be embedded in governance structures that define institutional responsibilities.

The integration of biosensors, artificial intelligence, and digital public health infrastructures can form the basis for a new generation of early warning systems, capable of acting both preventively and as surveillance or response tools. The proposed approach is not limited to technological innovation, but introduces a framework in which bioengineering, data analysis, and crisis governance are combined to strengthen public health systems.

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NATIONAL RESILIENCE AND REDUNDANCY PLAN FOR GREECE'S HORIZONTAL RESEARCH E INFRASTRUCTURES: GOVERNANCE LESSONS FROM THE DUTCH MODEL AND THE 2023 GRNET CYBERATTACK

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Keywords: Research e-infrastructures, cyber resilience, governance consolidation, Greece, Netherlands.

Greece's horizontal research e-infrastructures form the digital backbone of the national research ecosystem. The **Hellenic Data Service (HELIX)** is the only horizontal e-infrastructure on Greece's National Research Infrastructure Roadmap, now in full operation providing scalable computing and data processing services. **GRNET** serves as the national research and education network (NREN), interconnecting all academic and research institutions and operating cloud and HPC facilities. The **Hellenic Open Science Initiative (HOSI)** coordinates national open science policies and aligns Greece with the European Open Science Cloud (EOSC). Additional horizontal assets include **APOLLONIS** (digital humanities), **OMICEngine** (synthetic biology), and **HARDMIN** (federated research data repository) amongst others. Despite these assets, governance is fragmented: HELIX is managed by the Athena Research Center, GRNET and the University of Thessaly (while GRNET is itself governed by the Ministry of Digital Governance), and HOSI is a voluntary alliance of 16 organisations. The European Commission's PSF Expert Panel (2022) documented that most Greek research infrastructures, and electronic infrastructures among them, lack a single legal entity, face funding gaps that undermine staff retention, and suffer from insufficient maintenance budgets [1]. The vulnerability of this fragmented system was partially exposed in May 2023, when a largescale DDoS attack disabled GRNET's exam platform, described by the Ministry of Education as the most significant cyberattack ever carried out against a Greek public organisation, causing nationwide disruption to highschool examinations [2].

The Netherlands offers a contrasting consolidated model for most European states in terms of electronic infrastructures. **SURF** is the single ICT, nationally mandated, cooperative for Dutch research and education, providing compute, storage, data management, AAI, security, and innovative services under one legal umbrella. **DANS**, as an additional authority, acts as the Dutch national centre of expertise and repository for research data complementing SURF's services. The **Dutch EOSC Node**, developed and operated by SURF, is fully operational and integrated. The Netherlands has also long ago established **Open Science NL**, a multi-annual investment for a decade with €20 million, and in addition to this a 2025 advisory report recommends a structural increase of €165 million per year for digital infrastructure for research, warning that without it the country would "quickly lose scientific ground" [3].

A direct comparison reveals critical gaps for Greece. First, on the aspect of the **consolidation of governance**: the Netherlands has a single legal entity (SURF) covering all main horizontal eInfrastructure services, while Greece operates fragmented governance models across HELIX (and its 3 main contributing actors), GRNET, and HOSI. Second, with regards to **funding**: the Netherlands has structural multiannual investment and Greece relies mainly on projectbased funding with no baseline commitment. Third, on the issue of **EOSC readiness**: while HOSI actively coordinates policy and Greece contributes technically to the EOSC Core Platform (e.g., codeveloping the NodeRegistry), the country lacks a fully operational national EOSC Node with complete AAI interoperability, largely due to “lack of sustained commitment from ministries” and reliance on bottomup community efforts without dedicated national funding [4]. Fourth, on the **planning of electronic infrastructure resilience**: the Netherlands’ *ActieplanDigitaleConnectiviteit* includes an explicit “continuity” pillar for network resilience, while Greece has no nationallevel resilience plan for its horizontal eInfrastructures, lacking mandatory crosssite data mirroring or automated failover requirements.

The implications for risk governance and critical infrastructure protection are direct. Without a consolidated legal entity, Greece cannot meet eIRG’s core principle that “a strong European eInfrastructure is dependent on strong national building blocks” [5]. The 2023 GRNET cyberattack demonstrates that fragmentation is not merely an administrative inconvenience but a national security vulnerability. Priority actions aligned with Greece 2.0 include: a) establishing a single legal entity for horizontal eInfrastructures (following the SURF model), b) securing multiannual funding from the Recovery and Resilience Facility, c) completing the Greek EOSC Node with full AAI interoperability, and d) adopting a mandatory resilience framework requiring crosssite data mirroring, automated failover, and annual penetration testing for HELIX, GRNET, HARDMIN, and all thematic eInfrastructures. Without these steps, Greece risks not only falling behind but failing the foundational principle of European eInfrastructure resilience, while adopting them may transform Greece’s e-Infrastructure landscape into a resilient, European-aligned model.

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AI- BASED CARRER PATH RECOMMENDATION SYSTEM

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Keywords: Neural networks, machine learning, career recommendation systems, personalized learning, and educational technology

Results from experiments show that the hybrid recommendation model works noticeably better than individual methods. The system's total accuracy reaches up to 92%, with content-based filtering obtaining 85% accuracy and collaborative filtering reaching 89%. Furthermore, user feedback shows a high satisfaction percentage of about 85%, demonstrating the efficacy of tailored recommendations. Students can make wellinformed judgments about their professional and academic growth thanks to the system's successful identification of pertinent academic projects and career tracks.

Notwithstanding its efficacy, the study recognizes obstacles such the requirement for ongoing data updates, possible algorithmic bias, and worries about data security and privacy. In order to overcome these obstacles, a variety of datasets must be integrated, fairness-aware algorithms must be used, and stringent data protection regulations must be followed [5]. Future improvements could include expanding databases across several universities, creating mobile applications to increase accessibility and user involvement, and integrating real-time labor market data from websites like LinkedIn and Glassdoor.

The rapid advancement of technology and the volatile global labor market have significantly complicated students' decisions concerning academic projects and career trajectories. For many students, finding the right academic projects and career paths based on their interests, grades, money, and the needs of their industry is still a big problem. Current career guidance systems are frequently inflexible and reliant on fixed, rulebased methodologies that do not accommodate the varied and evolving requirements of contemporary learners [1]. Also, not having real-time information about the job market means that advice is out of date and decisions are not made well. To solve these problems, this study suggests an AI-based Career Recommendation and Planning System (CRPST) that gives each user personalized academic project ideas and structured career development plans.

To improve recommendation accuracy, a hybrid machine learning strategy combining content-based filtering, collaborative filtering, and neural network models is used [2]. While content-based filtering matches user profiles with pertinent project and job parameters, collaborative filtering finds trends among individuals with similar academic backgrounds and interests. By capturing intricate, non-linear correlations between user data and career outcomes, neural networks enhance these techniques even

further [3]. The system ensures thorough and context-aware recommendations by utilizing a variety of data sources, such as academic records, user preferences, skill sets, and current industry trends. To improve data quality and model performance, data preprocessing methods such as encoding, noise reduction, and normalization are used [4].

The system is designed as a web-based application with a user-friendly interface that makes it simple for students to enter their personal and academic data. In order to enable effective data processing and realtime suggestion creation, the backend architecture is constructed utilizing a scalable framework that incorporates machine learning models through APIs. The system's continuous feedback loop, which uses user interactions and preferences to retrain and improve the models over time, is a crucial component. The system's ability to adapt to changing user wants and shifting market conditions is ensured by this adaptive learning capability.

The significance of this research lies in its ability to bridge the gap between academia and industry by providing dynamic, personalized, and data-driven career guidance. Unlike traditional systems, the proposed solution adapts to user preferences and evolving market demands, offering a scalable and intelligent approach to career planning. It contributes to the field of educational technology by enhancing student career readiness, improving decision-making processes, and supporting institutions in delivering more effective guidance systems. Ultimately, this research presents an innovative framework that empowers students to navigate their academic and professional journeys with confidence and clarity.

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NEAR MISSES AND THE VIOLENT EDGE OF POLICY BACKLASH IN DISASTER RISK AND ENVIRONMENTAL GOVERNANCE

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Keywords: disaster risk governance, near-miss reporting, policy backlash, political violence, precautionary principle

Disaster risk governance frameworks are designed to identify, communicate, and mitigate hazards. Yet they rarely account for the secondary security risks their own interventions may generate. This work examines an emergent and undertheorized phenomenon at the violent edge of policy backlash — incidents of political violence and near-miss events that arise in response to public policy disclosures and decisions in disaster risk and environmental governance contexts. These responses may come from members of the public or from interested groups and are triggered when things of tangible value they hold are perceived to be threatened, whether it is property, livelihood, identity, or their sense of fairness and justice. I draw on documented Canadian and European cases to argue that governance-triggered political violence constitutes a distinct and poorly understood risk category demanding critical attention. The cases include increased arson against religious institutions following residential school burial announcements in Canada between 2021 to 2023 [1], and a pellet gun attack on a Quebec National Assembly member's constituency office following the release of new provincial flood maps in October 2024 [2]. A third example is the amplification of Spanish farmer protests, some of which turned violent, in response to drought-induced restrictions on water use in 2023 and 2024 [3].

The analysis presented here is grounded in risk communication theory, particularly Sandman and Covello's outrage framework [4] and the Social Amplification of Risk Framework (SARF) [5]. These are used to explain the affective mechanisms by which governance disclosures about hazards can, under conditions of perceived involuntary threat to tangible valuables and values, amplify into violent behavioural responses. Critically, while SARF has been applied extensively to how hazard risk signals are amplified through social systems, it has rarely been applied to government actors as amplification stations in their own right [5]. This work builds on that line of research by illustrating how governance disclosures can function as such amplification stations.

A central contribution of this work is to highlight the absence of a near-miss recognition and reporting culture in public disaster risk and environmental governance. In operational risk domains such as aviation, healthcare, and cybersecurity, near misses are routinely tracked because they reveal how often systems "get lucky" and create opportunities for learning and prevention. By contrast, in these governance contexts, early-stage, attempted, or narrowly averted violent responses to policy decisions are rarely documented, connected, or made sense of. As a result, it remains unclear how often such responses are already occurring but escaping attention, creating a blind spot where apparent rareness

may reflect under-observation rather than true low frequency.

This blind spot points to two interrelated gaps. First, existing governance frameworks do not typically anticipate violence as a downstream effect of legitimate risk disclosures and policy decisions. Second, there are no established mechanisms for identifying and learning from near misses before more serious harm occurs.

This work therefore advocates for the application of precautionary principle to curtail “getting lucky”. Where potential consequences include harm to elected officials, chilling effects on necessary risk disclosures or decisions, and erosion of public trust in governance institutions, mitigation efforts should not depend on complete empirical documentation and certainty. Proactive measures are needed, including standardized national incident and near-miss reporting systems, the integration of security risk assessment into major disclosure processes, and communication strategies informed by outrage theory.

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ENHANCING SAFETY ASSESSMENT IN POWER GENERATION THROUGH DETERMINISTIC METHODS, STATISTICAL ANALYSIS, AND AI INTEGRATION

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Keywords: Safety Assessment, Power Generation, Fault Tree Analysis (FTA), Analytic Hierarchy Process (AHP), Artificial Intelligence (AI).

Background: The power generation sector is characterized by high operational complexity and an increased level of occupational risk, arising from the interaction of advanced technological systems, hazardous working conditions, and evolving organizational structures. The ongoing energy transition toward renewable energy sources, combined with the growing integration of smart grids and digital technologies, further amplifies system complexity and introduces new risk dimensions [1]. Traditional safety assessment approaches, while effective in identifying hazards, often remain limited in their ability to capture dynamic risk interactions and emerging patterns. Therefore, there is a critical need for integrated and adaptive methodologies that enhance both the accuracy and predictive capability of occupational risk assessment in modern power generation environments

Methods: This study develops a hybrid safety assessment framework that combines deterministic and statistical methodologies, further extended through artificial intelligence (AI) integration [2]. The deterministic component is based on Fault Tree Analysis (FTA), enabling the systematic decomposition of critical events and the identification of causal relationships within complex systems. The statistical component utilizes Frequency–Severity Risk Assessment (FSRA/ERS2) and the Analytic Hierarchy Process (AHP) to quantify and prioritize occupational risks.

Empirical analysis is conducted using occupational accident data from the EUROSTAT database, covering the period 2014–2022, allowing for a comprehensive evaluation of risk frequency, severity, and contributing factors. Building upon this hybrid foundation, an AI-driven extension is introduced, incorporating machine learning and data-driven analytics to support predictive modeling, pattern recognition, and dynamic risk assessment. This integration enhances the framework's ability to process large datasets, detect non-linear relationships, and provide real-time decision support.

Results: The combined application of deterministic and statistical methods provides a robust and comprehensive evaluation of occupational risk in the power generation sector. FTA enables the identification of root causes and critical failure pathways, while FSRA and AHP facilitate the quantification and prioritization of risks based on empirical evidence. The analysis reveals that key hazards include exposure to electrical current, work at height, mechanical risks, and emerging hazards related to technological advancements and organizational changes. The integration of AI significantly enhances

the framework's performance by enabling predictive risk assessment and the identification of hidden patterns within large-scale datasets. AI-driven models improve the accuracy of risk forecasting, support early detection of high-risk scenarios, and enable continuous model adaptation to evolving system conditions. As a result, the proposed framework transitions from a static, retrospective evaluation approach to a dynamic, forward-looking safety assessment model.

Conclusions: The proposed hybrid framework demonstrates that the integration of deterministic methods, statistical analysis, and AI techniques leads to a more effective and adaptable approach to occupational risk assessment in power generation. By combining structural analysis, empirical data evaluation, and predictive intelligence, the framework enhances the identification, quantification, and management of risks. The AI-driven expansion represents a key advancement, enabling the transition from reactive safety management to predictive and intelligent safety systems. This approach supports proactive decision-making, improves resource allocation, and strengthens the overall safety culture within energy systems. The framework is particularly relevant in the context of modern energy transitions, where increasing system complexity necessitates advanced, data-driven safety methodologies.

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INTEGRATING UNMANNED AERIAL SYSTEMS IN SEARCH AND RESCUE OPERATIONS: EVOLUTION, TECHNOLOGY, AND STRATEGIC FRAMEWORKS

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Keywords: Drones, UAVs, Search and Rescue (SAR), Thermal Imaging, Disaster Management, Mission Effectiveness

Search and rescue (SAR) operations frequently occur in time-critical, complex environments where rapid situational awareness is vital to success. Unmanned aerial vehicles (UAVs), or drones, have become a pivotal tool in these missions, enabling access to hazardous or inaccessible areas without exposing human responders to direct risk. This paper explores the integration of drone technology into SAR missions, moving beyond hardware to examine the evolution, technological synergy, and operational factors that drive mission effectiveness.

During search and rescue (SAR) operations, rapid situational awareness is crucial. UAVs, or drones, can now access dangerous or inaccessible locations without risking human lives. This presentation explores how drone technology integrates into SAR efforts, focusing on development, collaboration, and operational improvements. Early drones from the 1910s to the late 20th century were experimental and limited. From 2000 to 2015, drones gained popularity for aerial mapping and for locating survivors in floods and earthquakes. Since 2015, advances in high-resolution cameras, thermal sensors, and AI have transformed drones into real-time decision-making tools. Future developments include autonomous swarms and integration with global networks.

Modern SAR drones are highly adaptable and support all stages of operations. During assessment, they quickly provide overviews; in the search phase, thermal imaging helps detect human heat signatures through smoke, darkness, or dense vegetation. In response and evacuation, they deliver emergency supplies or guide ground teams. During recovery, they monitor structural damage and assist with reconstruction planning. Choosing the right platform is vital. Multirotor drones excel at precise hovering for close-range tasks, whereas fixed-wing drones are well-suited to covering large areas over longer periods. Hybrid Vertical Take-Off and Landing (VTOL) systems and specialized indoor drones for collapsed structures add tactical versatility.

This presentation argues that successful drone-assisted SAR depends on an integrated system that combines careful planning, suitable sensors such as LiDAR, and robust real-time communication to reduce risks. Drone applications in SAR are not yet without challenges. Key challenges include limited battery life, weather, regulations, and data management. Ongoing research in autonomy and data processing is essential for future improvements.



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INTEGRATING ARTIFICIAL INTELLIGENCE RISKS INTO THE DISASTER AND EMERGENCY MANAGEMENT CYCLE

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Keywords: Artificial Intelligence, Hazard Identification, Disaster Management, Emergency Response, Algorithmic Governance

AI's rapid growth has shifted it from a helpful tool to a safety threat by 2026, requiring emergency management agencies at the local, regional, national, and international levels to revise their risk registries and emergency management plans to accommodate this emerging hazard. The main arguments for these revisions are the AI systems' potential capabilities to disrupt economies, cause social unrest, and threaten safety and trust.

Data from the OECD AI Incidents and Hazards Monitor shows an 85.41% year-over-year increase in AI-related incidents, with over 14,000 cases by early 2026 [2]. These hazards range from logic errors and hallucinations in rule-based systems to systemic and existential risks from emerging AGI. The World Economic Forum ranks emerging AnticlaSenerateigence (AS) among top five long-term threats for 2026, alongside extreme weather and biodiversity loss, calling it a "chronic risk" that threatens security and social cohesion [3].

Using examples of recent events and emerging AI-related incident datasets, this paper demonstrates that the impact of AI is becoming increasingly evident. These incidents exposed flaws in notification systems between AI developers and law enforcement, leading to public criticism and calls for inclusion of these threats in the emergency management processes, as well as taking regulatory measures to mitigate risks, and revising emergency plans to prepare jurisdictions for effective response to large incidents caused by AI tools, agents, and superintelligence systems [4].

To tackle these challenges, this study suggests a thorough integration of AI hazards into the standard Disaster and Emergency Management (DEM) cycle. During the Mitigation phase, focus should be on neuro-symbolic auditing and "least-privilege" protocols for agentic AI. Preparedness involves deploying the 2026 "Sanity-Test" protocols, regional model calibration, and haptic redundancy drills to ensure system functionality during "dark-start" scenarios where AI dependencies might fail. The Response phase calls for new specialized roles, including Technical First Responders and AI Incident Commanders (AIC), who have the forensic skills to handle AI loss-of-control incidents [5].

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YIELD MANAGEMENT AND DEMAND ELASTICITIES IN CRISIS-RESPONSIVE AIR TRANSPORT MARKETS: EVIDENCE FROM THE ATHENS–MILAN MARKET

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Keywords: Yield Management, Demand Elasticity, Crisis-Responsive Pricing, Air Transport Market Resilience, Dynamic Pricing Strategies

This study examines the role of yield management and demand elasticities in shaping crisis-responsive pricing strategies in air transport markets, using the Athens–Milan corridor as an empirical case. In the context of increasing volatility driven by demand shocks, operational disruptions, and external crises, dynamic pricing is not only a revenue optimization tool but also a mechanism that can influence system resilience and market stability. The paper investigates how airlines adjust fares across booking horizons and how passengers respond to these changes under varying market conditions. The empirical analysis is based on a primary dataset of economy-class fares collected across competing carriers operating between Athens and Milan. The dataset tracks fare evolution over a 60-day booking window prior to departure and captures both outbound and inbound flight patterns. This structure enables the identification of temporal pricing dynamics as well as directional asymmetries in demand behavior. The study applies log-log econometric models to estimate key elasticity measures, including own-price elasticity, cross-price elasticity between competing airlines, and income-related demand effects.

Results reveal that pricing behavior and demand responsiveness vary significantly across booking periods. Early-stage bookings tend to exhibit more elastic demand, indicating higher price sensitivity among leisure travelers, while last-minute bookings are characterized by relatively inelastic demand, typically associated with business or urgent travel needs. Cross-price elasticity estimates confirm the presence of competitive substitution effects, although these vary depending on market concentration and timing. Additionally, the analysis identifies asymmetries between outbound and inbound routes, suggesting that local market conditions and traveler profiles influence elasticity patterns. Scenario-based simulations are employed to evaluate pricing strategies under different demand conditions, including disruption-like environments characterized by uncertainty and fluctuating demand. The findings suggest that moderate price increases in late booking windows can enhance revenue without significantly suppressing demand, particularly when capacity is constrained. In contrast, aggressive early discounting strategies do not consistently lead to higher load factors or revenue gains, especially in competitive settings where price signals may trigger reactive pricing by rival carriers.

From a crisis resilience perspective, the study highlights the dual role of yield management systems. On one hand, dynamic pricing enables airlines to adapt rapidly to changing market conditions, thereby supporting operational flexibility and financial sustainability. On the other hand, excessive price volatility may undermine demand predictability and accessibility, particularly during periods of disruption when mobility is critical. These dynamics raise important considerations for governance and regulatory frameworks in air transport markets. The paper concludes that integrating elasticity-informed pricing strategies into broader crisis-response planning can enhance both economic efficiency and system resilience. It also underscores the need for balanced policy interventions that ensure market functionality while safeguarding equitable access to air transport services. By bridging transport economics with crisis governance, this study contributes to a more comprehensive understanding of how pricing mechanisms operate under stress conditions in competitive aviation markets.



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DYNAMIC PRICING AND DEMAND ELASTICITY UNDER MARKET DISRUPTIONS: A COMPARATIVE STUDY OF ATHENS–BRUSSELS AND ATHENS– LONDON HEATHROW ROUTES

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Keywords: Dynamic Pricing, Price Elasticity of Demand, Yield Management, Air Transport Economics, Cross-Price & Income Elasticity

This study provides a comparative analysis of dynamic pricing and demand elasticity across two major European air transport routes originating from Athens, specifically Athens–Brussels and Athens–London Heathrow, during the period March–May 2026. Positioned within the broader context of crisis-responsive transport systems, the research examines how airlines deploy pricing strategies under conditions of demand uncertainty, competitive pressure, and evolving passenger behavior. The objective is to assess whether dynamic pricing mechanisms contribute not only to revenue maximization but also to market stability and system resilience during periods of potential disruption.

The empirical analysis is based on a dataset comprising approximately 826 fare observations collected across multiple carriers operating on the two routes. The study applies log-log ordinary least squares (OLS) regression models to estimate key elasticity measures, including own-price elasticity, cross-price elasticity between competing airlines, and income-related demand effects. The modeling framework allows for a nuanced comparison of demand structures across the two markets, while also accounting for booking timing through the inclusion of days-to-departure (DTD) dynamics.

Findings indicate that both routes exhibit overall inelastic demand; however, important structural differences emerge. The Athens–Brussels route demonstrates moderate cross-price elasticity, suggesting a degree of substitutability between carriers and a more competitive pricing environment. Demand on this route appears to be predominantly leisure-driven, with air travel exhibiting characteristics of a luxury good, as reflected in positive income elasticity. In contrast, the Athens–London Heathrow route is marked by lower cross-price elasticity and stronger brand loyalty effects, indicating reduced competitive sensitivity. Notably, economy-class tickets on this route display features consistent with an inferior good in certain segments, potentially reflecting the presence of high-frequency business travelers with distinct booking behaviors.

Across both routes, the analysis identifies a consistent pattern in the effectiveness of dynamic pricing

strategies. Specifically, the final booking window (DTD 0–7 days) emerges as the most revenue efficient period, during which demand becomes less price-sensitive and airlines can implement higher fares without substantial reductions in load factors. Conversely, earlier booking periods are characterized by greater elasticity, limiting the effectiveness of aggressive pricing strategies. These findings underscore the importance of temporal price discrimination as a core component of yield management in competitive air transport markets.

From a crisis resilience perspective, the results highlight the dual role of dynamic pricing. While it enhances airlines' ability to respond flexibly to demand fluctuations and capacity constraints, it may also generate accessibility concerns, particularly when late-stage price increases disproportionately affect time-sensitive travelers. The study therefore raises important governance implications, suggesting that regulatory interventions—such as targeted price monitoring or public service obligations—may be warranted to balance efficiency with social equity. Overall, this research contributes to the integration of transport economics and crisis governance by demonstrating how elasticity-informed pricing strategies can support both financial sustainability and adaptive capacity in European air transport systems facing increasing uncertainty.



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DYNAMIC PRICING AND DEMAND BEHAVIOR IN THE ATHENS–AMSTERDAM AIR TRAVEL MARKET: A DATA-DRIVEN ANALYSIS

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Keywords: Dynamic Pricing, Air Transport, Yield Management Systems, Demand Elasticity

This study investigates dynamic pricing and demand behavior in the Athens–Amsterdam air travel market through a data-driven analytical framework. In increasingly volatile aviation environments characterized by demand uncertainty, competitive pressures, and fluctuating operational conditions, dynamic pricing has become a central mechanism for revenue optimization and market adaptation. The objective of this research is to examine how airline ticket prices evolve over time and to assess the responsiveness of demand to these pricing strategies, with particular emphasis on temporal dynamics and elasticity patterns. The empirical analysis is based on a primary dataset of economy-class fares collected via the Google Flights platform for flights operating between Athens and Amsterdam. The dataset captures price observations across multiple airlines over a defined booking horizon, structured around the Days to Departure (DTD) variable. This approach enables the systematic tracking of fare evolution as departure approaches, providing insights into the operational logic of airline yield management systems.

Results reveal a strong and consistent negative relationship between ticket prices and DTD, indicating that fares increase as the departure date nears. This pattern confirms the practical implementation of intertemporal price discrimination, a core feature of yield management. Early booking periods are associated with lower fares and greater price dispersion, reflecting efforts by airlines to stimulate demand among price-sensitive travelers. In contrast, the final booking window is characterized by higher and more stable prices, suggesting reduced price sensitivity and the presence of time-constrained passengers. The analysis also identifies substantial variability in pricing across airlines, highlighting differences in competitive positioning, capacity management, and revenue optimization strategies. These inter-carrier disparities suggest that while the general principles of dynamic pricing are widely applied, their execution varies significantly depending on market structure and strategic priorities. Furthermore, the study observes asymmetric revenue responses to price changes, indicating that fare increases and decreases do not generate proportional effects on demand, particularly in late booking stages.

A sensitivity analysis based on simulated price adjustments ($\pm 10\%$) provides additional insight into

demand responsiveness. The results indicate relatively inelastic demand in the final days before departure, where price increases have a limited impact on booking volumes. This finding reinforces the importance of late-stage pricing strategies in maximizing revenue. Conversely, earlier booking periods exhibit higher elasticity, implying that pricing decisions in these stages play a critical role in shaping overall demand and load factors. Overall, the study contributes to the empirical understanding of airline pricing behavior by demonstrating how dynamic pricing strategies interact with temporal demand patterns in a competitive European air travel market. By combining descriptive and sensitivity analyses, the research offers a robust, data-driven perspective on the mechanisms underpinning yield management. These insights are relevant not only for airline revenue optimization but also for broader considerations of market efficiency and passenger access in modern air transport systems.



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USE OF THE LOSS DISTRIBUTION APPROACH IN WIND FARM SETTING EMERGENCY PREPAREDNESS FROM EXTREME WEATHER

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Keywords: loss distribution approach, wind farms, extreme weather, emergency preparedness, digital twin.

Extreme weather is becoming an increasingly important source of operational disruption for wind farms, affecting not only asset integrity and energy production, but also preparedness planning, emergency response, and recovery management. In this context, wind farm operators require methods that can support anticipation of adverse events and provide a structured basis for decision-making under uncertainty. This work examines the use of the Loss Distribution Approach (LDA) as a structured approach for risk-informed decision support and emergency preparedness in wind farm settings exposed to extreme weather conditions, with particular attention to its strengths and limitations in an operational and digitalization context.

Originally developed for operational risk assessment in banking and insurance, the LDA offers an attractive conceptual structure because it separates the modelling of event frequency from the modelling of event severity and combines them into an aggregate loss distribution. Such a structure is especially relevant when addressing low-frequency, high-impact events, including weather-driven failures that may affect critical wind farm assemblies and sub-assemblies. In the present context, the value of the method lies not only in the production of summary risk metrics, such as expected loss and tail-risk indicators, but also in its potential to support preparedness-oriented decisions, including preventive shutdown planning, prioritization of inspections, contingency budgeting, spare-parts positioning, and sequencing of recovery actions after severe weather episodes.

At the same time, the practical application of LDA in wind farm environments remains conditional on data realism. The method requires a minimum degree of consistency in failure records, weather-event attribution, and cost information. In practice, however, these requirements are often only partially met. Historical records may be fragmented across maintenance logs, SCADA systems, weather monitoring platforms, contractor reports, and insurance documentation. Failure events are not always coded uniformly, cost data may be incomplete or unavailable, and indirect losses such as downtime, logistics disruption, delayed repair mobilization, or cascading operational effects are frequently difficult to estimate robustly. As a result, the implementation of LDA in this domain often depends on a combination of field data, engineering judgement, expert elicitation, simplifying assumptions, or external reference datasets. This affects both parameter estimation and the interpretability of outputs.

A further practical challenge concerns the underlying assumptions of the method. Classical LDA formulations generally rely on some degree of independence between events and on relative stability of statistical properties over time. In wind farm emergency settings, these assumptions may be strained. A single storm event can trigger multiple correlated failures across turbines or components, while climate variability, aging assets, repowering actions, changing maintenance regimes, and evolving operational strategies may alter both event frequencies and loss severities. Therefore, the method should not be interpreted as a fully self-sufficient predictive engine, but rather as a structured approximation that can be useful when its assumptions, boundaries, and uncertainties are made explicit.

From a digital twin perspective, LDA remains promising because of its modularity and compatibility with layered decision-support architectures. It can function as a risk-assessment module embedded within a wind farm digital twin, receiving inputs from asset-condition monitoring, operational logs, and weather intelligence, and translating them into preparedness-relevant indicators. In that role, LDA may enhance transparency and traceability in decision support, particularly where explainability is preferred over black-box complexity. Nevertheless, its usefulness within a digital twin depends on data governance, event taxonomy design, and regular recalibration.

Overall, we argue that LDA can offer meaningful support to wind farm emergency preparedness from extreme weather, provided that it is applied with methodological caution and strong awareness of data limitations. Its principal advantages are transparency, flexibility, and operational relevance; its main shortcomings arise from data scarcity, imperfect cost capture, and dependence structures.

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KEY FACTOR COMBINATIONS DRIVING GREEN INFRASTRUCTURE IMPLEMENTATION FOR SUSTAINABLE URBAN STORMWATER OUTCOMES

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Keywords: green infrastructure, nature-based solutions, urban flood resilience, sustainable stormwater management, fsQCA

Flooding is no longer an exceptional event for many cities; it is becoming the norm. As urban areas expand and natural land cover gives way to concrete, asphalt, and other impermeable surfaces, the capacity of cities to absorb and manage precipitation diminishes. Existing stormwater drainage systems, many of which are deteriorating or outdated, are increasingly unable to cope with rising volumes of runoff, particularly under the more intense precipitation events driven by climate change [1]. Green infrastructure (GI) offers a compelling response to this challenge. By working with natural hydrological processes rather than merely conveying water away, interventions such as bioswales, rain gardens, permeable pavements, and constructed wetlands provide a more resilient and adaptable approach to urban stormwater management. Beyond managing runoff, GI delivers multiple co-benefits, including climate change mitigation and adaptation, public health and well-being, and opportunities for tourism and recreation, making it a multifaceted investment for sustainable cities [2]. Despite clear evidence of its benefits, the implementation of GI faces multiple barriers, highlighting the need to examine the key factors that drive its adoption and successful implementation. In addition, much of the existing research examines factors in isolation, leaving a critical gap in understanding how the key factors for successful implementation interact and combine in real-world urban contexts [3][4].

To address this gap, the study aims to identify combinations of key factors that drive successful sustainable stormwater management outcomes. Rather than asking which single factor matters most for successful implementation, a question that tends to produce partial and sometimes contradictory answers. This research focuses on how factors combine. This distinction matters because real-world implementation does not happen through isolated variables or factors. It happens through the interaction of people, institutions, resources, and context. To capture this complexity, a fuzzy-set Qualitative Comparative Analysis (fsQCA) was conducted across 16 urban GI case studies drawn from diverse geographic and institutional settings. These include the Green City, Clean Waters project in Philadelphia, USA, the ABC Waters programme in Singapore, and the ATeNaS program in Kivisto, Vantaa, Finland. Four key factors were examined: stakeholder engagement, financial incentives, regulatory policies and regulations, and technical considerations. These were identified through a systematic review of the GI and sustainable stormwater management literature as the factors most consistently associated with implementation outcomes.

The analysis revealed two distinct configurations through which sustainable stormwater management outcomes are achieved. Across both configurations, stakeholder engagement and regulatory policies and regulations are common and underpin a useful foundation. The first configuration builds on this foundation through the inclusion of financial incentives, while the second does so through technical considerations. In each case, the additional factor, financial incentives in the first configuration and technical considerations in the second, served as the decisive element that completed the configuration. These findings highlight a clear message for practice. Successful GI adoption and implementation cannot rely on any single driving factor, not regulation alone, not funding alone, not technical considerations alone. The evidence consistently points to the need for integrated environments where stakeholders, regulatory frameworks, financial, and technical considerations converge simultaneously. By moving beyond single-factor analysis to examine how multiple factors interact, this study contributes to the growing evidence base for nature-based solutions as a strategy for urban flood resilience. It provides planners, municipalities, and community organizations with a more realistic understanding of what GI adoption and implementation require. As urban flood risk continues to intensify globally, incorporating these key factors into stormwater planning and policy is the next necessary step.

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RE-EXAMINING COMMUNITY RESILIENCE: A REVIEW OF COMMUNITY INITIATIVES TO DEVELOP RESILIENCE

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Keywords: Response, resilience, Workshop, Non-formal education

Communities and countries are now facing disasters more frequently than ever before. This increase in activity puts a strain not only on the levels of government responding but also on first responders, pushing them to a breaking point. Disaster and Emergency Management in Canada and many other countries follows a bottom-up approach, where the local community responds first, then the next level of government, and finally the national level if the situation warrants increased resources. At the same time resources are being used across a wider geographical area, it is important for communities and families to be prepared, to tune in, and to take action to protect themselves. The We're Ready Workshop is "based on disaster research to address the gap in emergency preparation at the community level and the shortage of resources at the municipal level". (Bogdan, 2026)

There is a disconnect between the community and the local government, and between the community's understanding of what people can do. It is important to recognize that multiple community initiatives can strengthen a community's ability to respond, such as the We're Ready! Workshops currently being run. This hands-on training workshop has been run across Canada and is designed first to bring communities together to identify their strengths, the gaps they need to address, and the collective resources they have. Activities are designed to be educational and fun to allow the participants to engage with others as the development of disaster knowledge is not just done as an individual but rather as a group. Some of the activities include disaster bingo, a mock simulation, a debrief and a call to develop momentum in your community to be prepared, know the risks and take action.

Furthermore, the program enables community-based discussions and planning, which can strengthen the capacity to respond to disasters at any time. The framework We're Ready! has built is flexible enough to support the development of additional community actions, such as mangrove restoration, community clean-ups, and further strengthening community connections to support the elderly and those who are more socially vulnerable. Other aspects of the flexibility of the workshop is the ability to tailor its content to adapt to cultural or religious groups as needed. This allows for actions to be specifically developed that will work for that group of people while respecting the culture's needs. This presentation will examine four case studies from four different communities, review the results, and apply them to the current communities being impacted. The framework can be used to help develop community programs and help connect communities to enhance their resilience.

The report will then connect other initiatives, such as the Resilient Hub in Mississauga, and the informal

education programs that the Red Cross, the World Organization of the Scout Movement, and the United Nations Disaster Risk Reduction Agency use to develop community resilience. The result of this research will allow community leaders to understand the workshop's framework, develop ideas of the workshop's usage to improve their own community's resiliency and help understand how to fill the gaps between preparedness and mitigation and how the preparedness of a family or individual using these techniques can save on disaster response costs and save lives.

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INTEGRATING A STIGMA-FOCUSED AGENDA INTO EMERGENCY MANAGEMENT PRACTICE: LESSONS FROM COVID-19 RESPONSE IN TORONTO, CANADA

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Keywords: stigma, stigmatizing forces, disaster management, COVID-19 response, Toronto Canada

COVID-19 was not only a public health emergency - it also generated a wave of stigma that shifted in form and intensity over the course of the pandemic. Although stigma is often treated as a peripheral social issue, separate from the technical and operational dimensions of emergency response, it had concrete effects on how the COVID-19 response was governed, coordinated, and experienced. Stigma is not simply a set of individual prejudices, but a relational and structural process through which certain groups, identities, and professions are devalued, blamed, or rendered suspect [1, 2, 3]. These processes shape risk perception, trust, authority, and decision-making, with direct implications for emergency response effectiveness. Just as emergency managers anticipate logistical and operational challenges, they must anticipate how stigma may emerge, whom it may target, and how it may undermine response efforts.

What began as anti-Asian stigma across the world at the start of the pandemic, soon evolved into broader discrimination faced by frontline workers and personal support workers, individuals testing positive, families of bereaved, and others. Stigma was reflected in people's attitude toward personal protective equipment (PPE), vaccine mandates, travel restrictions and border closures. Through a targeted case-study of the response to COVID-19 in Toronto, Canada, we present the impact of 'stigmatizing forces' across three interconnected levels: community, organizational, and individual, each impacting EM response efficiency.

At the *community level*, efforts to curb the spread of disease were inadvertently inhibited in early 2020 as anti-Asian and anti-Chinese stigma overshadowed early preventative actions by Chinese diaspora communities – one of many negative impacts of stigma observed across society. At the *organizational level*, stigma emerged through institutional dynamics that marginalized emergency management as a profession, relegated its expertise, and undermined coordination efforts. At the *individual level*, stigma was experienced personally by emergency management personnel who faced blame, threats, and ethical conflict as they navigated contentious decisions under conditions of uncertainty and political pressure, often resulting in moral injury.

Synthesizing findings from over 100 qualitative interviews conducted in the Greater Toronto Area between 2020 and 2024, we argue that stigma played a role in exacerbating the spread of the virus. Especially given the inevitability of future public health crises and the like, stigma should be a fundamental consideration in disaster and emergency management. Stigma-informed emergency management recognizes how community narratives, institutional structures, and individual experiences interact, such that emergency management can better anticipate unintended social consequences

of policy decisions, strengthen internal cohesion, and rebuild trust with the communities it serves. Integrating stigma awareness into emergency management practice is essential for building more equitable, adaptive, and effective disaster response systems.

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CLIMATE-NEUTRAL AND SMART CITIES: INTEGRATING RESILIENCE AND RISK GOVERNANCE IN URBAN SYSTEMS

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Keywords: Climate-Neutral Cities, Smart Cities, Climate Adaptation, Risk Governance, Urban Resilience.

Climate change constitutes one of the most significant challenges of the 21st century, affecting all sectors of human activity, particularly the urban environment. Cities, as primary hubs of population concentration, production, and energy consumption, are called upon to play a leading role in the transition toward a sustainable future. Within this context, the planning and development of climate-neutral and smart cities becomes of critical importance, integrating innovative technologies, sustainable policies, and participatory processes.

This paper explores the theoretical and practical framework guiding the transition of contemporary cities toward climate neutrality, focusing on the prerequisites, policy directions, and planning tools required for the development of climate-neutral, resilient, and technologically innovative urban systems.

According to the United Nations Framework Convention on Climate Change, climate neutrality “refers to the concept of achieving net-zero greenhouse gas emissions by balancing emissions so that they are equal to (or less than) the emissions removed through the planet’s natural absorption processes.” Similarly, the National Climate Law defines climate neutrality, or net-zero greenhouse gas emissions balance, as “the balancing of anthropogenic greenhouse gas emissions from sources with removals by sinks.” Achieving climate neutrality requires not only the reduction of greenhouse gas emissions but also the offsetting of any remaining emissions. Only in this way can a net-zero emissions balance be achieved. This can be accomplished through carbon capture, namely the removal of carbon from the atmosphere, or through offset mechanisms, which typically involve supporting climate-oriented projects.

A smart city combines technological innovation with sustainable development and social participation, aiming to improve citizens’ quality of life, enhance resource efficiency, and strengthen urban resilience. Cities are required to address challenges, crises, and unpredictable changes through the use of technology, not only to modernize but also to develop more resilient and sustainable urban systems. Smart technologies contribute to improved crisis prevention and management while facilitating adaptation to emerging urban models, thereby reinforcing urban resilience.

However, despite the significant potential of smart city applications to enhance urban resilience and citizen well-being, excessive reliance on technology entails risks and raises critical concerns. Issues related to cybersecurity, social inequalities, and governance may undermine both urban resilience and sustainability if not addressed through coherent and strategic planning.

Within this context, the concept of risk governance emerges as a critical dimension in the transition toward climate-neutral and smart cities. Risk governance extends beyond traditional risk management by incorporating institutional arrangements, stakeholder participation, and multi-level decision-making processes that shape how risks are understood, assessed, and addressed. In complex urban environments, where multiple factors interact across different scales and levels, effective risk governance requires the integration of technological tools to enable more comprehensive and holistic approaches.

The paper concludes that technology contributes significantly to urban development by strengthening urban resilience, offering tools that facilitate environmental understanding and protection, climate adaptation, and the management of risks and crises that are difficult to address through conventional approaches. Furthermore, it helps bridge the trust gap between institutions and citizens through transparency and increased participation in decision-making processes related to sustainability and well-being. Nevertheless, due to the complexity of these systems, clear strategic planning and well-defined roles and responsibilities are essential to prevent risks associated with systemic failures or malicious actions.



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ENHANCING URBAN COASTAL RESILIENCE UNDER CLIMATE CHANGE: A MEDITERRANEAN CASE STUDY APPROACH

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Keywords: Coastal Flood Risk, Coastal Resilience, Climate Change Adaptation, Mediterranean, Vulnerability.

Coastal flooding constitutes a critical global challenge that is increasingly exacerbated by climate change, leading to significant environmental, economic, and social impacts. Sea level rise, primarily driven by the thermal expansion of seawater and the melting of glaciers and ice sheets, represents a key contributing factor to this phenomenon. Low-lying coastal areas are particularly vulnerable to rising sea levels, as even minor elevation changes can result in substantial adverse environmental consequences [1].

Mediterranean coastal regions are disproportionately affected by the impacts of climate change, posing serious threats to both local economies and ecosystems. Rapid urbanization, climate variability, and intense seasonal precipitation events collectively contribute to an increased frequency of flood hazards, particularly within Mediterranean urban environments. Given that a significant proportion of the Mediterranean population resides along coastal zones, the protection of coastal urban areas from flood events is of paramount importance, especially as such events are becoming increasingly frequent and severe due to climate change. Urban resilience is defined as the capacity of cities to prepare for, absorb, adapt to, and recover from environmental stresses and shocks, such as flooding. In this context, the high vulnerability of Mediterranean urban areas to extreme rainfall events underscores the importance of addressing climate variability and enhancing resilience in urban expansion processes [2].

Coastal erosion represents one of the most pressing environmental threats associated with sea level rise. Due to their dynamic nature, coastal landscapes can undergo significant transformations even under minor fluctuations in sea level. Critical habitats, including wetlands, beaches, and mangrove forests, are increasingly lost as the frequency and intensity of coastal erosion processes escalate. For instance, wetlands play a crucial role in nutrient absorption, flood mitigation, and biodiversity support. The degradation of such ecosystems can lead to both biodiversity loss and wildlife displacement. Furthermore, coastal flooding contributes to saltwater intrusion into freshwater reserves as a result of rising sea levels. Coastal aquifers, which supply irrigation and drinking water to millions of people worldwide—particularly in densely populated regions—are increasingly at risk of salinization.

As seawater encroaches, these aquifers may become unsuitable for agricultural and human use. Additionally, increased salinity can damage crops and reduce soil fertility [3].

Coastal flooding also poses a significant threat to transportation infrastructure. Damage to such infrastructure is expected to become more frequent and severe as climate change accelerates, necessitating immediate action to mitigate associated impacts [4]. For example, severe coastal erosion can compromise road networks by weakening their structural foundations and increasing the occurrence of critical failure points [5].

In addition to physical damages, flooding exerts profound social impacts on communities worldwide. Beyond immediate physical harm, flood events can lead to long-term social challenges, including social disruption, mental health issues, economic hardship, and displacement. Flooding frequently results in both temporary and permanent population displacement. The extent of displacement tends to be greater in regions characterized by high exposure, low levels of development, weak governance, and ongoing conflict. Displaced populations often face limited access to essential resources such as food, clean water, and healthcare, particularly in areas with inadequate infrastructure. This can drive migration toward resource-rich areas, potentially resulting in overpopulation and additional socio-economic pressures [6].

The aim of this study is to analyze the potential risks associated with coastal flooding in Mediterranean urban areas, as well as to examine prevention measures and strategies for mitigation and impact management. Effective mitigation and prevention strategies are typically integrated within comprehensive crisis management frameworks. Prevention remains the most effective approach to reducing coastal flood risks, with long-term strategies focusing on minimizing exposure forming a key component of proactive risk management.

Integrated Coastal Zone Management (ICZM) aims to balance environmental, economic, social, cultural, and recreational objectives in coastal areas. It promotes the sustainable management of coastal resources while reducing risks such as coastal flooding through coordinated, multi-stakeholder approaches.

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URBAN RESILIENCE TO NA-TECH DISASTERS IN A LANDSCAPE OF CASCADING RISKS

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Keywords: Urban Resilience, Na-Tech Disasters, Climate Change, Risk Assessment, Cascading Effects, Governance.

Natural and technological disasters constitute complex and critical phenomena that contemporary societies are called upon to address, as they severely affect human lives, infrastructure, economic resources, and natural ecosystems. The increasing frequency and intensity of extreme natural events, combined with the climate crisis, rapid urbanization, and growing dependence on complex technological systems, have brought about profound changes in the field of risk and disaster management.

The aim of this paper is to investigate and assess urban resilience to Na-Tech disasters, namely events that occur when natural hazards trigger or exacerbate technological accidents. Of particular importance in the Na-Tech literature is the concept of cascading effects, referring to a sequence of successive events in which an initial incident generates a chain of technological and social impacts. In a Na-Tech scenario, a natural hazard may initially cause a technological failure, which in turn leads to further incidents, such as fires, explosions, or widespread environmental pollution. These cascading effects often significantly amplify the overall magnitude of the disaster and complicate effective crisis management by competent authorities [1]. Such disasters highlight the need for an integrated approach that takes into account all cascading effects and domino phenomena affecting critical infrastructure and social systems. This evolving context shifts the contemporary scientific and institutional discourse from a focus on response and impact mitigation toward institutional prevention, preparedness, and the strengthening of infrastructure and societal resilience.

This research seeks to determine the extent to which urban environments, infrastructure systems, and local communities are capable of preparing for, responding to, and recovering from such complex disasters, taking into account the spatial dimension of risks, social and institutional vulnerability, as well as the level of preparedness of citizens and responsible authorities.

The presence of installations falling under the Seveso Directive, along with their spatial proximity to urban areas, increases the importance of assessing Na-Tech risks in the Greek context. Furthermore, the country's high seismicity and the increasing frequency of extreme weather events reinforce the need to integrate Na-Tech risk considerations into civil protection planning and industrial risk management [2].

Recent disasters have revealed both the weaknesses and the necessity for restructuring the entire Civil Protection system, leading to significant institutional reforms aligned with the European framework and aimed at establishing a unified approach to risk management. Understanding natural disasters and technological accidents as interconnected phenomena is a critical prerequisite for contemporary risk prevention and management planning. The transition from fragmented approaches to integrated analytical frameworks allows for a more accurate representation of the actual risk profile of urban areas.

The Fukushima incident is considered one of the most significant Na-Tech events of recent decades at the global level, as it clearly demonstrated how a natural hazard can trigger severe technological failures in critical energy infrastructure [3]. At the European level, a notable case occurred in Italy in 2014, when severe flooding affected industrial facilities in the northern part of the country, resulting in the release of chemical substances into rivers and aquatic ecosystems. The floods caused damage to storage tanks and wastewater treatment systems, leading to the dispersion of hazardous materials into the natural environment. This event highlighted the vulnerability of industrial installations located near water systems and underscored the need to incorporate flood risk into the design and operation of facilities handling hazardous substances.

The conclusions of this paper highlight, first, the need to strengthen the transition from a system focused on “incident response” to one based on integrated risk analysis, preventive planning, and the cultivation of a resilience culture across all levels of governance and society. Second, they emphasize the need to enhance data infrastructures, geospatial analysis, and cross-sectoral collaboration, so that tools such as risk mapping and multi-hazard analysis move beyond being merely “best practices in studies” and become embedded in the everyday operation of Civil Protection. Third, they stress the importance of involving local communities, local authorities, and the private sector - especially in areas with elevated Na-Tech risk—in the development of emergency plans, exercises, and early warning mechanisms, ensuring that risk management does not remain confined to a narrow administrative core.

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CRISIS MANAGEMENT: CANADIAN CASE OF DISASTER RESPONSE SYSTEM

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Keywords: *Disaster Response, Resilience, Domestic Operations, Mitigation, Canada.*

Canadian disaster and emergency management is a multidimensional, multilayered system that is intended to be operated and administered primarily by provincial and local governments, with federal governance and resources stepping in when needed and requested. The civil system is challenged by the increasing frequency and impacts of natural disasters, which are outpacing the resources. Furthermore, the increasing population, people's property and assets, and the built environment have led to greater demand for the Canadian Armed Forces (CAF) to be involved in domestic response. The logistical challenges posed by Canada's vast terrain and the lack of infrastructure in remote regions further drive the need for CAF involvement due to their ability to provide aircraft evacuations. The federal government does not recover costs from the jurisdictions of the affected regions, and the provinces and territories have come to view CAF assistance as a resource entitlement [1], rather than as the 'last resort measure' it is intended to be. This trend is further complicated by the need to remain in affected communities until their commitments are fulfilled, so that people do not feel abandoned [2].

Recent geopolitical developments and conflicts around the world, especially as the recovery from the COVID-19 pandemic had not yet been fully achieved and combined with international commitments, such as those to NATO, raised concerns about whether the CAF can sustainably remain involved domestically [3]. Governments of all levels have acknowledged the need to reshape the emergency management system, reduce reliance on CAF, and explore fresh ideas for the way forward. A robust, well-integrated system must be designed in line with the emergency management cycle, encompassing mitigation, preparedness, response, recovery, and reconstruction, with CAF's involvement on a need basis in the response phase. It is worth noting that all emergencies start locally [4]; therefore, local capacity-building through structural and non-structural measures is critical. This approach, in accordance with theoretical underpinnings [5] and practical understanding, is expected to provide relief to the system by potentially reducing the scale and scope of disasters needing a response. National guidance on adaptation strategies geared toward community resilience, the emergency management framework, the disaster financial assistance arrangement program, the province of Ontario's emergency management action plan, and similar provincial initiatives and guidelines are among the newly developed resources to support the system holistically.

With the above background, this study aims to analyze the critical components of Canadian emergency

management systems to identify the stress points and their context within the system. One such critical component is the use of the Armed Forces for domestic disaster response operations, in particular, Operation LENTUS, which refers to domestic operations carried out by the CAF to assist in responding to disasters caused by natural hazards. Over the past decade, CAF has seen a surge in requests for assistance in wildfires and floods across the country, leading to increased pressure on resources and services. During this period, CAF participated in over 85 domestic operations nationwide, including approximately 50 natural hazard emergencies and more than 35 COVID-19 assistance operations. We have utilized an integrated quantitative and qualitative approach using a geospatial platform to develop a georeferenced database of all recorded domestic operations in Canada since 1948. The attributes associated with each datapoint included the start date of the hazard event, the date of the CAF deployment, the number of soldiers deployed, the deployment location, the mission duration, the impacted population, and the activities performed by the CAF members on the ground. The detailed information allowed for a combination of objective and descriptive assessment of domestic operations over the years. Finally, a set of evidence-based observations was derived from the comprehensive analysis described above that can inform future strategy development, system efficiency improvements, and policy decisions to support effective crisis management and disaster response.

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OPERATIONALIZING YIELD MANAGEMENT AND ELASTICITY THEORY FOR CRISIS-RESILIENT AIRPORT SYSTEMS: THE CASE OF FRANKFURT AIRPORT

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Keywords: Yield management, Demand Elasticity, Dynamic pricing, Transport economics, Regulatory policy interventions

This study investigates how yield management and demand elasticity theory can be operationalized to enhance the crisis resilience of airport systems, using Frankfurt Airport as an empirical case. While yield management is traditionally framed as a revenue-maximization tool, this paper repositions it as a strategic instrument for adaptive response under conditions of disruption, volatility, and demand uncertainty—key concerns in crisis and disaster governance.

The research examines the interaction between dynamic pricing mechanisms and multiple dimensions of demand elasticity, including own-price elasticity, cross-price elasticity across competing carriers and fare classes, and income elasticity. The central objective is to determine under what conditions dynamic pricing optimizes revenue without undermining demand stability, particularly during periods of systemic stress such as demand shocks, capacity constraints, or abrupt changes in traveler behavior. The empirical analysis is based on a primary fare dataset constructed to reflect the operational logic of airline yield management systems. The dataset focuses on the Athens–Frankfurt route, with particular attention to services provided by Aegean Airlines. This route was selected due to its high frequency, pronounced seasonality, and competitive market structure, making it suitable for analyzing both normal and disrupted demand conditions. The study employs descriptive statistical methods, booking curve analysis (price versus days-to-departure), and econometric modeling, including regression analysis with appropriate controls for seasonality and capacity constraints. Particular attention is given to price endogeneity, recognizing that fares are jointly determined with inventory control decisions.

Findings highlight a clear segmentation of passenger behavior. Early bookers tend to exhibit relatively elastic demand, responding sensitively to price changes, while late-booking passengers—often business travelers—display more inelastic demand patterns. This segmentation enables airlines to apply differentiated pricing strategies; however, under crisis conditions, excessive price discrimination may amplify demand volatility or suppress critical travel flows. The analysis demonstrates that while dynamic pricing can enhance short-term revenue efficiency, its effectiveness depends on maintaining a balance between price optimization and demand preservation.

From a resilience perspective, the study argues that yield management systems can contribute to adaptive capacity by enabling rapid pricing adjustments in response to shocks. However, without appropriate governance frameworks, these systems may also exacerbate inequalities in access to air transport, particularly for geographically constrained populations such as island residents. The paper therefore extends beyond technical modeling to consider policy implications, advocating for regulatory mechanisms—including price caps and public service obligations—to ensure that efficiency gains do not come at the expense of social equity and system robustness.

Overall, the study contributes to the integration of transport economics and crisis resilience by demonstrating how pricing strategies, when properly governed, can support both operational sustainability and equitable access in airport systems facing increasing uncertainty.



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CIRCULAR ECONOMY AS A RESILIENCE STRATEGY IN TRANSPORT INFRASTRUCTURE: THE CASE OF HEATHROW AIRPORT

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Keywords: Circular Economy, Sustainable Infrastructure, Heathrow Airport, Resource Efficiency, Digital Technologies

The transition from linear to circular economic models represents a fundamental shift towards sustainable infrastructure development and efficient resource management [1,2]. Within this framework, this study investigates the implementation of circular economy strategies in large-scale transport infrastructure, focusing on Heathrow Airport Ltd as a representative case [4]. The concept of a circular economy emphasizes the creation of regenerative systems that minimize resource consumption, environmental impact, and waste generation through structured practices, including reduction, reuse, recycling, and recovery [1,2]. Extending beyond the conventional 4R framework, more sophisticated models encompass up to 10R strategies, incorporating repair, refurbishment, remanufacturing, and redesign, thereby promoting the preservation of material value throughout the lifecycle of assets and infrastructure [2].

Integrating circular economy principles into infrastructure management offers multiple advantages, including operational efficiency, enhanced resilience against supply chain disruptions, and mitigation of energy crises, contributing to the long-term sustainability of essential systems [1,4]. Heathrow Airport has adopted a comprehensive approach that involves the reuse of materials and equipment, the deployment of energy-efficient technologies, the utilization of recyclable construction inputs, and the optimization of waste management processes [4]. These interventions demonstrate how circular strategies can be systematically applied within complex, large-scale transportation hubs to achieve measurable sustainability outcomes.

Beyond operational efficiency, circularity delivers significant environmental and socio-economic benefits. These include the reduction of greenhouse gas emissions, decreased energy and water consumption, minimization of waste streams, and promotion of employment and social inclusion [1,2,5]. The "Heathrow 2.0 – Connecting People and Planet" strategy exemplifies a holistic sustainability agenda, aiming to achieve net-zero emissions in both aviation and ground operations while simultaneously fostering community engagement, workforce development, and inclusive growth [4,5].

Nonetheless, the study critically addresses potential greenwashing risks, emphasizing that certain

sustainability initiatives may lack substantive impact without transparent methodologies, quantifiable performance indicators, and independent verification [3]. This underlines the importance of accountability and data integrity in corporate sustainability assessments [3,4].

Evaluation of key performance indicators (KPIs) for 2022–2025 reveals significant progress across economic, social, and environmental dimensions. Initiatives include Sustainability-Linked Bonds, enhanced stakeholder engagement, and measurable reductions in emissions, aligning with the United Nations Sustainable Development Goals (SDGs) and reinforcing the airport's strategic positioning within the global sustainability agenda [4,5].

The study further proposes advanced performance metrics such as employee training intensity in sustainability-related competencies, energy consumption per passenger, and the proportion of circular procurement [1,2]. Material, energy, and waste flows within airport operations are analyzed to identify critical areas for circular interventions, including construction, catering services, and equipment lifecycle management [2,4].

Finally, the integration of digital technologies, such as the Internet of Things (IoT), Big Data analytics, Digital Twins, and Blockchain, is highlighted as a key enabler of data-driven decision-making, operational transparency, and resource optimization [4,5]. Using multi-criteria decision analysis (MCDA) the study identifies strategic scenarios that prioritize environmental and social performance even when associated with higher operational costs. Overall the findings underscore both the opportunities and challenges inherent in transitioning to a circular and sustainable infrastructure management model [1,2,4,5].

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QUALITY-DRIVEN RESILIENCE IN GLOBAL LOGISTICS: STRATEGIC INTEGRATION OF TQM, ISO STANDARDS, AND DIGITAL GOVERNANCE IN DHL GROUP

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Keywords: Supply Chain Resilience, Total Quality Management (TQM), ISO Standards Integration, Digital Governance (eQMS), Quality-Driven Risk Management

This study explores the role of quality management frameworks as foundational enablers of resilience in global logistics systems, focusing on the strategic integration of Total Quality Management (TQM), international standardization, and digital governance within DHL Group. In an era characterized by supply chain disruptions, geopolitical instability, and increasing operational complexity, logistics organizations are required to move beyond efficiency-oriented models toward adaptive, crisis-resilient systems. This research investigates how quality-driven management approaches contribute to organizational robustness, continuity, and long-term sustainability in such environments.

The analysis adopts a systems-oriented perspective, examining the implementation of TQM principles in conjunction with internationally recognized standards, including International Organization for Standardization frameworks such as ISO 9001 (quality management), ISO 14001 (environmental management), and Transported Asset Protection Association (TAPA) security standards. These frameworks are evaluated not merely as compliance mechanisms but as integrated governance tools that structure processes, standardize risk management, and enhance decision-making across complex supply chain networks. The study also incorporates the European Foundation for Quality Management Excellence Model as a benchmarking and performance evaluation instrument, enabling a holistic assessment of organizational maturity and continuous improvement practices.

Empirically, the research analyzes key performance indicators (KPIs) related to operational efficiency, service reliability, environmental sustainability, and human capital engagement. Particular attention is given to how these metrics evolve under conditions of disruption, such as demand volatility, transport bottlenecks, and external shocks. The findings indicate that the integration of TQM and standardized management systems enhances process consistency, reduces variability, and improves responsiveness to unforeseen events. This is particularly evident in areas such as route optimization, inventory control, and service recovery, where standardized procedures enable faster and more coordinated responses.

A central contribution of the study lies in its examination of digital governance tools, specifically electronic Quality Management Systems (eQMS), as critical enablers of real-time monitoring and adaptive control. These systems facilitate data-driven decision-making, automate compliance processes, and provide early warning signals for potential disruptions. By embedding quality management within digital infrastructures, organizations can achieve greater transparency, traceability, and agility—key attributes of resilient logistics systems. The results demonstrate that the strategic integration of TQM, ISO standards, and digital governance mechanisms creates a synergistic effect that extends beyond regulatory compliance. Instead, it fosters a culture of continuous improvement, risk awareness, and proactive adaptation. This integrated approach not only strengthens operational resilience but also enhances competitive positioning in a highly dynamic global market.

From a governance perspective, the study underscores the importance of aligning quality management practices with broader resilience strategies and policy frameworks. It suggests that organizations operating in critical infrastructure sectors, such as logistics, should adopt standardized and digitally enabled quality systems as part of their core resilience architecture. Overall, this research contributes to the evolving discourse on crisis and disaster governance by demonstrating how quality-driven transformation can serve as a strategic lever for resilience in complex, large-scale supply chain environments.



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SUPPLY CHAIN RESILIENCE AND HUMANITARIAN LOGISTICS: CONCEPTUAL STRATEGIC FRAMEWORK FOR CRISIS RESPONSE AND RECOVERY

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Keywords: Supply Chain Resilience, Humanitarian Logistics, Disaster Response and Recovery, Crisis Governance, Resilient Logistics Systems Design

The present research seeks to develop a conceptual strategy, which would bring together the theories of resilience in the sphere of supply chains and practice of humanitarian logistics. Being in times of unprecedented increase in natural and other types of disasters of all kinds, such as those caused by climatic factors, geopolitical events, or pandemics, humanitarian supply chains should be able to work under extremely uncertain, limited, and time-limited conditions. The research will fill the existing gap in literature by suggesting a strategy based on theories of resilience. In this respect, the framework of the research will adopt a systems approach, whereby humanitarian supply chain resilience will be viewed as a multi-dimensional construct consisting of five features: robustness, redundancy, flexibility, adaptability, and rapid recoverability. The latter will be linked to the three stages of managing any disaster event, which include preparedness, response, and recovery. According to the developed framework, humanitarian logistics will serve as an operational tool that can help make use of the strategic capabilities of resilience mentioned above at the operational stage, e.g., procurement, transportation, warehousing, and distribution.

Relying on the research conducted by scholars from different fields, such as supply chain management, risk reduction during disasters, and humanitarian logistics, this paper will identify some of the major drivers behind resilience that will include pre-positioning of stock, sourcing from multiple sources, decentralized logistics system, and the involvement of local players in humanitarian logistics plans. Another key element that will be considered is coordination efforts, since they will allow elimination duplication, enhancing flow of relevant information and rational resource allocation. An important

component of the framework that needs to be elaborated will concern digitalization as the way of improving situational awareness. In particular, some technological solutions like real-time information exchange will help enhance responsiveness to changing conditions characteristic of disasters, where time becomes especially scarce factor. As regards governance in the area, it is important to consider measures which will allow establishing transparency, efficiency, and interoperability. Finally, the framework will also address possible dilemmas concerning efficiency and resilience.

At a more strategic level, the paper will stress the importance of adopting a holistic approach and developing a resilience mindset. In this respect, it is important to measure the success of humanitarian logistics processes against such metrics as robustness or resilience. Moreover, there is the need to invest in building capacity and foster the culture of learning, adaptation, and innovation. Community engagement is another important aspect, which will have to be considered in designing humanitarian logistics systems.

The contribution of this research lies in offering a comprehensive and adaptable framework that can guide policymakers, humanitarian organizations, and logistics practitioners in designing and managing resilient supply chains. By aligning conceptual insights with practical considerations, the study advances the discourse on crisis and disaster governance and provides a foundation for future empirical and modeling-based research in humanitarian logistics.

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EVALUATING SDG IMPLEMENTATION AND FIRM RESILIENCE WITHIN CIRCULAR ECONOMY: A DATA-DRIVEN PERFORMANCE INDEX

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Keywords: circular economy, Sustainable Development Goals (SDGs), management performance, human capital, sustainable strategies

Circular economy business models have proven effective for sustainable development while offering considerable benefits for the resilience of organizations during systemic disruptions. In terms of the latter, such models can contribute significantly by focusing on efficient use of resources and reducing wastage and pollution. However, the integration of sustainability efforts with organizational capabilities is yet to be properly understood, especially concerning the potential role of the alignment of corporate strategies and actions with the United Nations Sustainable Development Goals (SDGs). This is mainly because sustainability performance measurement is highly complex and data-intensive. Therefore, this study proposes the adoption of a multidimensional performance evaluation approach focused on assessing SDG implementation in circular economy firms and its impact on their resilience. The proposed methodology departs from traditional approaches and relies on a performance index that allows managers to evaluate the effectiveness of their strategic decisions regarding sustainability and resilience.

Specifically, the Managerial Performance Index (MPI) introduced herein represents a data-driven approach to the evaluation of organizational performance in relation to SDGs and sustainability. This framework is based on the assumption that the management's actions influence performance outcomes and thus should be analyzed within an integrated framework to understand its contribution to SDG achievement. Furthermore, the MPI accounts for the interrelationships between sustainability indicators, thereby providing a holistic measure of organizational success in meeting the requirements of sustainability. In particular, the MPI relies on the weighted average of all selected performance indicators and uses the entropy method to establish weightings.

The empirical analysis employs data collected from European aviation companies, which represent a sector particularly vulnerable to the effects of crises and, therefore, facing increasing pressure to move towards sustainable, resilient business operations. The data come from corporate sustainability

reports and GRI indicators and allow for the analysis of managerial performance within the context of human and intellectual capital, which includes dimensions of diversity and equality, occupational safety, training and education, and employee engagement. All these indicators are relevant in terms of organizational resilience, being related to organizational adaptability, workforce stability, and knowledge management capacity.

All sustainability indicators included in the study are normalized to ensure their comparability. The entropy method used to evaluate the informative component of individual indicators leads to assigning higher weights to the most diverse and discriminative measures. After determining weights and normalizing indicators, they are aggregated at a sub-index level and finally combined to yield a composite MPI measure. It has been found that integrated, data-driven performance evaluation frameworks increase the likelihood of success in implementing SDG strategies and improving organizational resilience. In particular, the results of the analysis indicate positive correlations between the MPI score and certain SDG dimensions related to human capital. The latter suggests that organizational adaptability and flexibility contribute greatly to resilience in crises.

Overall, it could be said that the development of frameworks such as the MPI facilitates the process of implementing SDGs and evaluating their effectiveness in achieving sustainability and organizational resilience.

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IDENTIFYING CRITICAL AND VULNERABLE FREIGHT ROUTES IN ROADWAY NETWORKS: A GAME THEORY FRAMEWORK AND APPLICATION IN THE STATE OF FLORIDA

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Keywords: Transportation resilience, Freight network vulnerability, Critical link identification, Network topology analysis, Disruption modeling.

Transportation networks constitute a fundamental component of economic activity and sustainable development, enabling the movement of people, goods, and services across regions. Their efficient and uninterrupted operation is essential for supporting daily mobility, production logistics, and supply chain continuity. However, transportation systems are inherently vulnerable to a wide range of disruptions, including natural disasters, infrastructure failures, and human-induced incidents such as traffic accidents. These disruptions can result in temporary or permanent reductions in network capacity, leading to cascading effects that significantly impact regional and national economies. In this context, resilience, the ability of a transportation network to withstand, adapt to, and recover from disruptions, emerges as a critical performance dimension, particularly for freight networks that function as economic lifelines.

Freight transportation networks play a pivotal role in distributing goods and sustaining economic activity. Disruptions within these networks can propagate rapidly, causing delays, increased costs, and service unreliability. Consequently, identifying and protecting critical components within the network is essential for enhancing resilience. Critical links and routes are those whose failure or degradation leads to disproportionate impacts on overall network performance. The systematic identification of such components provides valuable insights for infrastructure planning, investment prioritization, and emergency response strategies.

This study presents a comprehensive methodological framework for identifying critical links and routes within large-scale, real-world transportation networks, with a specific focus on freight movement. The proposed approach integrates traffic flow characteristics and network topology to evaluate the relative importance of network components under both normal operating conditions and disruption scenarios. The analysis is conducted using the multimodal passenger and freight transportation network of Broward County, Florida, a region of significant logistical importance. Broward County serves as a critical freight hub due to the presence of major infrastructure assets, including Port Everglades, Fort

Lauderdale–Hollywood International Airport, Interstate 95, Interstate 595, and the Florida Turnpike, as well as dense commercial activity.

The methodology builds upon hybrid criticality measures that combine elements of traffic equilibrium analysis and graph-theoretic centrality metrics. These measures, originally developed by [1], enable the ranking of links and routes based on both their structural importance within the network and their operational significance in terms of traffic demand and flow distribution. By incorporating both dimensions, the framework provides a more holistic assessment of network vulnerability compared to traditional single-metric approaches.

To further enhance the identification of critical network components under disruption scenarios, the study adapts and extends a multi-objective optimization framework developed by [2]. This framework considers multiple decision-makers and competing objectives, such as minimizing system-wide travel cost and maintaining network connectivity under partial or complete link failures. A key contribution of this research lies in the integration of network topology characteristics into the solution algorithm, which significantly reduces the feasible search space and computational complexity. This enhancement enables the efficient analysis of large-scale networks and facilitates the identification of combinations of critical links whose simultaneous disruption would have the most severe impact on network performance.

In addition, the study extends an existing GIS-based decision-support tool to incorporate the proposed hybrid criticality measures and topology-informed optimization procedures. The enhanced tool allows for spatial visualization and analysis of vulnerable links and routes, providing practitioners and decision-makers with an intuitive platform for assessing network resilience. The integration of geographic information systems with advanced analytical methods supports more informed decision-making in infrastructure planning, risk assessment, and resilience enhancement strategies.

Overall, the proposed framework contributes to the advancement of resilience-oriented transportation planning by offering a robust, scalable, and data-driven approach to identifying critical freight network components. By enabling the evaluation of both day-to-day operational vulnerabilities and extreme disruption scenarios, the methodology supports the development of targeted interventions aimed at improving network robustness and recovery capabilities. The findings are particularly relevant for regions with high freight activity and complex transportation infrastructures, where proactive resilience planning is essential to mitigate the impacts of disruptions and ensure the continuity of economic activities.

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RESILIENCE AND RECOVERY OF POINTS OF INTEREST FOLLOWING HURRICANE HELENE: A TEMPORAL ANALYSIS

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Keywords: Disaster recovery, Temporal analytics, Timeseries forecasting, Business resilience, Hurricane Helene

Natural disasters disrupt local economies in uneven and complex ways, yet most resilience assessments are conducted at aggregated spatial scales, obscuring how impacts vary across individual economic actors. This study addresses this gap by developing a businesslevel resilience assessment framework and applying it to quantify the impacts of Hurricane Helene on 5,671 Points of Interest (POIs) across western North Carolina. Using 616 days of highresolution mobility data (May 2023 to February 2025), we integrate foottraffic observations with environmental and infrastructural datasets, including precipitation, elevation, and road closure information, to capture both exposure and disruption mechanisms.

To estimate the causal impact of the hurricane on visitation patterns, we employ a counterfactual forecasting approach using the Times FM foundation time series model, alongside classical models such as SARIMAX and Prophet and the transformerbased ChronosT5 model for comparison. The models are trained on predisaster data to generate expected visitation trajectories in the absence of disruption. We then quantify deviations between predicted and observed trajectories using a normalized signed Area Under the Curve (AUC) metric, which captures both the magnitude and persistence of disruption over time. This formulation allows for consistent comparison across heterogeneous POIs without imposing arbitrary recovery thresholds.

Model evaluation demonstrates that transformer based architectures, particularly Times FM, outperform classical approaches in longhorizon forecasting, exhibiting lower error propagation and greater stability. The AUCbased impact metric reveals pronounced heterogeneity in recovery trajectories across business sectors. Educational services, healthcare facilities, and public administration sites experienced the most severe and persistent declines in visitation, reflecting prolonged institutional closures and service disruptions. In contrast, sectors such as retail, real estate, and accommodation services exhibited faster recovery or even increased visitation, likely driven by postdisaster demand for housing, supplies, and recoveryrelated services.

To further explain variability in disruption, we employ an XG Boost model with SHAP based interpretability, using the derived AUC scores as the dependent variable. The results indicate that business sector, prehurricane visitation levels, peak rainfall intensity, and cumulative weekly precipitation are the most influential factors driving recovery outcomes. Peak rainfall is associated with acute negative impacts, while cumulative precipitation shows mixed effects, reflecting both prolonged disruption and recovery phase activity. High traffic establishments demonstrate greater resilience, often acting as anchors for local recovery by stabilizing or increasing visitation more rapidly than lower traffic counterparts.

The findings highlight that economic function is a primary determinant of resilience and recovery dynamics, emphasizing the importance of sector specific analysis in disaster response planning. By shifting the unit of analysis from aggregated spatial scales to individual establishments, this study provides a microscale perspective that complements existing community and network level resilience frameworks. The proposed methodology offers a scalable and interpretable approach for integrating mobility data with environmental context, enabling policymakers to identify vulnerable sectors, prioritize infrastructure restoration, and allocate resources more effectively.

Overall, this work demonstrates the value of combining high resolution mobility analytics with advanced time series forecasting and interpretable machine learning to quantify disaster impacts at the business level. The framework is broadly applicable to other disaster contexts and provides actionable insights for resilience planning, continuity of operations strategies, and infrastructure investment decisions.



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CONSTRUCTION TECHNOLOGY, SEISMIC BEHAVIOR AND CULTURAL MONUMENTS: EXPERIENTIAL EDUCATION FOR HERITAGE AWARENESS

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Keywords: Construction Technology; Experiential Learning; Cultural Heritage.

This study focuses on the structural and building technology of modern monuments of our cultural heritage. It aims at the differentiated education of students of all levels (primary, secondary and university education) through active teaching, experiential learning, as an effective tool that can be integrated into the framework of environmental school education and guidance for historical building technology and science. The effectiveness of Experiential Learning reinforces the necessity of applying the approach to the topics and scientific concepts of structural, and especially, building science, by focusing on the monuments of our cultural heritage, to strengthen the awareness of the new generation of all levels on a good basis. Principally, this study combines structural and building science knowledge with the educational methods of active and differentiated learning. For this purpose, a strategic plan is proposed for integrating this innovative learning into the curricula of all education levels.

Preserving monuments requires a deep knowledge of advanced construction technologies and the seismic behavior of historical structures. Traditional educational methods have failed to effectively engage students in experiential learning, creating an educational gap that only a meaningful solution can bridge. Introducing a pedagogical approach called experiential learning, which emphasizes hands-on learning and direct experience, is a potential solution to bridge this educational gap.

While modern construction technology introduces innovative materials and techniques to improve the structures' seismic response, effective environmental education on this subject for students at different levels, remains elusive. By implementing these educational methods and improving teaching practices, teachers ultimately achieve improved outcomes in student performance, engagement, and motivation

through an assessment process that is also tailored to their abilities [1,2]. Using assessments, teachers can then tailor their teaching strategies at each grade level to the readiness, profile, and interests of students.

Active student participation, direct experience, and reflection are the central tenets of Experiential Learning, based on the theory of John Dewey, David Kolb and Kurt Hahn. This educational approach fosters critical thinking, teamwork, and metacognitive problem-solving skills, thus simulating real-world challenges [3,4].

In the challenge of adapting Experiential Learning to all educational levels, the instructional approach requires recognizing the diverse backgrounds and distinct abilities of students by emphasizing the modification of content, process, objectives, and learning environments. This synergy enables students to access knowledge regardless of their cognitive background, resulting in their appropriation of that knowledge, developing the necessary metacognitive skills, and cultivating a lifelong love of learning. By implementing these educational methods and improving teaching practices, teachers ultimately achieve improved student outcomes through an assessment process that is also tailored to their abilities [5,6].

According to the international bibliography, despite the intense technological development, only about 15% of global research combines the interaction of the science of seismic constructions with experiential learning. However, the usual practice of experiential workshops is mainly found in architectural studios, civil engineering work-shops or environmental educational programs to raise public awareness after seismic disasters. The present work, which is particularly relevant in countries with high seismic risk and a rich cultural heritage, such as Greece, Italy, Turkey, Nepal, Iran, Peru, etc., innovates in the combination of the cultural heritage of monuments as a need to highlight and raise awareness among the young generation.

The multidisciplinary dynamic of this research shows a clear convergence between civil engineering, earthquake science, cultural heritage studies and environmental education. It is widely recognized that monuments are learning stages, engineering is intertwined with culture, and STEM can be taught through the structures of cultural heritage. The educational impact of all this synergy is resonant with experiential learning models, a) simplifying complex seismic concepts, b) improving student engagement, c) enhancing social awareness and appreciation of built heritage, and c) developing transversal cognitive and metacognitive skills such as design thinking, problem solving, ethics etc. [7,8].

This work introduces the experiential learning theory (Kolb) with real architectural challenges, offering new avenues for STEM education in cultural heritage environments while respecting historical authenticity. Thus, practical learning models can be integrated into curricula of primary and secondary schools, as well as academic schools such as civil engineering and architectural schools. In addition, the development of thematic units around real monuments of each place is encouraged, making the content culturally rooted and geographically connecting scientific concepts with their national or local heritage [2,6,9].

Adapts engineering principles such as the center of mass, stiffness, and failure modes into accessible formats for students from elementary school to university, using low-cost seismic simulation tools for the seismic behavior of monuments, easy access to high-level engineering knowledge, especially in resource-poor educational settings.

When combined, adaptive differentiated pedagogy and experiential learning create a powerful framework for fostering deeper understanding and engagement in the classroom. This synergy allows educators to design lessons that are not only relevant and challenging but also accessible to all students, regardless of their starting point. As a result, learners are empowered to take ownership of their education, develop essential life skills, and cultivate a lifelong love for learning.



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Adaptive Differentiated Pedagogy represents a state-of-the-art approach that proactively modifies the educational experience to meet the unique needs, strengths, and preferences of each learner. By leveraging data-driven assessments, educators can identify student readiness, interests, and learning profiles, allowing them to tailor their instructional strategies accordingly. This individualized approach fosters an inclusive and supportive learning environment where all students can thrive. Research indicates that differentiating instruction can significantly improve student achievement, engagement, and motivation.

This work is an interdisciplinary study that combines structural technology with innovative educational methodologies, uniquely approaching a field that has not been fully explored to date. The work introduces an innovative educational model that utilizes experiential learning at all levels of education to teach historical construction technology and seismic behavior of monuments, aiming to enhance students' aware-ness of the contemporary challenges of preserving historical and cultural heritage monuments.

This work's novelty lies in the experiential education implementation in the construction technology context, specialized in historical monuments and their seismic behavior, potentially introducing new methodologies, tools, or insights that advance both educational practices and technical knowledge in this field. The foundation of this approach is the students' experience with hands-on learning methods. The uniqueness of this paper can be depicted in several aspects, such as: the introduction of a New Educational Framework with an interdisciplinary approach, methodological innovation, novel tools and technologies, and learning results impact.

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SUSTAINABILITY ASSESSMENT OF MINE VENTILATION SYSTEMS: ESG RISK AND INFRASTRUCTURE RESILIENCE INSIGHTS FROM MULTI-SITE CASE STUDIES

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Keywords: Mine Ventilation, ESG Risk Management, Infrastructure Resilience, Ventilation-on-Demand (VoD), Life Cycle Sustainability Assessment (LCSA)

Underground mine ventilation systems are critical infrastructure with significant implications for energy consumption, operational safety, and environmental performance. They are among the most energy-intensive subsystems in the raw materials sector, often accounting for 30–50% of total mine electricity use, depending on configuration and operating conditions [1]. This high demand makes them key leverage points for sustainability improvements, as well as risk mitigation and resilience enhancement in mining operations. Conventional ventilation practices, typically based on static and over-dimensioned assumptions, lead to persistent inefficiencies, elevated emissions, and increased operational and economic risks.

Within this context, ventilation optimisation emerges as a technological and governance challenge, directly linked to Environmental, Social and Governance (ESG) performance. ESG frameworks interpret energy inefficiencies, safety conditions and operational inflexibility as interconnected risk factors affecting regulatory compliance, financial performance and long-term system resilience [2,3]. In this regard, adaptive, data-driven ventilation systems, particularly Ventilation-on-Demand (VoD), enable real-time monitoring, predictive control, and more efficient resource allocation, supporting a shift from static to dynamic, risk-informed decision-making [4]. Ventilation-related electricity consumption is a major contributor to indirect emissions and a key decarbonisation lever. At the same time, ventilation quality is directly linked to worker health and safety, while the ability to dynamically monitor and control ventilation reflects governance maturity in terms of operational transparency, compliance and accountability.

This study, conducted within the framework of the VOT3D project, evaluates these interdependencies through the application of the VOT3D ventilation optimisation system across three underground mining case studies: the KGHM Polkowice–Sieroszowice copper mine as the primary case study, and the Nowy Łąd anhydrite mine in Poland and the Boliden Garpenberg zinc mine in Sweden as supporting case studies. The assessment is conducted using a Life Cycle Sustainability Assessment (LCSA) framework, integrating environmental (LCA), economic (LCC) and social (S-LCA) dimensions to compare optimised

ventilation with conventional continuous operation. To our knowledge, this study is one of the first integrated life cycle sustainability assessments specifically focused on mining ventilation systems.

The KGHM case study provides the most detailed and fully quantified analysis. The results show that ventilation electricity consumption is the dominant contributor to environmental impacts across all categories, significantly exceeding the impact of the digital infrastructure required for optimisation. Even under conservative assumptions of a 1.5% reduction in ventilation energy demand, the scale of operations results in substantial savings in greenhouse gas emissions, fossil resource use, and operational costs. Annual reductions are estimated at approximately 845,000 to over 3.1 million kg CO₂-equivalent emissions, and 270,000 to nearly 1 million kg oil-equivalent in fossil resource use. These benefits are accompanied by measurable cost savings and short payback periods, confirming the economic viability of the optimisation approach. The findings further indicate that benefits scale with baseline energy demand, highlighting the importance of ventilation optimisation in large-scale mining systems. In parallel, the social assessment identifies improvements in occupational health and safety through reduced worker exposure and improved air quality. Beyond this, digitalisation supports social inclusion by enabling remote monitoring and reducing the need for physical presence in hazardous environments. This is particularly relevant in crisis scenarios, such as pandemics, workforce shortages, or extreme weather events, where maintaining safe operations with reduced on-site personnel is critical.

The Boliden Garpenberg and Nowy Łód case studies provide complementary validation under different mining contexts and operational conditions. While these cases are characterised by lower data resolution and more limited quantification, they consistently confirm the same systemic pattern observed at KGHM. Ventilation energy consumption remains the dominant driver of environmental and economic impacts, and optimisation leads to reductions in energy use and associated emissions. These findings support the transferability of the approach across different mining environments and reinforce the robustness of the conclusions.

Consistently across all case studies, the results show that the environmental and economic performance of ventilation systems is primarily driven by electricity consumption, confirming ventilation as a key leverage point for sustainability improvements, while the impact of digital optimisation technologies remains negligible. From an ESG risk perspective, VOT3D contributes to transition, operational and workforce risk mitigation through emissions reduction, reduced energy dependency, and improved safety conditions. By integrating digital monitoring, predictive modelling and adaptive control, the system enables a shift from static, compliance-driven operation to dynamic, risk-informed decision-making.

Overall, the findings show that the environmental, economic and social benefits of digitalisation in mining can enhance risk management and system resilience within an ESG framework. Ventilation optimisation emerges as a high-impact intervention, transforming ventilation systems into actively managed, sustainability-driven infrastructure that supports both risk mitigation and long-term operational resilience.

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DESIGNING EDUCATOR FORMATION FOR DISRUPTION: A POST-GRADUATE CURRICULUM ARCHITECTURE AT THE INTERSECTION OF RESILIENCE, DRR, AND SUSTAINABILITY.

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Keywords: educator formation; disruption-sensitive education; curriculum architecture; disaster risk reduction; resilience

Educational disruption is no longer an exceptional condition around which schools can improvise. In 2024, climate-related hazards disrupted schooling for at least 242 million learners, while the education-in-emergencies agenda has placed renewed emphasis on continuity of learning, safe and inclusive environments, psychosocial support, hybrid provision, and better preparation for educators [1,2]. The Comprehensive School Safety Framework 2022–2030 also moves school safety beyond emergency drills or infrastructure protection alone. It frames safety through an all-hazards, all-risks and whole-of-society approach, connecting policy, educational continuity, well-being, infrastructure, participation, and risk reduction [3]. For higher education, this creates a demanding curriculum question. Educator preparation is still too often organised through separate disciplinary or professional compartments, while contemporary disruption asks future educators to work across pedagogy, risk literacy, sustainability, inclusion, justice, and implementation.

Recent work on disaster risk reduction education points in the same direction. Teacher preparation in DRR remains unevenly institutionalised; environmental and disaster education are not always embedded in teacher education as coherent and mandatory fields; and universities continue to face difficulties in linking conceptual learning with operational competence, interdisciplinary work, and credible certification [4]. The issue, then, is not simply that teacher education needs more topics. It is that fragmented exposure does not, by itself, prepare educators to make situated decisions in uncertain, emotionally charged, ethically sensitive, and politically unequal educational environments.

This paper presents the PATH environmental and Disaster Education strand of the MSc “**Resilience, Risk, Crisis, Emergency Management, and Homeland Security**” as a curriculum-design response to this problem. It is a conceptual and framework-oriented paper, not an impact evaluation. Its guiding question is straightforward: what kind of postgraduate curriculum architecture can prepare educators not only to teach about disruption, but also to teach under disruption? The paper argues that such preparation requires more than an interdisciplinary list of modules. It requires a sequenced formation pathway, grounded in educational theory and in the field-specific demands of disaster risk reduction, sustainability, and crisis-sensitive pedagogy.

The proposed architecture draws on four main principles. Constructive alignment is used to connect

intended outcomes, learning activities, assessment, and evidence, so that themes such as climate risk, preparedness, injustice, and trauma do not remain at the level of general awareness. Transformative learning is equally important, because educators working in disrupted contexts must often confront disorienting realities, revise assumptions, engage in critical reflection, and translate new meanings into responsible action [5]. A critical and justice-oriented pedagogical stance is also necessary, since disaster exposure, vulnerability, environmental harm, and educational loss are not distributed evenly; they are shaped by infrastructure, language, recognition, participation, and power. Finally, the model draws on disaster-education frameworks that increasingly support whole-school, intersectoral, inclusive, and participation-centred approaches rather than narrow, drill-based understandings of preparedness [3,4].

On this basis, the Path“Environmental and Disaster Education” is organised as a professional formation architecture rather than a thematic catalogue. It moves students through five connected curricular functions. First, it establishes a pedagogical stance for crisis-aware, inclusive, and psychologically safer educational practice. Second, it translates that stance into curriculum design through aligned outcomes, tools, learning tasks, and assessment. Third, it develops literacies in disaster risk reduction, sustainability, and environmental change at school, community, and intersectoral levels. Fourth, it treats policy, power, equity, leadership, and justice as curriculum questions, not as external background. Fifth, it culminates in a Living Lab practicum in which students design, justify, pilot, and evaluate a bounded intervention in a real educational context.

The contribution of PATH Environmental and Disaster Education is not simply that it brings together pedagogy, DRR, sustainability, crisis management, and justice. Its value lies in how these fields are organised into a curriculum sequence: from stance, to design, to literacy, to policy interpretation, and finally to intervention in a real educational setting. This sequence matters because educators are not only asked to know about disruption. Increasingly, they are asked to make defensible decisions while disruption is unfolding.

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A POSITIVE PSYCHOLOGY INTERVENTION FOR BUILDING WORKFORCE RESILIENCE and wellbeing IN GREEK HEALTHCARE AND EDUCATION SYSTEMS

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Keywords: resilience, positive psychology interventions, nursing professionals, workforce wellbeing, crisis preparedness

This study investigates the necessity of implementing preventive and resilience-enhancing initiatives for frontline practitioners, particularly nurses in hospital and school settings. Workforce resilience emerges as a critical component of national readiness for crises and occupies a central position within contemporary frameworks of health security governance. In the context of public health emergencies, both healthcare and educational systems are among the earliest to be mobilized, providing essential services to at-risk populations, such as critically ill patients and children in educational environments. However, a critical gap is evident in literature. Empirical evidence from a study involving 380 Greek hospital nurses, assessed fourteen months after the pandemic's onset, revealed that 46.8% displayed symptoms of professional burnout, 56.1% reported insomnia, and 26.3% scored low on resilience measures[1]. Conversely, a cross-sectional analysis of 677 female nurses in Greece demonstrated that psychological resilience serves as a key protective mechanism against anxiety and depression during the post-pandemic phase. Notably, individuals exhibiting higher resilience levels display enhanced job commitment, superior performance under stress, and markedly reduced turnover rates [2]. These attributes are pivotal in sustaining operational effectiveness in both public health and education sectors during crises. Resilience thus functions as a catalytic factor, amplifying positive outcomes across institutional systems and their service populations. Consequently, strategic investment in workforce resilience is important, as resilient personnel contribute fundamentally to the formation of resilient organizations capable of meeting societal demands effectively.

This study outlines the theoretical underpinnings of an ongoing, structured intervention study comprising six sessions conducted between 2025 and 2026, grounded in the PERMA model of positive psychology [3]. Empirical evidence indicates that positive psychology interventions (PPIs) derived from this framework have proven efficacious in mitigating occupational burnout and fostering resilience among healthcare providers [4, 5]. The intervention integrates empirically supported practices drawn from scholarly research, including gratitude exercises, identification and application of character strengths, meaning-making strategies, and evidence-based stress regulation techniques. The study targets two professional cohorts central to crisis response: nurses employed in public hospitals within the National Health System (ESY) and school nurses operating in the public education sector. These groups are responsible for serving high-risk populations and have been increasingly burdened with managing overlapping emergencies, such as the SARS-CoV-2 pandemic, climate-related environmental crises, and the migration emergency. The convergence of these events contributes to elevated

occupational risk profiles, potentially compromising both individual well-being and systemic support capacity. Drawing on existing literature, the intervention is anticipated to enhance psychological resilience, subjective well-being, and work engagement among participants, factors that may influence long-term workforce sustainability and institutional preparedness for future crises. To assess efficacy, standardized psychometric instruments are administered at three time points: pre-intervention, immediately post-intervention, and at a three-month follow-up.

Conducting such an intervention in Greece has become urgent and strategically necessary. This ongoing research seeks to advance the integration of psychological resilience-building through targeted interventions for frontline personnel within national crisis preparedness frameworks, health security governance, as well as the formulation of policies related to crisis and emergency management. The outcomes are anticipated to enrich scholarly discourse on the efficacy of mental health prevention initiatives targeting healthcare professionals operating in high-risk environments. Furthermore, the results are expected to provide a foundational basis for the development of comprehensive, system-level interventions. Concurrently, they are expected to guide policy recommendations aimed at embedding resilience-building strategies within public institutions, positioning psychological resilience as a cornerstone of routine professional performance and long-term organizational sustainability. In conclusion, this study argues that the psychological readiness and resilience of professionals in healthcare and education sectors constitute essential prerequisites for broader national and societal resilience.

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FROM GLOBAL FRAMEWORKS TO SCHOOL PRACTICE: POLICY TRANSLATION IN CRISIS, DRR, AND RESILIENCE EDUCATION

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Keywords: policy translation, policy enactment, global-local mediation, school routines, resilience education

Global frameworks on crisis, disaster risk reduction (DRR), and resilience increasingly expect education systems to protect learning when disruption becomes unavoidable. The Comprehensive School Safety Framework 2022–2030 links protection, educational continuity, risk reduction, resilience building, and sustainable development through an all-hazards and all-risks approach [1]. UNESCO's work on education in emergencies similarly emphasises safe and inclusive environments, continuity of learning, psychosocial support, hybrid provision, teacher development, and stronger preparedness and response capacities at system level [2]. These frameworks are valuable because they give education a clearer place within wider risk, crisis, and resilience agendas. Their weakness, however, appears when their language is assumed to move smoothly from international policy documents into schools. Formal recognition does not mean that such agendas become part of curriculum, routines, professional roles, or classroom decisions.

Crisis-, DRR-, and resilience-oriented education is therefore better understood not as the simple adoption of global policy language, but as a process of translation across institutions, actors, and practices. The issue is not only whether education systems endorse international agendas. It is how those agendas are interpreted, selected, mediated, reshaped, and made educationally meaningful. Research on policy enactment has shown that schools are not passive implementation sites. Policy is read and reworked through local histories, institutional cultures, leadership patterns, staffing realities, material constraints, community expectations, and professional judgement [3]. Studies of policy translation reach a similar conclusion from a global-local perspective: frameworks do not travel intact from one level to another; they are transformed as they encounter specific social, political, and educational conditions [4]. OECD work on policy implementation also supports this view, presenting implementation as a multidirectional change process shaped by design, context, stakeholder engagement, and strategy rather than as a linear delivery mechanism [5].

The paper develops this argument through the Environmental and Disaster Education strand of the MSc “Resilience, Risk, Crisis, Emergency Management, and Homeland Security,” designed within a Greek-Canadian postgraduate development initiative, used here not as a descriptive programme case, but as a conceptual lens for examining what should happen when broad frameworks on crisis, DRR, and resilience are expected to acquire practical meaning in schools. The concern is not only administrative implementation, but the educational work of making policy usable, teachable, situated, and durable. Several translation moves are involved. Schools and educators must first decide which parts of a global

framework matter most in their setting, since not all risks, responsibilities, or policy emphases can be taken up with equal force. These choices are then mediated through local hazards, institutional capacity, community conditions, social inequalities, available infrastructures, and professional cultures. Translation also requires curricular conversion: policy language has to become learning outcomes, teaching sequences, classroom tasks, materials, and assessment practices that make pedagogical sense. It must also become organisationally visible, entering school routines, staff roles, communication protocols, continuity planning, and whole-school practices. Finally, translation is tested in enactment. Teachers and schools adapt policy through everyday practice, and in doing so they reveal both its practical value and its limits.

This perspective is especially important in DRR education, where the gap between global ambition and local enactment remains persistent. Recent research reports increasing policy attention and curriculum integration, but also continuing weaknesses: limited subject integration, insufficient use of indigenous and local knowledge, and weak alignment with emerging pedagogies [6]. What appears coherent at the level of international frameworks may therefore become partial, symbolic, or uneven at school level. The relevant question is not whether schools formally “have” DRR or resilience policies. It is whether these policies become educationally operational, institutionally durable, and locally credible.

The contribution of the paper is twofold. First, it reframes crisis, DRR, and resilience education as a process of translation rather than straightforward implementation. Second, it argues that educator formation must prepare future professionals to act as policy mediators. Educators need to interpret global frameworks critically, connect them to local realities, convert them into curriculum and routine, and recognise when translation becomes superficial, selective, or ineffective. The paper therefore shifts attention from abstract policy alignment to the practical and ethical work through which global agendas become meaningful forms of school life.

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PSYCHOLOGICAL DISTRESS, RESILIENCE, AND WORK ENGAGEMENT IN FRONTLINE NURSING PROFESSIONALS: A MEDIATION ANALYSIS

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Keywords: psychological resilience, work engagement, psychological distress, mediation analysis, frontline healthcare workers

Nursing professionals function under a constant amount of pressure. Beyond the typical amount of pressure that nurses experience due to their roles in caring for patients and vulnerable populations within care systems, nurses within the public health and education systems have experienced additional pressure placed upon them due to the crises faced by those systems, whether related to public health, the spread of COVID-19, the climate crisis, economic conditions, or even migration movements. These various types of crises have contributed to the strain upon the nursing profession throughout Europe. The WHO/Europe Mental Health of Nurses and Doctors (MeND) survey of 2025 of over 90,000 nurses and doctors in Europe revealed that one in three suffers from symptoms of depression and anxiety, and that they are five times more likely to develop depression compared to the general public [1]. Therefore, understanding how the mental health of these professionals impacts their ability to function within the health care industry is important for institutional resilience and crisis response capacity.

The present study draws on two complementary theoretical frameworks. The Conservation of Resources Theory (COR; Hobfoll, 1989) suggests that psychological distress depletes an individual's resources, such as psychological resilience which protects individual from stress negative implications [2]. Furthermore, the Job Demands-Resources model suggests that psychological resilience is one of the personal resources of an individual that impacts that individual's motivation to perform well in their job [3]. Thus, this research hypothesis is that healthcare workers' psychological distress will deplete their resilience to cope with crises and through this depletion they will be less engaged to their work. A cross-sectional study was conducted to test this hypothesis in 1,998 frontline nurses both within Greek public hospitals and public schools. Three well-established and validated psychological questionnaires were administered to each participant; the Depression Anxiety Stress Scales - Short Form (DASS-21), the Connor-Davidson Resilience Scale (CD-RISC-10), and the Utrecht Work Engagement Scale (UWES-15) [4]. An analysis of the mediator model used the PROCESS macro (Model 4) for mediation analysis with bootstrapped confidence intervals with 5,000 resamples.

Results confirmed a significant partial mediation model ($p < .001$). Psychological distress exerted a significant negative direct effect on work engagement ($p < .001$), and a significant negative indirect effect through resilience (95% Boot CI [-.26, -.16]). The path from distress to resilience was significant ($p < .001$), as was the path from resilience to engagement ($p < .001$). The mediation pattern remained substantively equivalent across both professional subgroups, indicating that the resilience pathway

operates as a consistent mechanism across distinct frontline public service contexts rather than being specific to a single institutional setting.

These findings suggest that psychological distress reduces employees' engagement with their work because it undermines their sense of psychological resilience to cope effectively with the crises they face. As a result, these findings have significant implications for organizational support policies in the context of preparedness for potential future crises. Specifically, our findings indicate that interventions aimed at strengthening employees' mental health and work engagement in critical sectors such as public healthcare and education systems must directly aim to strengthen employees' psychological resilience. In conclusion, the results of this study highlight psychological resilience of frontline healthcare workers as a fundamental prerequisite for the robust and sustainable institutions as they are being proposed by Sustainable Development Goals 3, 8, and 16 of the 2030 Agenda for Sustainable Development [5].

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FROM POSTGRADUATE LEARNING TO EDUCATIONAL INTERVENTION: THE LIVING LAB PRACTICUM AS AN IMPLEMENTATION BRIDGE

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Keywords: living lab practicum, implementation bridge, theory of change, feasibility, reflexive intervention design

Practicum-based learning is widely treated as a defining element of professional education, its value, however, depends less on the simple presence of field activity than on the kind of professional judgement the practicum is designed to cultivate. In teacher education, field experiences are often valued because they connect coursework with practice, but this connection is not automatic and field placement alone does not guarantee reflective, ethically grounded, or context-responsive learning [1]. This limitation becomes even sharper in fields shaped by disruption, disaster risk reduction (DRR), and resilience, where educational action rarely unfolds under stable or ideal conditions. It is shaped by uncertainty, institutional constraint, uneven vulnerability, limited evidence, and the practical limits of what schools and communities can sustain. The question that emerges is therefore not only how students apply prior knowledge, but how they learn to design, justify, adapt, and evaluate educational interventions that are feasible, ethically defensible, and responsive to real settings.

This paper examines that question through the Living Lab Practicum within the Path of Environmental and Disaster Education strand of the MSc “Resilience, Risk, Crisis, Emergency Management, and Homeland Security,” designed within a Greek-Canadian postgraduate development initiative. The practicum is not understood as generic field exposure. On the contrary, it is framed as an implementation bridge between postgraduate learning and bounded educational intervention purposed to move students from conceptual understanding to situated professional judgement. Students are expected to define a real but manageable educational problem, justify the scale of their response, identify relevant actors, anticipate ethical and practical risks, and clarify what their intervention can and cannot reasonably demonstrate.

The Living Lab dimension matters because it places educational intervention in environments shaped by stakeholders, institutional routines, community expectations, and local constraints. Living Lab approaches in education emphasise authentic learning, collaboration with external actors, and engagement with real-world problems rather than purely simulated exercises [2]. This logic is used to prevent postgraduate learning from remaining at the level of policy awareness, theoretical familiarity, or general commitment to resilience as students must test the credibility of their ideas through a structured process of intervention design.

The MSc’s practicum is organised around a demanding but deliberately bounded sequence: scoping and feasibility, ethics and risk scanning, theory-of-change formulation, stakeholder mapping, intervention

design, piloting, debriefing, modest but credible evaluation, revision, sustainability thinking, and integrity reporting. These elements do not stand as a checklist for producing neat solutions. They are a way of slowing down action, asking students to examine assumptions, identify constraints, avoid exaggerated claims, and consider how participation, context, mechanisms, and unintended effects shape what an intervention can actually do.

This framing draws on design-based implementation research, which calls for closer connections between research, practice, intervention design, and situated improvement [3]. It also resonates with complex-intervention guidance, where context, uncertainty, feasibility, stakeholder perspectives, adaptation, and evaluation are treated as integral to intervention development rather than as secondary concerns [4]. Theory-of-change work in teacher education is relevant for the same reason that it requires programme designers and students to make explicit the assumptions, pathways, and mechanisms through which educational change is expected to occur [5]. Together, these perspectives support a view of the practicum not as a practical appendix to coursework, but more as a disciplined setting where professional action is designed, tested, questioned, and revised.

The Living Lab Practicum is therefore best understood as the point where analysis, design, action, and accountability meet. It does not treat implementation as the final application of prior learning, but rather as a formative process through which students learn to act within limits, justify design choices, revise assumptions, and distinguish credible educational contribution from unsupported claims of impact. This distinction stands especially important in crisis-, DRR-, and resilience-oriented education, where there is pressure to demonstrate relevance, but where interventions are necessarily partial, situated, and ethically sensitive. The practicum then becomes a test of postgraduate seriousness: students must show not only what they can do, but also what they cannot responsibly claim. In this sense, the Living Lab Practicum offers a transferable model for preparing educators to intervene carefully, reflexively, and with public responsibility in disrupted educational worlds.

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SIMULATION OF THE EFFECTS OF CHEMICAL SUBSTANCES FROM INDUSTRIAL ACCIDENTS AND TERRORIST ATTACKS ON COASTAL ECOSYSTEMS THROUGH COMPUTATIONAL APPROACHES

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Keywords: System dynamics, coastal ecosystems, nerve agents, nonlinear modeling, environmental fate

Coastal ecosystems are among the most sensitive environmental systems, due to their dynamic nature and the complex interactions between physical, chemical, and biological processes. These environments are particularly vulnerable to contamination events originating from industrial accidents as well as intentional chemical releases. Among hazardous substances, nerve agents, such as V-agents and A-agents (Novichok-type compounds), represent a class of highly toxic organophosphorus compounds that can pose significant risks to both ecosystems and human health.

Understanding the environmental fate and transport of such compounds is essential for risk assessment, emergency response planning, and environmental protection. However, the behavior of toxic substances in coastal environments is difficult to predict due to the influence of hydrodynamic variability, physicochemical transformations, and ecological interactions. Traditional modeling approaches often fail to fully capture the complexity of these systems, particularly when nonlinear processes and feedback mechanisms are involved.

In this study, a system dynamics modeling approach is employed to simulate the fate and transport of toxic compounds in coastal ecosystems. The model is implemented using the software “Stella” and is conceptually based on previous work by S. Gamito, which demonstrated the applicability of system dynamics in representing environmental processes in coastal zones. The modeling framework incorporates key processes such as advection, dispersion, degradation, and partitioning between environmental compartments, including water, sediment, and biota.

A key feature of the proposed model is the integration of nonlinear system behavior, specifically through the introduction of anharmonic oscillatory dynamics. Unlike simple linear or exponential decay models, anharmonic oscillations allow for the representation of more complex temporal patterns, including asymmetric fluctuations, delayed responses, and feedback-driven variability. These characteristics are particularly relevant in coastal systems, where external forcing (e.g., tides, currents) and internal interactions (e.g., biogeochemical processes) can lead to non-equilibrium conditions.

The inclusion of nonlinear dynamics enables the model to better capture the interplay between pollutant transport and environmental response. For example, feedback mechanisms between pollutant concentration and degradation rates, or between contamination and ecological processes,

may lead to oscillatory or unstable system behavior. By incorporating such effects, the model aims to provide a more realistic representation of pollutant persistence and spatial-temporal variability.

The proposed framework is designed to support the analysis of different contamination scenarios, including accidental releases and deliberate chemical incidents. Although the model is primarily conceptual at this stage, it provides qualitative and semi-quantitative insights into the factors controlling pollutant fate in coastal environments. Expected outcomes include the identification of critical parameters affecting system stability, pollutant attenuation, and potential ecological impact.

Overall, this work contributes to the development of flexible and scalable modeling tools for environmental risk assessment. By integrating system dynamics with nonlinear modeling approaches, the study provides a foundation for improved understanding of complex environmental systems and supports decision-making in the context of coastal pollution events.

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VALORIZATION OF OLIVE MILL BY-PRODUCTS FOR EXTRACTS RICH IN AMPHIPHILIC BIOACTIVES WITH ANTI-INFLAMMATORY AND ANTIOXIDANT HEALTH PROMOTING PROPERTIES, IN A SUSTAINABLE AND CIRCULAR ECONOMY DESIGN

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Keywords: olive mill by-products, amphiphilic bioactives, phenolic, antioxidant, anti-inflammatory

The increasing frequency of global crises, including public health emergencies and environmental challenges, places significant pressure on healthcare systems and highlights the need for sustainable strategies that enhance population resilience. Within this context, the identification and utilization of bioactive-rich natural resources that support disease prevention represent a critical component of risk mitigation and resilience planning. Olive oil production generates substantial quantities of by-products, including olive mill wastewater, olive leaves, and olive pomace, which are increasingly recognized as environmental hazards on the one hand, while on the other as underutilized yet valuable sources of bioactive compounds [1].

In the present study, environmentally friendly extraction methodologies were employed to isolate total amphiphilic compounds (TAC) from these matrices, aiming to evaluate their composition and biological potential within a sustainability-and circular economy-oriented framework [2]. The extracts were characterized in terms of total phenolic content (TPC) and total carotenoid content (TCC), while their antioxidant capacity was assessed using ABTS, DPPH, and ferric reducing antioxidant power (FRAP) assays. Structural characterization was conducted using attenuated total reflectance Fourier-transform infrared spectroscopy (ATR–FTIR) and liquid chromatography–mass spectrometry (LC–MS), providing insight into the molecular diversity of the extracted compounds. ATR–FTIR analysis indicated the co-existence of multiple classes of amphiphilic bioactives, including phenolic compounds, carotenoids, and polar lipids with long-chain fatty acids. LC–MS further revealed the presence of complex lipid species, such as glycerophospholipids and glyceroglycolipids, along with characteristic fatty acid profiles that are known to influence biological activity. Among the studied matrices, olive pomace exhibited the highest phenolic content and antioxidant activity, followed by olive mill wastewater, whereas olive leaves showed comparatively lower values under the applied extraction conditions. The biological relevance

of these findings was further explored through the evaluation of anti-inflammatory and antiplatelet activities in human platelet-rich plasma. Specifically, the inhibitory effects of the extracts on platelet aggregation induced by platelet-activating factor (PAF), a key inflammatory mediator, and adenosine diphosphate (ADP), a classic platelet agonist, were assessed. Extracts derived from olive pomace and olive mill wastewater demonstrated stronger inhibitory activity against platelet aggregation compared to those obtained from olive leaves, indicating a higher potential for modulating inflammation-related pathways and thrombotic processes.

From a public health perspective, the observed antioxidant, anti-inflammatory, and antithrombotic properties of these extracts are particularly relevant, as chronic inflammatory and cardiovascular conditions constitute major risk factors that exacerbate vulnerability during health crises [3]. The development of functional ingredients derived from agro-industrial by-products may therefore contribute to preventive health strategies, reducing the long-term burden on healthcare systems and enhancing societal resilience, in a low cost and environmental friendly way. The application of green extraction technologies supports the valorization of olive mill by-products within circular economy and frameworks, transforming waste streams into high-value resources. This approach aligns with broader policy objectives related to sustainability, environmental protection, and resource efficiency, while also offering opportunities for innovation in the food, nutraceutical, cosmetic, and pharmaceutical sectors. Overall, this study highlights the dual role of olive mill by-products as both a sustainable source of bioactive compounds and a strategic asset in the development of resilience-oriented public health interventions, bridging the gap between technological innovation, environmental sustainability, and risk-informed policy planning.

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PREVENTIVE PLANNING, PREPAREDNESS & EFFECTIVE RESPONSE TO EMERGENCIES THROUGH ADVANCED TECHNOLOGIES

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Keywords: Civil Protection, Disaster Management, Situational Awareness, Emergency Response, Advanced Technologies

The severe climate change and man-made threats are fundamentally altering the global disaster landscape. As extreme weather events grow in frequency, intensity, and duration, the catastrophic potential of natural disasters has surpassed the capabilities of traditional emergency management. To address these evolving challenges, there is an urgent necessity to expand technological boundaries, ensuring that both authorities and citizens are better prepared and protected. The use of Advanced Technologies into a unified framework of prevention, preparedness, and effective, intelligent field response, have become a necessity.

Proactive disaster management begins with proactive planning and reinforcement of vulnerable locations through permanent, pre-existing infrastructures. A central component of this prevention strategy is the deployment of smart - autonomous - multipurpose cylinder solar poles. These durable versatile units serve as foundational nodes, providing essential outdoor lighting and surveillance of critical areas via cameras even in case there is power failure. Furthermore, they can function as environmental sentinels when they are equipped with sophisticated sensors for fire detection, air quality monitoring, and wind speed measurement. Integration of telecommunication equipment and digital panels on the solar poles, provides a critical mean for communication, allowing authorities to broadcast real-time warning messages and safety information directly to the public, ensuring that alerts are received precisely where they are needed most.

This physical layer is supported by a centralized digital platform that facilitates preparedness through coordinated response and guidance. This system bridges the gap between civil protection authorities, first responders, and the general public, creating a shared operational picture and a direct communication channel. By streamlining communication, this platform ensures that all stakeholders can act as unified entities, from the first sign of danger through the entire lifecycle of an incident.

When a crisis escalates to the response phase, the primary objective is accurate situational assessment. Intelligence, Surveillance, and Reconnaissance (ISR) systems utilize advanced embedded video processing, for improved detection and classification in order to provide accurate real-time data to decision-makers. This is achieved through a multi-domain fleet comprising modular, automated, and autonomous drones, unmanned ground vehicles (UGVs), and unmanned surface vessels (USVs). This aerial and ground-based intelligence is further enhanced by mobile detection and tracking solutions

powered by big data analytics. By extracting and analyzing radio log files from cellular networks, these systems can track the geolocation of users in real-time, offering a powerful, nation-wide solution to authorities for managing mass casualty incidents and monitoring traffic loads during mass evacuations.

The physical response within a disaster zone prioritizes the safety of first responders and civilians by minimizing direct human exposure to hazardous conditions. Unmanned ground vehicles are crucial in this task as they are able to handle high-risk operations such as fire suppression and chemical, biological, radiological, and nuclear (CBRN) decontamination. The use of Unmanned solutions and advanced drones detection & mitigation systems designed to neutralize unauthorized drone activity, create secure environments where personnel can operate. During mass evacuations, these efforts are supported by high-output, long-distance voice and sound warning systems, which guide civilians effectively to safe paths & areas.

Search and rescue operations are becoming more effective by engaging special equipped and amphibious all-terrain, all weather vehicles capable to operate in challenging landscapes and detect people in the areas of disaster. First responders can also carry backpacks special equipped with sensors that allow them to locate potentially trapped or injured individuals in disrupted areas. Following the rescue phase, medical continuity is established through the rapid deployment of mobile healthcare units and field hospitals.

Operational sustainability in disrupted areas is maintained through a combination of decentralized power and utility support. Mobile wind turbines and fast-deployed solar arrays with integrated energy storage, provide reliable electricity, while containerized utility modules supply essential water treatment, independent power generation, and heating capabilities. Finally, the logistical backbone is managed by a diverse fleet of automated vehicles, including medical-delivery drones for urgent supplies, heavy-lifter drones for rapid transport, and UGVs. Together, these technologies create a resilient, intelligent, and highly effective model of civil protection that is prepared to meet the demands of an increasingly demanding field of operations.



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ENVIRONMENTAL ASSESSMENT OF CLASSICAL AND SUSTAINABLE APPROACHES TO PORPHYRIN SYNTHESIS

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Keywords: Porphyrin synthesis, Green chemistry, Sustainability, Ionic liquids, Microwave-assisted

Porphyryns are highly versatile macrocyclic compounds with widespread applications in catalysis, materials science, photodynamic therapy, and energy-related technologies. Despite their broad utility, traditional synthetic routes toward porphyryns are often associated with significant environmental burdens, including the use of hazardous reagents, high energy input, and substantial solvent consumption. This work provides a comprehensive comparative environmental assessment of classical porphyrin synthesis methodologies, particularly the Adler-Longo [1] and Lindsey [2] protocols, in contrast with emerging alternative approaches such as microwave-assisted synthesis, mechanochemical methods, and the use of ionic liquids as reaction media.

Classical methods, while robust and widely adopted, typically require elevated temperatures, prolonged reaction times, and chlorinated solvents, contributing to poor sustainability profiles. In contrast, modern synthetic strategies aim to minimize environmental impact by reducing reaction times, lowering energy demands, and replacing hazardous solvents with greener alternatives. Microwave-assisted synthesis, for example, offers significant reductions in reaction time and energy consumption [3], while mechanochemical approaches enable solvent-free or solvent-minimized conditions [4]. Ionic liquids present another promising avenue, providing tunable, recyclable media with reduced volatility, though their overall environmental footprint remains under evaluation [5].

To quantitatively assess the sustainability of these methodologies, key green chemistry metrics are critically examined, including atom economy, reagent toxicity, process mass intensity (PMI), solvent selection, and overall energy requirements. Particular attention is given to the choice of aldehydes, pyrrole sources, and acid catalysts, as well as their associated hazards and environmental persistence. Solvent selection is evaluated using established green solvent guidelines, highlighting the continued reliance on problematic solvents such as dichloromethane and chloroform in conventional protocols, and the gradual shift toward more benign alternatives such as ethanol or water-based systems in newer methods.

A significant focus of this work is placed on downstream processing and purification, which are often overlooked contributors to environmental impact. Column chromatography, frequently employed in porphyrin purification, is identified as a major source of solvent waste and inefficiency. Greener work-up strategies, including recrystallization, precipitation, and solvent recovery techniques, are discussed

as viable alternatives to reduce environmental burden.

In addition to laboratory-scale considerations, the scalability and industrial feasibility of both classical and alternative methods are evaluated. While greener approaches demonstrate clear advantages in principle, challenges remain in terms of reproducibility, cost, and adaptation to large-scale production. By systematically comparing traditional and emerging synthetic routes, this work identifies current limitations and highlights opportunities for further optimization, including the integration of continuous flow systems and improved catalyst design.

Overall, this work aims to provide a critical framework for assessing porphyrin synthesis through the lens of green chemistry, supporting the development of more sustainable, efficient, and environmentally responsible practices in this important field. Future progress will depend on combining methodological innovation with standardized sustainability metrics and interdisciplinary collaboration, ensuring that advances in porphyrin chemistry align with broader environmental and industrial priorities. Furthermore, increased transparency in reporting experimental conditions and green metrics will be essential for enabling reproducibility, facilitating cross-study comparisons, and accelerating the transition toward more sustainable synthetic practices across both academic and industrial setting, whilst lowering environmental impact.

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FROM AGRICULTURAL WASTE TO CLEAN ENERGY: SUSTAINABLE SYNTHESIS OF CARBON DOTS FROM OLIVE LEAVES FOR PHOTOCATALYTIC GREEN HYDROGEN PRODUCTION

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Keywords: carbon nanodots, biomass, olive leaves, photocatalysis, green hydrogen

One of the critical challenges concerning modern Greece is the escalating frequency of extreme weather events, such as floods and windstorms (e.g., Storm Daniel), exacerbated by climate crisis[1]. The prevalence of these phenomena has resulted in the accumulation of vast quantities of «dead» biomass, specifically uprooted trees, which typically remain unutilized or are disposed of through incineration, contributing to CO₂ emissions. Addressing this environmental issue, we adopted a ‘waste-to-wealth’ approach by utilizing olive tree leaves as a sustainable precursor for the synthesis of advanced carbon nanomaterials. Specifically, Carbon Nanodots (CDs) were developed, garnering significant scientific attention due to their nanoscale dimensions and the resulting unique physicochemical and optical properties.

The selection of this specific precursor is primarily justified by the abundance of olive trees within the Greek ecosystem, ensuring a steady and sustainable supply of biomass. Furthermore, despite being a rich source of polyphenolic compounds, olive-derived biomass remains relatively under-explored in nanomaterial synthesis research. These polyphenols play a crucial role in surface functionalization, as they provide a plethora of oxygen-containing groups on the surface of the resulting CDs, significantly enhancing their physicochemical and optical properties[2]. Water was used exclusively as a solvent in pyrolytic method, while in the hydrothermal method, materials with the addition of a minimal amount of ethylenediamine (N-Doped Olive Dots) were studied to enhance and compare their properties with the same materials without a nitrogen source. In the first case, the physicochemical and optical properties of the so-called “Olive Dots” were studied in three graded pyrolytic temperature ranges (260-280°C, 280-300°C, 300-320°C) followed by FT-IR, XRD, UV-Vis, Fluorescence, and SEM characterization techniques. Optimal product performance was showed at a temperature of 260-280°C, while exhibiting at the same time oxygen-rich surface groups, ultraviolet absorption due to the sp² carbon atom core states, as well as emission dependent on the excitation length, shifted to blue wavelengths [3,4]. The core of the materials is amorphous with small areas of graphitization, and the surface exhibits agglomerates with a wide dispersion in CDs sizes.

The hydrothermal N-doped Olive Dots, on the other hand, showed additional surface nitrogen groups and a new peak in the UV due to the addition of ethylenediamine, as well as more intense emission in the blue wavelength range. Finally, the possibility of photocatalytic water splitting for green hydrogen production was examined using a molecular cobalt catalyst specifically a tetraaza-macrocyclic cobalt derivative $[\text{Co}^{3+}(\text{CR})\text{Cl}_2]^+$ and a sacrificial donor mixture of TCEP/ascorbic acid with gas chromatography-mass spectrometry. Specifically, Olive Dot_{260°-280°C} were used as photosensitizers, where they produced a negligible amount of hydrogen but demonstrated the existence of a photodegradation-stable photocatalytic system with satisfactory interaction of its components[5]. Based on the aforementioned results, this study demonstrates the successful synthesis of innovative, green, and sustainable materials characterized by a pivotal dual role. On one hand, they offer a nature-based solution by reclaiming waste generated from environmental disasters and on the other, they facilitate the production of green energy with a net-zero environmental footprint. This approach introduces the potential for energy autonomy in disaster-stricken regions, turning the remnants of a crisis into the fuel for a sustainable future.

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EVALUATION OF NSAID ADSORPTION ONTO MONTMORILLONITE/GRAPHENE OXIDE IN MONO AND BINARY AQUEOUS SOLUTIONS AND ENVIRONMENTAL WASTEWATER SAMPLES

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Keywords: chitosan, graphene oxide, montmorillonite, vanillin, adsorption

Nonsteroidal anti-inflammatory drugs (NSAIDs), including diclofenac (DCF) and ketoprofen (KTP), have emerged as important environmental pollutants in wastewater[1]. Due to their high chemical stability, these compounds are not effectively degraded by conventional wastewater treatment systems, leading to their accumulation in aquatic ecosystems. This persistence can disrupt biodiversity and negatively affect the reproductive behavior of aquatic organisms. Even at trace levels, the presence of NSAIDs in rivers, lakes and groundwater poses potential risks to both human health and the ecological balance. Consequently, the development of effective and sustainable strategies for the removal of pharmaceutical residues from wastewater has become an urgent priority.

In recent years, a variety of treatment approaches, such as advanced oxidation process (APOs), adsorption, chemical precipitation, flocculation and flotation, have been extensively investigated for the removal of pharmaceutical contaminants. However, identifying methods that simultaneously combine high efficiency, stability and economic feasibility remains a challenge. Among these approaches, adsorption has gained significant attention due to its simplicity, cost-effectiveness and environmental compatibility[2]. In particular, the development of innovative adsorbent materials, including natural, semi-synthetic and synthetic polymers, nanomaterials and biocarbons, offers remarkable advantages such as high adsorption capacity, flexibility, low cost and reusability.

Chitosan (CS) is a biodegradable, environmentally friendly and economically attractive polymer, widely recognized for its remarkable adsorption capacity[3]. This property is mainly attributed to the presence of amino ($-NH_2$) and hydroxyl ($-OH$) functional groups, which play a crucial role in the adsorption mechanisms through hydrogen bonding, electrostatic interactions and complexation processes. Despite these advantages, the practical application of CS is limited by its low mechanical strength, low stability under extreme pH conditions and reduced reusability. To overcome these disadvantages, CS is often chemically modified or combined with complementary materials to enhance its structural integrity and functional performance.

Montmorillonite (MT) is a natural layered silicate mineral belonging to the smectite group, known for its high cation exchange capacity, large specific surface area and excellent adsorption properties[4]. Its unique 2:1 layer allows the intercalation of organic and inorganic species, making it particularly suitable

for environmental applications. Compared with other clay minerals, MT exhibits superior swelling behavior, improved surface reactivity and improved structural stability, which significantly increases its ability to adsorb a wide range of contaminants, including heavy metals, dyes and pharmaceuticals.

To improve the mechanical and chemical performance of CS-based systems, blending with poly (vinyl alcohol) (PVA), a highly biocompatible and hydrophilic polymer has been widely proposed. Furthermore, vanillin 9Van) can act as a green crosslinking agent, where its aldehyde groups react with the amino groups of CS to form Schiff base bonds, resulting in a more stable and crosslinked polymer network. Moreover, the incorporation of graphene oxide (GO) enhances the adsorption performance due to its high surface area and oxygen-containing functional groups, which facilitate hydrogen, electrostatic attractions and π - π^* interactions with pharmaceutical molecules[5]. These modifications collectively improve the mechanical stability, adsorption efficiency and reusability of the material.

Recent studies have demonstrated the effectiveness of CS-based composites in the removal of pharmaceutical contaminants. Based on these findings, this study introduces three new composites, PVA/CS/MT (PCM), PVA/CS/MT/Van (PCMV) and PVA/CS/MT/Van/GO (PCMVG), as advanced multifunctional adsorbents. These systems integrate the mechanical stability and hydrophilicity of PVA with the synergistic adsorption properties of MT, GO and Van, offering a promising solution for wastewater treatment applications. The above composites were tested in batch experiments to determine the optimal pH conditions and contact time. Finally, the optimal adsorbent was tested in both binary system and simulation real wastewater, providing information on its effectiveness under realistic environmental conditions.

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ECONOMIC EVALUATION OF LABORATORY RISK REDUCTION THROUGH SEM SAFETY TRAINING

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Keywords: Physicochemical characterization, Cost–benefit analysis, Accident cost, Monte Carlo simulation, Risk analysis

Introduction: The expansion of academic research institutions has increased the number of laboratories operating advanced physicochemical characterization equipment, often in environments where hazardous chemicals, radiation sources, high voltages, and complex utilities coexist. Among these instruments, Scanning Electron Microscopes (SEM) are widely used for nanoscale imaging and compositional analysis. Although essential for materials science and nanotechnology, SEM systems also present occupational risks, including electrical hazards, X-ray leakage, slips and falls caused by auxiliary cooling systems, and costly equipment damage. Despite the recognized technical importance of such equipment, the economic value of preventive safety investments in academic laboratories remains underexplored. This study evaluates whether structured safety training for SEM users can be economically justified through avoided accident costs over the operational lifetime of the equipment.

Novelty: The novelty of this work lies in applying an integrated risk–economic framework to an academic nanocharacterization laboratory, combining Event Tree Analysis (ETA), Cost–Benefit Analysis (CBA), sensitivity analysis, and Monte Carlo simulation. While laboratory safety is commonly treated as a regulatory or ethical obligation, this study quantifies it as an investment decision. To the best of the authors' knowledge, this is among the first studies to estimate the financial return of safety training for SEM-related accidents in a university research setting, using both deterministic and probabilistic indicators.

Materials and Methods: The case study was conducted at the Hephaestus Laboratory of the International Hellenic University (Greece), an advanced materials research laboratory equipped with SEM instrumentation. The examined accident scenario involved failure of the SEM chiller system, leading to water leakage, employee slipping, and leg injury. The methodological framework consisted of four stages: **Event Tree Analysis (ETA):** Possible accident sequences were modeled beginning with the initiating event (chiller leak), followed by success/failure of barriers such as maintenance, housekeeping response, user awareness, and safety training. **Cost Identification:** Direct and indirect accident costs were collected from laboratory annual reports and historical records. Categories included: medical treatment and first aid, equipment/property damage and clean-up, insurance reporting and premiums, administrative and legal expenses, staff replacement and lost productivity, retraining and maintenance costs. **Cost–Benefit Analysis (CBA):** Two scenarios were compared over a 20-year SEM service life at

a 3% discount rate: **Scenario I:** mandatory safety training for users. **Scenario II:** no additional training. **Risk and Uncertainty Analysis:** Sensitivity analysis identified variables with the greatest influence on Net Present Value (NPV). Monte Carlo simulation (10,000 iterations) was used to estimate probabilistic NPV ranges. Based on literature evidence, training effectiveness in reducing accident rates was assumed at approximately 50%, while the probability of successful training implementation was set at 89%.

Results and Discussion: The deterministic CBA demonstrated that the benefits of safety training exceed its costs. Over the 20-year evaluation period: Total cost of trained scenario: **€72,490**, Total cost without training: **€144,980**, Estimated avoided losses after accounting for training success probability: **€64,516**. Since avoided accident costs were higher than the required investment, training was economically favorable. The baseline investment generated a **positive NPV of €266,422.04**, with an Internal Rate of Return (IRR) of **567.21%**, indicating a highly profitable prevention measure. Sensitivity analysis showed that the most influential variables were: insurance-related benefits, and damage repair costs. Together, these explained nearly half of the NPV variance, meaning that laboratories with expensive equipment or high insurance exposure gain the greatest benefit from preventive measures. Probabilistic analysis confirmed the robustness of the investment. The expected NPV was **€269,770.31**, with a standard deviation of **€55,709.03**. Monte Carlo simulation indicated that the NPV would remain positive with 90% probability within a range of approximately **€268,931 to €320,564**. This demonstrates low financial downside risk and strong resilience to uncertainty. Beyond monetary gains, the results support broader institutional benefits: fewer injuries, improved compliance culture, reduced downtime, higher researcher confidence, and protection of strategic scientific assets.

Conclusion: This study demonstrates that safety training for SEM operation is a value-generating intervention that strengthens laboratory resilience while delivering significant economic returns. By integrating Event Tree Analysis (ETA), Cost–Benefit Analysis (CBA), and probabilistic risk modelling, the study demonstrates that preventive interventions can yield substantial economic returns through accident avoidance of laboratory activities.

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SULFO-FUNCTIONALIZED 3D PRINTED HIGH IMPACT POLYSTYRENE MONOLITHS AS ORGANIC MICROPOLLUTANT ADSORBENTS FOR ENVIRONMENTAL REMEDIATION APPLICATIONS

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Keywords: Additive manufacturing, post-3D printing modification, emerging contaminants

In the context of the current environmental challenges, the protection and management of water resources play a key role in supporting more resilient urban and environmental systems through sustainable approaches. Organic micropollutants, such as synthetic dyes and pharmaceuticals, are commonly present in wastewater at several concentrations and can significantly deteriorate water quality due to their low biodegradability and environmental persistence. Methylene blue (MB) is a frequently used cationic dye, and its presence in wastewater originating from various industrial activities, including the paint, pharmaceutical, textile industries. It affects both aquatic organisms and humans, as it may cause several effects such as cyanosis, increased heart rate, and diarrhea[1]. Atenolol (AT) is one of the most widely detected beta-blockers in wastewater, aiming to regulate hypertension. The high polarity of the atenolol molecule, compared to other beta-blockers, in conjunction with its strong resistance to conventional wastewater treatment processes, makes its removal challenging. Atenolol has been associated with several severe health effects, including hypotension, carcinogenicity, and endocrine disruption[2].

One of the most effective and scalable water treatment techniques is adsorption, which relies on well-designed materials that efficiently remove target molecules while also allowing material regeneration and reuse. Its cost-effectiveness, minimal secondary pollution, and ability to remove contaminants resistant to conventional treatment processes make the adsorption process ideal for water purification[3]. A group of adsorbent materials consists of polymer-based materials. Ion-exchange polymer adsorbents are polymer networks functionalized with acidic or basic groups, such as sulfonic ($-\text{SO}_3\text{H}$) and carboxylic acid ($-\text{COOH}$) moieties. These functional groups enable the selective binding of target ions through ion-exchange processes. The main mechanism governing these systems is electrostatic interaction between the charged functional groups on the sorbent and oppositely charged ions in solution. During this process, the counter-ions initially associated with the polymer surface are replaced by ions of opposite charge from the solution[4].

Three-dimensional (3D) printing is an innovative manufacturing technique that enables the layer-by-layer fabrication of a wide range of complex-shaped structured materials, including polymeric materials, such as thermoplastics and photopolymerizable resins, with low production cost and low material

waste[5]. The most common 3D printing technique is the Fused Deposition Modeling (FDM). In this technique, a thermoplastic filament is melted, extruded and selectively deposited to gradually create a 3D object with a defined structural geometry. However, only few of the existing thermoplastics possess the desired physical and chemical material properties, such as low expansion factor, high thermal and mechanical stability, and an appropriate melt rheology, that determine their 3D printability.

In this work, sulfonated 3D-printed monolithic adsorbents towards organic micropollutant removal from water are presented. Firstly, triply periodic minimal surface (TPMS) Diamond-type structures using a commercial high impact polystyrene (HIPS), which is a polybutadiene rubber-reinforced polystyrene thermoplastic, were developed by FDM. Next, post-printing sulfo-functionalization of the adsorbent's benzene rings was carried out by the immersion of the monoliths in concentrated (98%) sulfuric acid at room temperature. Finally, the monoliths were rinsed with water until complete neutralization and vacuum oven-dried.

Sulfonated HIPS' pH point of zero charge (pH_{pzc}) was determined according to the drift method. The functionalized materials, as well as their unmodified counterparts, were morphologically, structurally and chemically characterized by Scanning Electron Microscopy (SEM) and Attenuated Total Reflection–Fourier Transform Infrared Spectroscopy (ATR-FTIR), while their wettability was determined by Contact Goniometry. Their adsorption efficiency towards the cationic MB and AT pollutants was evaluated by batch adsorption experiments at various pH values at 30°C, achieving experimental adsorption capacities of 97.3 mg/g (at pH = 6) and 32.7 mg/g (at pH = 4), respectively. Overall, the results indicate that the post-printing functionalization of HIPS with sulfonic acid groups greatly affects the adsorbents' morphology, structure, surface polarity, and organic micropollutant adsorption capacity. Hence, these novel 3D printed sulfonated HIPS monoliths can be considered as potential candidates in environmental remediation applications of organic micropollutant-contaminated water bodies.

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DEVELOPMENT OF A PORPHYRIN-CURCUMIN HYBRID MOLECULE AS INNOVATIVE ANTIMICROBIAL AGENT FOR PUBLIC HEALTH PROTECTION IN POST-DISASTER ENVIRONMENTS

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Keywords: Porphyrin, Curcumin, Antimicrobial Activity, Photodynamic Therapy, Natural Disasters

Natural disasters, beyond their well-documented environmental and ecological impacts, have severe and often long-lasting consequences for human life, both directly and indirectly. In particular, it is widely recognized that such events are frequently associated with increased risks of microbial contamination and outbreaks of infectious diseases, mainly due to disruptions in sanitation systems, water infrastructure, and healthcare services. These conditions pose significant challenges to public health systems and crisis management mechanisms, highlighting the urgent need for the development of innovative and effective antimicrobial agents capable of operating under emergency conditions [1].

In this context, the present study focuses on the synthesis and characterization of a novel hybrid molecular system based on porphyrin and curcumin, aiming to investigate its potential as an antimicrobial agent in crisis-related environments [2][3]. The developed hybrid compound consists of a tin(IV) metalloporphyrin core axially functionalized with curcumin moieties, thereby combining the well-established photodynamic properties of porphyrins with the intrinsic antimicrobial activity of curcumin [3][4]. Curcumin, a naturally occurring polyphenol (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione) derived from *Curcuma longa*, is known for its broad spectrum of biological activities, including antimicrobial, anti-inflammatory, and antioxidant effects. [3] In parallel, porphyrins are widely recognized as efficient photosensitizers due to their ability to generate reactive oxygen species upon light irradiation, making them particularly suitable for antimicrobial photodynamic therapy applications. [5] The integration of these two components into a single hybrid system is expected to promote synergistic effects, enhancing overall antimicrobial performance [2][4].

Regarding the experimental methodology, a four-step synthetic route was employed, starting from the synthesis of the free base porphyrin in order to form the porphyrin–curcumin hybrid system. Initially, the free-base porphyrin was synthesized, followed by its metalation with tin(IV). Subsequently, axial chlorine substituents were replaced by hydroxyl groups through an intermediate reaction step, enabling the final conjugation with curcumin and the formation of the target hybrid molecule.

The synthesized compounds were thoroughly characterized using a range of spectroscopic techniques, including Mass Spectrometry (MS), Infrared Spectroscopy (IR), Ultraviolet-Visible Spectroscopy (UV-Vis), and Nuclear Magnetic Resonance (NMR), confirming their successful synthesis and structural integrity.

The physicochemical properties of the developed hybrid material render it a promising candidate for a wide range of antimicrobial applications, particularly in scenarios associated with increased microbial risk, such as post-disaster environments. Potential applications include surface disinfection, water purification, infection control in aquatic systems, and wound treatment. Moreover, its potential implementation in antimicrobial photodynamic therapy offers an alternative strategy to combat antibiotic resistance, a growing concern in both emergency response settings and modern healthcare systems.

Future research will focus on evaluating the antimicrobial activity of the hybrid molecule against representative bacterial strains, including *Escherichia coli*, in order to assess its effectiveness and practical applicability in real-world public health crisis scenarios.

Overall, this study contributes to the interdisciplinary field of crisis resilience by bridging advanced chemical synthesis with public health protection strategies, highlighting the potential of innovative hybrid materials in mitigating the impact of infectious diseases in disaster-affected environments.

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HEMP WASTE DERIVED ACTIVATED CARBONS FOR THE DECONTAMINATION OF PHARMACEUTICALS FROM AQUEOUS SOLUTIONS

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Keywords: Wastewater management, adsorption, waste biomass, activated carbon, pharmaceuticals.

The rapid expansion of industrial activities has led to the uncontrolled generation and discharge of wastewater, resulting in the widespread contamination of water resources. Among the various classes of emerging contaminants, pharmaceutical compounds have attracted increasing attention due to their persistence, bioaccumulation potential, and resistance to conventional treatment processes. As a result, these substances are frequently detected in surface water, groundwater, and wastewater effluents at concentrations that may pose significant ecological and human health risks. Through continuous exposure and trophic transfer, such pollutants can adversely affect aquatic organisms and ultimately impact human populations.

A representative compound of concern is ketoprofen, a widely used non-steroidal anti-inflammatory drug (NSAID), which is commonly detected in wastewater streams due to its extensive consumption and incomplete removal in wastewater treatment plants. Its presence has been associated with toxic effects in aquatic organisms, including oxidative stress, endocrine disruption, and behavioral alterations. Despite growing awareness, the efficient removal of ketoprofen and similar pharmaceuticals remains a significant challenge, highlighting a gap in the development of cost-effective and sustainable treatment technologies.

Adsorption has emerged as one of the most promising techniques for the removal of such persistent organic pollutants, owing to its simplicity, effectiveness, and adaptability. In recent years, increasing emphasis has been given on the development of low-cost and sustainable adsorbents derived from biomass waste. In this context, industrial hemp waste represents an abundant and renewable precursor for the production of activated carbon with favorable physicochemical properties. However, limited studies have systematically evaluated the influence of activation conditions on adsorption performance, particularly for pharmaceutical contaminants such as ketoprofen.

In this study, industrial hemp waste was utilized as a precursor for the synthesis of activated carbon aimed at enhancing ketoprofen removal from synthetic wastewater. The precursor material was thermally treated at three different temperatures (400, 500, and 600 °C) to investigate the effect of activation temperature on the structural and surface characteristics of the resulting adsorbents. The prepared carbon materials were characterized using Fourier-transform infrared spectroscopy (FTIR) to identify functional groups, Scanning Electron Microscopy (SEM) to examine surface morphology, and

nitrogen porosimetry to determine surface area and pore structure.

The adsorption performance was evaluated by examining key operational parameters, including solution pH, contact time, initial pollutant concentration, and adsorbent dosage. Kinetic modeling was applied to elucidate the adsorption mechanism and rate-controlling steps, while isotherm models were used to describe the interaction between ketoprofen molecules and the adsorbent surface. Additionally, thermodynamic analysis provided insights into the nature and feasibility of the adsorption process.

The experimental results demonstrated that the optimal pH for ketoprofen removal was 3, indicating that acidic conditions favor adsorption, likely due to enhanced electrostatic interactions and surface protonation. Equilibrium was reached within less than one hour, suggesting rapid adsorption kinetics. The kinetic data were best described by the pseudo-second-order model, indicating that chemisorption is the dominant mechanism governing the process. Furthermore, an increase in temperature led to enhanced adsorption capacity across all samples, suggesting an endothermic process.

Isotherm analysis revealed that the Langmuir model provided the best fit to the experimental data, indicating monolayer adsorption on a homogeneous surface. The maximum adsorption capacity reached 168.7 mg/g, demonstrating the high efficiency of the developed material. Overall, this study highlights the strong potential of hemp-derived activated carbon as a sustainable, low-cost, and high-performance adsorbent for the removal of pharmaceutical contaminants, contributing to the advancement of wastewater treatment technologies and addressing critical gaps in current environmental remediation strategies.



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AUTONOMOUS INTELLIGENCE ON THE FRONT LINE: INTELLIGENT AGENTS AS FORCE MULTIPLIERS IN CRISIS MANAGEMENT

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Keywords: Intelligent agents, crisis management, multi-agent systems, decision support, autonomous systems

Amidst a catastrophe in an emergency operations center sometimes there is too much data, too little time, and decisions must be made immediately. Radio communications, satellite imaging, weather forecasts, and material needs have to be dealt under circumstances of limited information and tired personnel. In spite of emergency procedures and training, human cognitive abilities always pose a limitation. The focus of the present paper lies precisely on this issue. In this contextm, we propose Intelligent Agents (IAs), autonomous computer programs able to perceive the environment, reason about it, and act within it, that can be integrated into the entire cycle of catastrophe management, starting from warning systems up to recovery processes.

Intelligent Agents (IAs) are intelligent programs able to perceive the environment through multimodal sensors, reason under conditions of uncertainty, perform plan formation, and adapt to partially observable environments [1]. Contrary to conventional approaches, IAs function in MAS environments, that is, multi-agent frameworks in which diverse agents coordinate, negotiate, and collaborate. The agents play different roles such as sensor fusion agents, responsible for fusing sensory inputs from IoTs, satellites, social networks; planning agents that create and revise action plans by employing reasoning; resource allocation agents that allocate personnel, equipment, and logistics by solving combinatorial problems; and interface agents that connect automatic processes with commanders.

At the heart of our approach lies the idea of “crisis cognition loop,” which refers to a circular process where the agents observe, analyze, make decisions, perform actions, and learn from those actions. In the case of compound crises, such as earthquakes causing hazardous chemical leaks, a well-coordinated MAS would be able to assess hazards, toxic plumes, vulnerable populations, and surge capacity for medical support, developing dynamic evacuation corridors and triage priorities [2]. For realizing our proposed framework, a 4-layer IA architecture is proposed (Figure 1). The Perception Layer will receive data from various sources: seismic sensors, UAV video feeds, citizens’ reportings, and weather conditions from APIs, all of which will be assigned confidence weights. The Reasoning Layer will use a combination of methods to make decisions for each individual agent regarding immediate tactics as well as strategic goals. The Coordination Layer uses a decentralized approach of bidding among multiple agents for scarce resources, where agents will bid based on their utility functions based on urgency, proximity, and mission-criticality; such an approach helps circumvent bottlenecks associated with centralized approaches and allows global consistency. Lastly, the Interaction Layer provides a transparent mechanism to display the reasoning of agents for every action that takes place, using an

Explainable AI (XAI) dashboard powered by the SHAP value method, enabling any human operator to interrogate, modify, or approve every decision made within seconds [3].

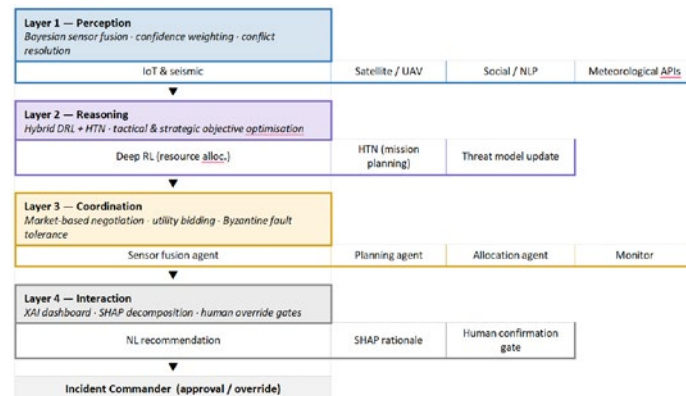


Figure 1. Four-layer IA architecture for crisis management

The proposed architecture was successfully validated using a number of simulation studies within the RoboCup Rescue framework with extensions incorporating realistic seismic and urban data. Three experimental groups were used for testing: one involving purely human teams working according to standard incident command practices, another group with a rule-based baseline AI approach, and the proposed MAS framework. In 120 runs, the latter improved evacuation completion time by 34% in relation to the human-only scenario and by 18% against the baseline rule-based approach, at the same time reducing redundancy of resource mobilization by 41%. Importantly, in cases where sensor information included noise intended to mimic communication problems, the Bayesian-based fusion process continued to function efficiently with up to 12% loss in decision-making accuracy, something that neither humans nor rule-based approaches could do [4].

Our solution explicitly tackles five threats to our framework. The algorithmic biases in vulnerability mapping are combatted using learning based on demographically varied datasets, with the fairness audit operating as a separate monitoring agent. Network cascades are mitigated using a fault tolerance mechanism, where even if one-third of the agents are lost, consensus can still be achieved. For sensor tampering, we include a pre-processing step where anomalies in sensor readings are detected. We also maintain an immutable record of decisions taken by any agent along with its explainability, ensuring accountability. Finally, to ensure that human expertise is not diminished due to overdependence on agents, we mandate human approval for irreversible action. Thus, while agents will provide advice, final decisions such as evacuation orders and demolition permission will require human approval.

Yet, the technologies used by the architecture have already been developed, and the principles of integration required by the architecture can be implemented using the existing structures of civil protection operations. The final hurdle left to overcome is the willingness of an institution to design and build such a system in collaboration with the emergency response personnel who would be using them. What is truly challenging is establishing the trust and training systems that will enable human operators to depend on intelligent agents during their moments of crisis.

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3D-PRINTED BEADS FOR THE ADSORPTION OF HEXAVALENT CHROMIUM

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Keywords: adsorption, wastewaters, graphene oxide, 3D-printing, environmental remediation.

Heavy metals contribute significantly to industrial progress, but they also pollute the environment. They are exceptionally hazardous and non-biodegradable, which allows them to accumulate in trace levels throughout the food chain[1]. As a result, sectors such as electroplating, aerospace, and metal finishing are among the most dangerous when it comes to heavy metal effluent discharge. The environmental risks associated with chromium, especially its hexavalent form (Cr(VI)), have escalated to a critical point owing to its significant toxicity, carcinogenic properties, and mobility in both aquatic and terrestrial ecosystems.

Designated as a priority hazardous pollutant by the U.S. Environmental Protection Agency, chromium (VI) presents significant toxicity to both animals and plants. Its increased mobility facilitates leaking into groundwater, even when adsorbed to soil, hence heightening environmental concerns. Consequently, it is imperative to eliminate chromium from polluted water to safeguard human health and the environment. To achieve this objective, several methods have been devised, including coagulation-flocculation, ion exchange, membrane filtration, improved oxidation processes, adsorption, electrochemical treatment, chemical precipitation, and bioremediation[2]. Among these, adsorption stands as the most effective treatment technique, since it is straightforward, economical, and easy to operate procedure that does not release harmful pollutants and is adaptable in addressing a diverse array of contaminants[3].

Current trends involve the fabrication of advanced adsorbents that can offer adsorption efficiency, scalability and reproducibility. Such materials can consist of nanomaterials or polymers and should have advanced structures. One of the most novel approaches that can combine these aspects is 3D-printing-additive manufactory technology[4]. It facilitates the fast production of intricate patterns with exceptional accuracy due to its layer-by-layer manufacturing technique. 3D-printed structures excel in homogeneity, cost-effectiveness, scalability, and mechanical strength, rendering them optimal for water treatment applications. The benefits of 3D printing combined with engineered nanomaterials present a distinctive potential to create efficient and portable point-of-use water treatment devices for populations without access to dependable, centralized water treatment. Among the several 3D printing methodologies, vat polymerisation constructs tangible things incrementally by selectively solidifying photocurable resin in each layer. This process yields polymeric materials with elevated thermal and mechanical resilience, high-resolution characteristics, and superior surface finishes.

In this study, 3D-printed spherical beads were prepared using commercial resin and graphene oxide

(GO) as a filler. GO has been thoroughly investigated for environmental applications and functions as a multifaceted component in the fabrication of 3D-structured composites. The oxygenated functional groups (e.g., epoxy, hydroxyl, and carboxyl) on GO structure augment its interaction with polymer matrices, leading to more uniform and stable composites, while also improving the adsorptive properties of the final composite[5]. The 3D-printed materials were analyzed using FTIR and XRD, and their mechanical properties were assessed. Adsorption tests were performed in batch experiments, demonstrating that optimal conditions were achieved at pH 3 and a contact period of 180 minutes, at a dosage of 0.5 g/L. Kinetic studies revealed that the data follow better the pseudo-first order model, suggesting that physisorption is the predominant process. Lastly, isothermal analysis revealed that adsorption occurs in monolayers on homogeneous surfaces, according to Langmuir model.

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BRIDGED rGO-GO@TERNARY LAYERED DOUBLE HYDROXIDES FOR THE REMOVAL OF ANTIPSYCHOTIC DRUG SULPIRIDE FROM WASTEWATER

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Keywords: Graphene, Adsorption, Pharmaceuticals, Wastewater treatment, Nanomaterials

In the last few years, awareness for mental health and its significance has increased rapidly which resulted in manufacturing large amounts of advanced pharmaceutical products, capable of treating a plethora of diseases. As of 2000, 33 organic compounds were identified in surface water, freshwater and marine water bodies, and have been emphasized by the European Union (EU) as priority pollutants to be removed within two decades, to protect the ecological status of the aquatic environment. The EU market has registered around 3000 commonly used pharmaceuticals, with their applications still increasing globally. Therefore, legislating and maintaining the regulatory guidelines, while understanding their distribution in the environment is complicated and challenging. Psychotropic drugs and their bioactive metabolites often persist in aquatic environments due to their typical physicochemical properties, which made them resistant to removal. Sulpiride is a first-generation antipsychotic agent belonging to the benzamide class, that exerts a selective inhibitory action on dopamine receptors. This property renders it an effective therapeutic option for treating various central nervous system disorders, such as schizophrenia, depression, panic attacks and other psychotic conditions. Even at low concentrations, Sulpiride amongst other antipsychotics, can possess a serious threat to aquatic ecosystems and organisms. Toxicological assessments show effects on reproductive system, embryonic development and neurobehavioral functions of many aquatic species. A number of treatment methods have been used to remove pharmaceuticals in aquatic systems. These include conventional treatment, advanced oxidation processes, activated carbon filtration, advanced ozonation, biodegradation, electrochemical degradation and microfiltration. Adsorption is a cost-effective way, recyclable and efficient, although conventional adsorbents seem unsuitable when it comes to intricate organic molecules and pharmaceuticals. Thus, the development of highly selective and efficient adsorbents is of need and is presented in the current work.

The development of advanced graphene oxide-based composite materials has gained exceptional attention thanks to their tunable physicochemical properties and versatile functionalization potential. In the present work, a novel hybrid nanomaterial was synthesized by integrating two distinct forms of modified graphene oxide within a unified system. Graphene oxide (GO) was selected as the matrix owing to its high specific surface area and abundance of oxygen-containing functional groups, which facilitate chemical modification. The first form of the material consists of a trimetallic layered double hydroxide (LDH) nanostructure, composed of cobalt (Co), iron (Fe), and aluminium (Al) cations, which was grafted onto nitrogen and boron co-doped reduced graphene oxide (N,B-rGO). Incorporating

heteroatoms into the graphene lattice, ensures intermolecular interactions between the drug and the absorbent, while achieving a tailored electronic structure. The LDH phase contributes to the formation of a well-defined nanostructured framework through synergistic metal ion coordination. The second component involves the covalent functionalization of graphene oxide nanosheets with melamine, introducing nitrogen-rich amino moieties into the carbon matrix. Subsequently, a diazotization reaction was carried out to bridge the modified GO and rGO components via melamine linkers, resulting in a complex, interconnected hybrid architecture.

All of the materials were characterised to confirm their successful fabrication and structural features. Fourier-transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD) analyses verified the presence of the targeted functional groups and crystalline phases, validating the effectiveness of multi-step synthesis strategy. Factors affecting the adsorption, such as the pH solution, contact time and isotherms, were also explored.

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SYNTHESIS AND CHARACTERIZATION OF MODIFIED CHITOSAN-BASED ADSORBENT FOR FLUORIDE REMOVAL

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Keywords: Chitosan, Fluoride, Graphene oxide, adsorption, wastewater

Fluoride is an essential trace element that can be beneficial to human health at low concentrations. It benefits dental health, because it supports the calcification of tooth enamel and protects teeth against tooth decay. However, excessive exposure to fluoride, mainly through drinking water, may result in serious health issues, such as dental fluorosis and skeletal fluorosis, depending on the level and duration of fluoride exposure. Increased fluoride concentrations in drinking water can be attributed to both natural geological occurrence and various anthropogenic and industrial sources[1]. Therefore, the occurrence of fluoride at elevated concentration in water resources is a major environmental and public health concern, highlighting the necessity of developing efficient and sustainable fluoride removal technologies.

Several treatment approaches have been examined to achieve this, such as membrane technology, electrodialysis, and photocatalysis. However, conventional treatment technologies are often accompanied by significant limitations, such as high operational costs, membrane fouling, complex maintenance, and high energy requirements. Among the available techniques, adsorption has emerged as an effective and widely applied method due to its operational simplicity, cost-effectiveness, high efficiency, and adaptability to different water treatment conditions[2].

In the present work, chitosan beads were synthesized and successively modified with fluorinated functional groups, graphene oxide, and magnetic curcumin to enhance their adsorption performance. The beads were prepared in spherical form in order to ensure uniform particle size, improved mechanical stability, and enhanced mass transfer during the adsorption process. Additionally, spherical beads facilitate easier handling, separation, and regeneration in practical applications, especially in column systems. Fluorinated groups were introduced to enhance fluorophilic interactions with fluoride ions, thereby improving selectivity. Chitosan was selected as the primary matrix due to its facile chemical modification enabled by the presence of reactive amino and hydroxyl groups[3]. Similarly, graphene oxide was incorporated to enhance the specific surface area and provide additional active sites for adsorption, while magnetic curcumin contributes hydrophobic interactions and magnetic properties, facilitating the easy recovery of the beads using an external magnetic field[4].

The synthesized materials were systematically characterized in terms of their physicochemical properties. Swelling and stability tests demonstrated the satisfactory structural integrity of the

synthesized chitosan beads under various conditions. Furthermore, Fourier-transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD) analyses confirmed the successful incorporation of the respective functional components and structural modifications. In addition, pH at the point of zero charge (pHpzc) experiments were conducted to better understand the surface charge properties of the adsorbents and their interaction behavior with fluoride ions at different pH values.

Removal experiments were conducted to evaluate the efficiency of the materials towards fluoride ions, demonstrating satisfactory removal under near-neutral pH conditions, which is particularly relevant for drinking water treatment applications. The synthesized materials achieved removal efficiencies of approximately 60%. The enhanced removal efficiency is attributed to the synergistic effect of fluorophilic interactions, electrostatic attraction, and the increased surface area provided by graphene oxide. Overall, the results indicate that the developed materials are promising candidates for efficient fluoride removal, offering strong potential for practical application in sustainable and cost-effective water treatment technologies.

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INFORMATION VALUE FOR RISK

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Keywords: information value, uncertainty, risk communication.

Information is a critical parameter for management of risks, particularly when it comes to risk communication and major risks. Despite extensive literature on the impact of a negative event on the public perception of the relevant risk, there is no quantified measure to evaluate risk information of such an event, i.e. an objective measure of the impact of the event on our knowledge and perception about its risk.

According to information theory [1], the standard measure of value for factual information, is information entropy, i.e. the negative logarithm of its probability. The lower the probability of an event, the higher its information content, i.e. its value of information entropy. Besides the applications of information entropy in various fields, this measure is not sufficient to evaluate information related to risk, for three reasons.

Firstly, information entropy requires precisely known probability values, which is generally not the case for risks, particularly for rare events. Secondly, it is a function of probability only, and it does not take into account the effect of the consequences, which an equally important parameter for risks. Thirdly, information value is based on objective probability values and it does not take into account human preferences and subjectivity, that are also important for risks, and particularly for risk communication.

This study is an attempt to address these challenges by proposing a measure that aims to evaluate factual risk information, i.e. observations of occurrence of an event. It is limited to binary (i.e. an event that either happens or not), unambiguous (i.e. not subject to interpretation or assessment) and rare phenomena. Regarding the first challenge (exact probability values), constant probability values are replaced with updated probabilities, according to the approach of Prospective Reference Theory [2], as probabilities for rare real-world events are continuously shaped by our experience and the context changes over time. This replacement also allows to estimate the impact of unexpected phenomena, for which no probabilities existed before the occurrence. Regarding the second challenge (the effect of consequences), utility is added as a proxy of the size of consequences. The third challenge, (human preferences and subjectivity), is partly covered by using updated perceived probabilities and utility, as a measure of human preferences.

The result of this analysis is a conventional, quantified measure of information value of an event for risk. Such a measure is useful in comparing the potential impact of different messages for a new observation of occurrence for a risk, as well as of different messages for different risks. It also demonstrates the main factors that affect the impact of the occurrence. More particularly, this measure indicates that the

major effect for the impact that an observation of occurrence will have in shaping our beliefs about the likelihood of an event, as well as about the risk involved in such an event, comes from the perceived number of occurrences of this event in the past.

Of course, this measure was analytically rather than empirically developed. Due to the multitude of factors affecting attitudes and behaviors, such an empirical verification is quite difficult and uncertain. New research that will estimate prior and posterior values is required in the future for its testing. Moreover, such an analysis is limited to the certain kind of risk information (observations of occurrence) and to its potential for shaping beliefs. Perception of risk is also subject to further factors out of the scope of this analysis. This measure aims to facilitate evaluation of messages, rather than to introduce a complete theoretical framework.

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GRAPE POMACE BIOMASS AS A FUNCTIONAL INGREDIENT IN NATURAL COSMETIC EMULSIONS

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Keywords: extracts, grape pomace, emulsions, nanoparticles, plant-based oils.

The continuous exposure of human skin to environmental stressors, such as UV radiation, smoking, and excessive alcohol intake, increases the production of free radicals in the skin, which accelerate aging and contribute to the development of various dermatological conditions. Antioxidant compounds are widely recognized for their ability to neutralize free radicals and protect skin structure and function. Consequently, there is an increasing demand for innovative cosmetic formulations enriched with natural, plant-derived antioxidants.

For the last few years, particular attention has been given to incorporating natural ingredients, rich in antioxidants, into products we use in our everyday routine. Grape pomace, has shown to be a promising by-product of the wine industry, rich in bioactive compounds including flavonoids, protein, lipids, phenolic acids, fatty acids, stilbenes such as resveratrol and many more [1]. Researchers have been heavily promoting its cardioprotective effects, antioxidant and anti-inflammatory properties as well as positive effects against metabolic disorders, making it an exceptional candidate for cosmeceutical applications. The utilization of such biomass aligns with circular economy principles, contributing to waste reduction while generating high-value functional ingredients.

This present study seeks to fill the gaps by combining two directions that have not been fully integrated, focusing on both sustainability and functional performance. First, the preparation of chitosan-lecithin solid lipid nanoparticles (SLNs) to encapsulate grape pomace extracts [2], which were prepared using ethanol-water mixtures at different concentrations and temperatures to determine optimal extraction conditions. Secondly the formulation of oil-in-water (O/W) emulsions with all natural ingredients [3], containing jojoba oil enriched with grape pomace through a maceration process, in order to enhance its antioxidant activity.

SLNs are often used to encapsulate lipophilic antioxidants such as resveratrol, tocopherols and polyphenols as their lipid matrix protects sensitive active ingredients from chemical and photodegradation. In addition, the small-sized particles promote deeper epidermal penetration. The combination of natural emulsions with nanoparticle-based delivery systems represents an innovative approach that bridges sustainability with advanced formulation strategies.

Three types of O/W emulsions were formulated, differing in the oil phase composition: (i) commercial

oils, (ii) grape pomace-infused oil obtained after 7 days of extraction, and (iii) grape pomace-infused oil obtained after 14 days. The emulsions were prepared using a heat-assisted method and evaluated in terms of physicochemical stability by measuring pH, viscosity, density, and centrifugation tests over a period of 35 days [4].

The results demonstrated that all three formulations showed pH values within the acceptable range for topical application (4.5-6.0). The emulsions containing GP-infused oils (ii and iii) showed increased stability overall compared to the one containing commercial oils (i), as they maintained consistent pH and viscosity values over time. Rheological analysis revealed typical shear-thinning behavior, while the infused oil formulations presented better texture and feel. Centrifugation studies did not show any separation, which indicated the thorough homogenization of the products. Lastly, density measurements remained relatively constant with the first (i) showing a higher density measurement than the other two, suggesting no significant degradation or mass loss.

The antioxidant activity of both grape pomace extracts and infused oils was evaluated using the DPPH radical scavenging assay. The obtained results presented that the incorporation of grape pomace significantly increased the antioxidant activity compared to commercial oils. This confirms the successful transfer of antioxidant compounds from grape pomace into jojoba oil, resulting in an enhanced oil phase for cosmetic formulations.

Overall this study highlights the significant potential of grape pomace as a natural and effective antioxidant source for cosmeceutical formulations. The combination of plant-based emulsions with nanotechnology-based delivery systems offers a promising strategy for enhancing the stability and efficacy of natural ingredients. These findings support the growing trend toward environmentally friendly and circular approaches in the cosmetic industry, where waste materials are transformed into high-value products. Future research should focus on scaling up the incorporation of bio-based ingredients for potential industrial applications.

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3D-PRINTED RECYCLED PET POROUS STRUCTURES WITH ENHANCED ABSORPTION CAPACITY

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Keywords: recycled PET (rPET); FDM 3D-Printing; oil-water separation; extrusion filament; Additive Manufacturing

Nowadays the persistent chemical and petroleum industry development and the accumulation of oil-contaminated wastewater remain one of the most significant global environmental challenges. Furthermore, oil-water separation remains a significant process in wastewater treatment, which can be accomplished using filter membranes and 3D printed absorbents. However, the widespread utilization of PET (Polyethylene Terephthalate) in consumer bottles and in packaging contribute to environmental degradation, due to the increasing percentage of plastic waste. In order to address that challenge, recycled Polyethylene Terephthalate (rPET) can be used via FDM 3D printing process, a low cost, simple technology, compatible with most thermoplastic polymers, offering a sustainable solution for wastewater treatment. This innovative process aligns with circular economy principles, by transforming plastic waste, through eco-friendly processes, into significant materials preventing environmental degradation.[1]

Three-dimensional (3D) rPET porous structures were fabricated to investigate recycled polymer materials' oil absorption capacity. PET consumer bottles were collected and converted into filament through recycling and extrusion process, offering a rPET filament that maintain stable diameter and appropriate characteristics for additive manufacturing purposes, regardless of the difficulties during extrusion, where a strict extrusion thermal profile was used. The results confirm that could offer a sustainable solution to thermoplastics that are used for 3D printing[2]. The rPET filament offering enhanced printability despite the challenges associated with its properties as an engineering polymeric material, characterized by high melting point and rapid cooling rate.

The significant innovation of this project is the combination of recycled materials with additive manufacturing, filling the insufficiently investigated gap for environmental remediation. The main object was the fabrication of 3D printed rPET porous structures, offering controlled stable porosity and different pore sizes, enhancing high oil absorption capacity. The oil absorption capacity was systematically assessed over a period of 2 to 10 minutes at 2-minute intervals. The initial absorption capacity was at 60%. However, after further investigation regarding the influence of pore size, were performed several adjustments as having a big influence on absorption capacity. Specifically, the optimal performance was the rPET structure of 200 μm at 10 minutes, achieving the absorption capacity of 215%. However, the most significant parameter of their structure was the increase of the surface area in order to facilitate

capillary transport of fluid. The combination of rPET's properties and structural design is essential for achieving high absorption capacity without additional surface treatment.

Nevertheless, due to inherent properties of PET, rPET printed structures experimentally demonstrated hydrophobic and oleophilic behavior after contact angle measurements [3], allowing efficient oil absorption. The rPET porous structures demonstrate resistance to structural degradation, promising their applicability in continuous systems. Thus, compared to conventional techniques, this approach offers lower energy consumption, simplified process requirements, and decreased chemical consumption.

Furthermore, material characterization using Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD) was conducted in order to evaluate its structure and crystallinity. FTIR data verified the presence of PET's functional groups (saturated aliphatic ester's carbonyl stretching, ester linkage (C-O-C), benzene ring), while also providing minor structural modification due to the recycling process and further thermal exposure during extrusion and 3D printing[1], [4]. Equally, XRD data also demonstrated a crystallinity degradation in rPET compared to the commercial PET sample due to thermal processing and blow molding during rPET bottles' production due to rapid cooling. Consequently, the rPET filament offers sufficient structural stability for additive manufacturing purposes[5].

In summary, the use of rPET in additive manufacturing is promising as an efficient solution to tackle and prevent environmental degradation by developing a 3D-printed porous structure from recycled PET filament, originating from PET consumer bottles, via FDM technology. The resulting, durable porous structures with the precise grid geometry and dimension, stable porosity, and high absorption capacity will be a sustainable material addressing industrial wastewater remediation and oil spills, while emphasizing rPET as a viable, non-conventional material, highlighting further research in the field of sustainable and eco-friendly materials and processes.

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ANTIOXIDANT, ANTI-INFLAMMATORY AND ANTITHROMBOTIC POTENTIAL OF AMPHIPHILIC BIOACTIVES FROM SHRIMP AND CRAYFISH BY-PRODUCTS, FOR SUSTAINABILITY AND CIRCULAR ECONOMY DESIGN

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Keywords: shrimp, crayfish, carotenoids, marine phenolics, antioxidants

Marine organisms have emerged as an important source of bioactive compounds with significant potential in the prevention and management of chronic diseases, including cardiovascular disorders and inflammation-related conditions. Among them, crustaceans such as shrimp and crayfish are particularly rich in lipid-derived bioactives, including polyunsaturated fatty acids, carotenoids, and phenolic compounds, which exhibit antioxidant, anti-inflammatory, and antithrombotic properties. [1], [2] The present study aimed to comparatively evaluate the valorization of amphiphilic fractions derived from shrimp and crayfish by-products (Heads), with emphasis on the influence of tissue type and extraction methodology.

Total lipids were extracted using both a green extraction approach. Extraction yields, total carotenoid content (expressed as β -carotene equivalents), and total phenolic content (expressed as gallic acid equivalents) were determined spectrophotometrically. Antioxidant activity was evaluated using DPPH, ABTS, and FRAP assays, while anti-inflammatory and antithrombotic properties were assessed through inhibition of platelet aggregation induced by platelet-activating factor (PAF) and ADP. Structural characterization was performed using UV–Vis and ATR–FTIR spectroscopy.

The results demonstrated that extraction yield was strongly influenced by tissue type, with head tissues exhibiting significantly higher yields compared to muscle in both species, indicating a higher concentration of lipid-soluble bioactive compounds. Amphiphilic fractions consistently showed higher yields than lipophilic ones, suggesting a predominance of polar lipid constituents. Carotenoid analysis revealed substantial variability depending on species, tissue, and extraction method, with the highest concentrations observed in green-extracted samples (up to 57 mg CE/g extract), particularly in muscle tissues.

Total phenolic content was significantly higher in crayfish extracts compared to shrimp, especially in head-derived amphiphilic fractions. These elevated phenolic levels were associated with enhanced

antioxidant activity, as confirmed by ABTS and DPPH assays. Crayfish extracts consistently exhibited superior radical scavenging capacity compared to shrimp, likely due to their higher content of carotenoids and phenolic compounds. In contrast, FRAP results showed less consistent trends, suggesting methodological limitations in evaluating certain extract types.

Importantly, amphiphilic fractions demonstrated the highest biological activity across all assays, including antioxidant, anti-inflammatory, and antithrombotic effects, as evidenced by lower IC₅₀ values in platelet aggregation experiments, highlighting the key role of amphiphilic lipid components as carriers of bioactivity. These findings underline the importance of lipid polarity in determining biological functionality.

Spectroscopic analyses further supported these results. UV–Vis spectra revealed characteristic absorption peaks in the regions of 230–240 nm and 280–320 nm, corresponding to proteins and phenolic compounds, respectively. ATR–FTIR analysis confirmed the presence of functional groups associated with lipids, proteins, and phenolics (O–H, C–H, Amide I and II), while strong absorptions in the phospholipid region (1000–900 cm⁻¹) were particularly evident in crayfish extracts, indicating a higher phospholipid content.

Overall, the study demonstrates that crustacean-derived amphiphilic fractions, particularly from their by-products, represent a rich source of bioactive compounds with significant antioxidant, anti-inflammatory, and antithrombotic potential. The findings also highlight the critical role of extraction methodology and tissue selection in determining both chemical composition and biological activity. Furthermore, the valorization of crustacean by-products, such as heads and shells, offers promising opportunities for the development of functional foods, nutraceuticals, and bioactive ingredients, contributing to sustainable resource utilization and circular bioeconomy design, and as mitigation strategies to increase resilience of the agri-food sector against climate change and associated natural crisis-hazards.

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FROM DEGRADATION TO DETOXIFICATION: KINETIC PROFILING AND HRMS CHARACTERISATION OF BISPHENOL A TRANSFORMATION PRODUCTS UNDER METALLOPORPHYRIN-BASED PHOTOCATALYSIS

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Keywords: photocatalysis, power-law kinetics, toxicity, transformation products

Bisphenol A (BPA, 4,4'-isopropylidenediphenol) is a high production-volume chemical primarily used in the manufacture of polycarbonate plastics and epoxy resins, with additional applications in optical and electronic materials[1]. Beyond its environmental occurrence, BPA is recognized as a potent endocrine-disrupting chemical (EDC) with estrogen mimicking activity, capable of interfering with reproductive, neurological, and immune functions.

These concerns have led to its classification as a Substance of Very High Concern (SVHC) under the EU REACH framework due to its reproductive toxicity and endocrine-disrupting properties[2]. In this work, a visible-light-active TiO₂-metalloporphyrin hybrid photocatalyst was developed via surface sensitization of TiO₂ with zinc tetrakis (4-carboxyphenyl) porphyrin (ZnTCPP) and evaluated for BPA degradation in aqueous media. The hybrid material was characterized by UV-Vis spectroscopy (UV-Vis), Fourier Transform Infrared (FT-IR) Spectroscopy, powder X-ray diffraction (PXRD), and scanning electron microscopy (SEM), confirming successful porphyrin immobilization without altering the anatase crystal structure.

Photocatalytic experiments under visible-light irradiation demonstrated efficient BPA removal, reaching up to 70 % degradation within 180 min, while maintaining stable performance over three successive cycles. The kinetic behavior of the system was described using a power law type model, consistent with non-classical relaxation dynamics frequently reported in complex and heterogeneous media, with enhanced reaction rates under acidic conditions and optimized catalyst loading[3].

For the porphyrin load, while 1×10^{-5} and 5×10^{-5} M indicated comparable results (50.28 and 48.27 min half-life values, respectively), the lower porphyrin concentration was chosen for further experimental tests due to practical considerations. Regarding pH, the optimal kinetic profile was observed in pH 3 and was accordingly chosen. Lastly, the initial BPA concentration of 20 mg L^{-1} revealed the lowest half-life and was subsequently used throughout this work. To clarify the role of the main reactive species involved in the photocatalytic degradation of BPA, quenching experiments were performed using selective radical scavengers, and the reaction products were analyzed using LC-Orbitrap HRMS. Isopropanol (IPA), p-benzoquinone (p-BQ), and EDTA were employed as scavengers for hydroxyl radicals (HO·), superoxide species (O₂·⁻), and photogenerated holes (h⁺), respectively. Radical scavenging experiments indicated that superoxide and hydroxyl radicals were the dominant reactive species governing the oxidation

process.

The reusability of the synthesized Porphyrin-TiO₂ catalyst was evaluated by testing it in three consecutive cycles. After the second cycle, the catalyst lost some of its ability. High-resolution Orbitrap mass spectrometry enabled the identification of major transformation products and the elucidation of degradation pathways, which were dominated by aromatic hydroxylation and C–C bond cleavage reactions. ECOSAR was used to perform in silico toxicity assessments focusing on acute and chronic endpoints, to analyze the potential hazardous effects of BPA and its resulting TPs.

The toxicity assessment showed a substantial reduction in acute and chronic aquatic toxicity for the main intermediates compared with the parent BPA molecule. Overall, the toxicity profile of the system shifts from “high risk” in the presence of BPA to “very low risk” or “non-toxic” after photocatalytic transformation, confirming the environmental safety and effectiveness of the hybrid TiO₂-metalloporphyrin catalyst for BPA remediation. The TiO₂-metalloporphyrin hybrid effectively extends photocatalytic activity into the visible region and enables efficient pollutant removal with reduced environmental risk, highlighting its potential for sustainable solar-driven water treatment applications.

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EFFECTIVENESS OF HOUSEHOLD AND INDUSTRIAL WASHING AND THERMAL METHODS ON PESTICIDE RESIDUE REMOVAL FROM TOMATOES: A FOOD SAFETY AND PUBLIC HEALTH PERSPECTIVE

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Keywords: pesticide residues, food safety governance, processing factors, QuEChERS, dietary risk assessment

Pesticide residues in food commodities represent a growing public health concern. While essential for pest control, pesticide residues may adversely affect human health, ranging from acute symptoms, like nausea and headaches, to chronic effects, such as neurotoxicity, infertility and cancer. Tomatoes (*Solanum lycopersicum*), a staple in the Mediterranean diet, are widely cultivated and highly prone to pesticide exposure. This necessitates the monitoring and regulation of pesticide residues in tomatoes and the assessment of effective reduction methods. Processing techniques, such as washing and thermal treatments, can alter the physical and chemical characteristics of produce and influence residue levels [1].

The QuEChERS approach (“Quick, Easy, Cheap, Effective, Rugged, Safe”) is a widely adopted sample preparation method for pesticide residue analysis in various food matrices, known for its simplicity, efficiency, minimal solvent use, and broad analyte recovery. It combines liquid–liquid extraction with dispersive solid-phase extraction (dSPE) and is often coupled with advanced high-resolution mass spectrometry techniques for accurate quantification and screening.

This study aimed to evaluate five pesticide residues (acetamiprid, fluopyram, tebuconazole, spirotetramat, and cyprodinil) in tomatoes subjected to various household and industrial processing methods, including washing and thermal treatments. For the pesticide extraction the validated QuEChERS protocol (EN 15662:2018) was used, while for quantification was performed with Liquid Chromatography – High Resolution Mass Spectrometry (LC-HRMS). The effectiveness of each process was assessed using the Processing Factor (PF), where $PF > 1$ indicates residue increase and $PF < 1$ a decrease. Although tomatoes are a globally consumed crop, limited studies explore residue behavior during their processing. This study addresses this crucial gap, thereby supporting food safety, pesticide regulation, and public health.

In brief, 10 g of homogenized tomato and 10 mL of acetonitrile were placed into a 50 mL polypropylene tube. After stirring (1 min, 2500 rpm), extraction salts ($MgSO_4$, NaCl, trisodium citrate, and disodium citrate) were added. The mixture was stirred again (3 min) and centrifuged (5 min, 4000 rpm). The supernatant was purified via d-SPE ($MgSO_4$ and PSA), stirred and centrifuged, and finally a 1-mL aliquot

was filtered (0.22 µm PTFE) into an autosampler vial. Analysis was performed by means of an LC–LTQ/Orbitrap MS with a reversed-phase pentafluorophenyl column (50×2.1 mm, 2.6 µm) under a 20-min gradient program (methanol/water with 0.1% formic acid, 300 µL/min flow rate, 5 µL injection). The mass spectrometer operated in positive mode (60,000 FWHM, m/z 120–600), identifying compounds via $[M+H]^+$ ions and characteristic fragments using XCalibur v2.2 software.

The results indicate that thermal treatments were the most efficient and consistent in reducing pesticide residues, with boiling achieving the highest removal rates (85–100%, PFs < 0.15), due to processes like evaporation, hydrolysis or co-distillation, which chemically degrade residues. Among washing methods, household treatments proved to be more effective, particularly 6% lemon juice solution (23–50%, PFs: 0.51–0.76), followed by running tap water (40°C), environments that destabilize pesticides. The least successful treatments were the industrial washing ones, especially 1% H₂O₂ and 6% NaCl solutions (PFs: 1.4–3.2), possibly due to high boiling points and K_{ow} of the pesticides, implying hydrophobicity and hence difficulty in washing-off. Overall, spirotetramat residues were the most consistently reduced by washing methods, due to its unstable nature. Despite data variability, a distinct pattern emerged: almost all washing (>78%) and thermal methods (100%) were effective for at least one pesticide.

In the subsequent dietary risk assessment, all tested washing treatments achieved residue levels well below Acceptable Daily Intake (ADI) thresholds, indicating negligible health risks under the evaluated conditions. These findings underscore the importance of optimizing decontamination protocols according to pesticide physicochemical properties, and emphasize the necessity for evidence-based washing recommendations. This study thereby contributes to a more accurate dietary exposure assessment, supporting consumer protection, pesticide regulation, and the broader framework of food safety governance and public health resilience.

In conclusion, this study aimed to facilitate a more accurate dietary risk assessment of pesticides from tomato processing, considering the growing need to identify food safety risks and minimize pesticide use. Washing and especially thermal treatments can substantially diminish pesticide residues in tomatoes, which can serve as a valuable tool, both in household and industrial scale, to ensure consumer safety. This novel data will contribute to gaining a better understanding of the relationship between the selected pesticides and their removal efficiency and support the integration of PFs into dietary exposure assessments and food safety strategies.

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PESTICIDE RESIDUE MONITORING IN PET FOOD: ANALYTICAL METHOD DEVELOPMENT AND IMPLICATIONS FOR FOOD CHAIN SAFETY GOVERNANCE

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Keywords: Pet feed, Pesticides, QuEChERS, Animal feeds, Suspect Screening, GC-HRMS, Feed Safety, Pet Feed Contamination, companion animals.

In this day and age, there are over 350 million pets in Europe, and around a billion worldwide, with estimates showing that over half of which are dogs and cats [1,2]. The increased popularity has led to a heightened focus on their health and well-being, from concerned pet owners, with their diet being a main focus point [2–4]. There are 3 categories of pet feed, dry, wet and semi-solid, encompassing a wide range of formulations, and each species can rip the benefits of different formulations.

For instance, cats due to being mandatory carnivorous tend to benefit from wet/semi-solid feed that has higher protein and lower carbohydrates compared to the more processed dry feed. In all actuality, a dry feed-based diet on cats can lead to obesity and diabetes as their digestive tracks are not equipped to handle great amounts of carbohydrates, in conjunction with dogs whose diet is rich on carbohydrates relating to the fact that they are omnivorous and can handle greater amounts of starch [5]. This variety in feed, results in diverse and complex composition increasing the risk of introducing harmful compounds such as pesticides in the retail product, potentially causing severe health issues to companion animals through this exposal, such as lymphoma, bladder cancer, and mammary tumors in dogs and hyperthyroidism in cats [1].

Contamination can stem from plant-based ingredients because of pesticides applied during the cultivation, transportation, and storage of raw materials that can persist in the final pet food product [3]. Also, animal-derived ingredients can contribute to contamination through bioaccumulation, a process in which pesticide residues can accumulate in livestock tissues used as protein sources [3]. In view of making way for new regulations to protect dogs and cats, several studies investigate the development of multi-component analytical methods for feed, using European Union's Regulation (EC) No 396/2005, which sets maximum residue levels (MRLs) for feed of plant and animal origin for production animals as a reference, in absence of specific guidelines for pet's feed [1]. However, the analysis of pet feed is no easy task, as they are highly complex matrixes comprised of a broad range of interfering substances (such as fat and protein) that can compromise the detection of target analytes by causing signal suppression or enhancement [1,3].

Therefore, multiresidue methods need to balance the extraction & detection of numerous analytes with a vast range of chemical properties, which increases the risk of co-extracting interfering

matrix components [1,3].

However, research on methods for pesticide extraction in animal feed remains relatively scarce with even fewer studies including pet food, among the matrices investigated. Nevertheless, growing awareness among pet owners about the importance of safe and nutritionally balanced diets for companion animals is increasing the demand for more comprehensive monitoring of contaminants. Most existing approaches are based on variations of the QuEChERS technique (Quick, Easy, Cheap, Effective, Rugged, and Safe), which is widely applied in multi-residue pesticide analysis due to its simplicity, versatility, and cost-efficiency.

This study utilizes the official AOAC.2007 method for the extraction of analytes, in which 5 g of homogenized spiked sample is placed in plastic Falcon centrifuge tubes (50 ml) and vortexed for 1 minute. 10 ml of acidified -with acetic acid- acetonitrile, together with 5 ml of water and the extraction salts, i.e. 4 g MgSO_4 & 1 g CH_3COONa , are placed in Falcons and vortexed. The samples are subjected to ultrasound for 15 minutes and centrifuged. From the supernatant, 1 ml is taken and placed in 15 ml Falcon centrifuge tubes.

Then two types of clean-ups were tested:

a. Clean-up with PSA: 50 mg PSA & 150 mg MgSO_4 are added and vortexed for 1 minute. The samples are centrifuged, and 1 ml of supernatant is placed in the vials which are sealed with Parafilm tape. Finally, the samples are analyzed by GC-MS/MS.

b. Freezing out: The centrifuge tubes are frozen at -24°C in darkness for 1 h and centrifuged at 4200 rpm for 5 min (one cycle). After that, the supernatant was transferred to a clean tube and refrozen for cycles 2 and 3, respectively. Finally, 1 ml of supernatant is placed in the vials which are sealed with Parafilm tape. Finally, the samples are analyzed by GC-MS/MS.

Clean-up with PSA showed the best results and thus was the chosen method. With that in mind, method validation was performed covering a wide range of concentrations in the matrix (1 - 5 - 10 - 50 -100 ppb) for the matrix matched calibration and the recoveries and RSD% were evaluated from 3 spiking experiments at 1 (used to calculate method limits) - 5 - 10 -50 $\mu\text{g/kg}$.

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DEVELOPMENT OF MICRO AND NANOFIBERS FROM RECYCLED POLYETHYLENE TEREPHTHALATE VIA ELECTROSPINNING USED FOR EFFICIENT OIL ABSORPTION

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Keywords: electrospinning, nanofibers, polyethylene terephthalate, graphene oxide, oil absorption.

The aim of the present study was the fabrication of micro and nanofibers from recycled polyethylene terephthalate (PET), derived from plastic bottles using the electrospinning method. The mattresses that were synthesized were appropriate for the absorption of oil pollutants. This study contributes to environmental decontamination and valorization of recycled plastic materials.

The use of plastic products has caused a global crisis. Their production has grown rapidly in recent decades, causing environmental pollution as the waste ends up in land and sea. Plastic pollution has affected the soil and aquatic ecosystem as well as the atmosphere. Due to their chemical structure, plastics have high resistance to degradation, and they remain for many years in the environment. Plastics have a wide diversity in terms of shape, morphology, size and origin which makes their management more complex. As a result, they can carry hazardous substances, including organic pollutants, heavy metals and microorganisms. The impacts of plastic pollution affect living organisms and human health, as one of the main crises that are happening are microplastics. Exposure to them during food consumption causes their accumulation in biological tissues, a process associated with oxidative stress and potential inflammatory. Marine ecosystems also face the negative effects of this pollution due to plastic debris being entangled in marine organisms [1].

Among the most widely used plastics is polyethylene terephthalate (PET), commonly utilized in the manufacturing of beverage bottles due to its high mechanical strength, chemical resistance, and low production cost. Although PET has useful properties, it contributes to plastic pollution because of low percentages of recycling, causing a major challenge. PET is a semi-crystalline thermoplastic that is resistant to hydrolysis, making conventional recycling more difficult. Therefore, the development of alternative strategies for recycling and reusing PET is essential, not only to reduce environmental pollution but also to promote sustainable material management [2].

Along with plastic pollution, oil pollution has also been harmful in aquatic environment and in human health. Oil spills and industrial discharges in seas have as a result complex mixtures of hydrocarbons into ecosystems, causing severe ecological damage. These pollutants can persist in the environment, disrupt marine life and enter the food chain through bioaccumulation, affecting human health. With plastic and oil pollution affecting living conditions, the development of innovative and sustainable remediation approaches is of high importance [3].

In this study PET nanofibers are constructed by the innovative method of electrospinning, resulting in fiber mats that have strong mechanical properties and can absorb oil pollutants. More specifically the fabrication method involves the process of electrospinning and the study of various conditions, changing the voltage, the distance from the tip of the needle to collector and the flow rate of the solution. The method of electrospinning refers to the use of high voltage that helps the solvents to evaporate, and the fibers to solidify and form a mat on the collector's surface. Fibers' morphology was analyzed via the images from scanning electron microscopy (SEM). Alongside the electrospinning conditions, the concentration of the polymer PET has a significant role as it determined the final diameter of the fibers. Aiming to the construction of a small fiber diameter for oil absorption there were selected fibers with a mean fiber diameter of $0.215 \pm 0.0543 \mu\text{m}$. These were fabricated with polymer concentration of 12% w/v and solvent ratio of TFA:DCM 25:75. Regarding the electrospinning parameters, the voltage was maintained at 20 kV, the distance at 10 cm and the flow rate at 1 ml/h, resulting in the formation of several fiber mats. Furthermore, graphene oxide (GO) was added to the initial PET solution at a concentration of 0.5% wt. related to polymer. That offered small fiber diameters of the mats, making the nanofibers of PET, an appropriate nanomaterial to remove oil pollutants.

The absorption results exhibit the effective absorption of diesel as an oil pollutant. In ten minutes time both PET and PET/GO materials had high absorption percentage with an oil absorption capacity of approximately 10 g/g, indicating that 1 g of material can absorb around 10 g of oil. PET nanofibers are successfully contributing to environments needs and they are managing to utilize PET plastic waste bottles to remove oil pollutants, offering a circular economy and recycling procedure.

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BRIDGING FRAGMENTATION IN WILDFIRE RISK GOVERNANCE: A MULTI-LEVEL MODEL BASED ON THE CASE OF NORTH MACEDONIA

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Keywords: risk governance, wildfire management, disaster risk reduction, institutional coordination, resilience

The increasing frequency and intensity of climate-driven wildfires are reshaping the global risk landscape and placing growing pressure on national risk governance systems. This trend is particularly visible in Southeast Europe, where wildfires are no longer seen as isolated events but as part of a broader, interconnected Earth system [1, 2]. Rising temperatures, prolonged droughts, and shifts in land-use patterns have amplified both the likelihood and the consequences of wildfire events, making the overall risk environment more complex and difficult to manage. In response, international policy frameworks have consistently highlighted the need for more integrated and adaptive approaches to disaster risk governance, as reflected in the Sendai Framework for Disaster Risk Reduction 2015–2030 [3]. Yet, despite efforts to align with European Union policies, many national systems continue to struggle with structural fragmentation, limited data interoperability, and weak links between risk assessment, early warning, and operational response [4].

Within this context, a clear research gap becomes evident. While the existing literature offers strong conceptual insights into risk governance, there is still a shortage of empirically grounded and operationally applicable models that bring together institutional coordination, data systems, and decision-support mechanisms into a coherent whole. This gap is especially pronounced in wildfire risk management in Southeast Europe, where risk assessment, coordination, and response are often treated as separate functions rather than as interconnected elements of a unified governance system. As a result, policy frameworks do not always translate effectively into practice.

To address this gap, the paper focuses on wildfire risk governance in North Macedonia as a representative case of a system in transition. The study adopts a qualitative case study approach, combining institutional mapping with comparative policy analysis to examine how key actors are structured and how they interact within the national disaster risk management framework. Particular attention is given to the roles of the Crisis Management Center (CMC) and the Protection and Rescue Directorate (PRD), as well as to existing practices related to data collection, risk assessment, and inter-institutional coordination.

The analysis highlights several systemic weaknesses that limit the effectiveness of wildfire risk management. To begin with, there is no unified, nationally mandated methodology for risk assessment and early warning that is consistently applied across institutions. Although both the CMC and PRD conduct relevant analyses, their approaches are not harmonized, resulting in parallel processes and, at times, inconsistent outputs. This issue has also been identified in the European Union Peer Review on disaster risk management in North Macedonia [5], which points to the absence of a unified risk analysis framework aligned with international standards.

A second issue concerns data. While multiple institutions generate risk-related information, these datasets are rarely integrated or systematically shared. As a result, stakeholders often develop different interpretations of risk, which weakens the foundation for coherent, evidence-based decision-making. A further limitation is the absence of a comprehensive national risk assessment that provides a clear, cross-sectoral overview of risks. This reflects both unclear institutional responsibilities and the lack of a coordinated and standardized process for identifying and analyzing risks. At the same time, coordination between key institutions remains limited, particularly between the CMC and PRD, which form the core of the national system. This fragmentation reduces the effectiveness of preparedness planning and makes it more difficult to translate risk assessments into actionable decisions.

In response to these challenges, the paper proposes a multi-level model for risk governance built around three interrelated dimensions: data integration and risk analytics, institutional coordination and decision-support mechanisms, and capacity development through education and training. What sets this model apart is its emphasis on linking data systems, governance structures, and operational processes into a single, coherent framework, rather than treating them as separate components.

The contribution of this study is twofold. First, it provides an empirically grounded analysis of wildfire risk governance in a Southeast European context, highlighting structural limitations that are often underexplored in the literature. Second, it introduces a scalable and operationally oriented model that helps bridge the gap between policy frameworks and practical implementation. In doing so, it offers a clear pathway for improving coordination, strengthening data-driven decision-making, and enhancing institutional resilience. While grounded in the case of North Macedonia, the proposed framework has broader relevance for countries facing similar challenges and can serve as a basis for integrating advanced technologies, including data-driven and AI-supported risk assessment tools, into future risk governance systems.

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MAPPING THE INVISIBLE: CRITICAL AND RADICAL APPROACHES TO REPRESENTING CRISES, DISASTERS AND HIDDEN SPATIAL CONDITIONS

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Keywords: Critical realism, Radical cartography, thermal springs, disaster maps, palimpsest, layer superimposition

Maps constitute one of the most powerful means of representing space, as they combine scientific methods of documentation with visual strategies that shape perception and construct realities. The conventional assumption that maps are objective representations has been extensively challenged by critical and radical cartography, which foregrounds their selective, constructed, and often ideologically embedded nature. Within this framework, maps do not merely record reality; they actively narrate, reveal, or conceal particular aspects of it.

This paper explores maps that depict crises, disasters, and latent or “hidden” spatial conditions, focusing on their capacity to communicate complex and sensitive realities in an immediate and affective manner. Through a historical overview, it examines examples of cartographic representations of disasters from the medieval period to the present, highlighting how the visualization of risk, loss, and crisis has contributed to the formation of collective imaginaries. From medieval symbolic depictions of threats to contemporary mappings of pandemics, wars, and environmental disasters, a persistent interplay between scientific information and visual expression can be observed, enhancing the communicative power of maps.

Particular emphasis is placed on contemporary approaches within critical and radical cartography, which seek to foreground aspects of reality that remain invisible or marginalized within dominant mapping paradigms. These approaches mobilize mapping as a form of social and political intervention, aiming to render visible issues such as inequality, exclusion, environmental pressure, and spatial injustice. By employing hybrid methodologies that integrate quantitative data with qualitative and experiential information, maps operate simultaneously at the level of evidence and affect, engaging both rational understanding and emotional response.

Within this context, the paper addresses the question of how contemporary cartographic practices can represent complex problems in ways that foster awareness and mobilization. The discussion draws on the concept of multilayered representation, which enables the coexistence of multiple perspectives, temporalities, and conceptual dimensions within a single cartographic framework. Mapping is thus approached as a palimpsest, where overlapping narratives and data layers reveal the complexity of spatial phenomena.

As a case study, the paper presents the “Spatial Ontology of Loutrotopos” (SOL*), a research-based design tool developed within a critical cartographic framework to analyze thermal spring sites in Greece. The SOL* constitutes a deliberate reinterpretation of the institutional “Special Operation License,” (SOL) which is primarily based on technical and medical criteria, excluding crucial cultural, social, spatial, and environmental dimensions of spa locations. In contrast, the visual identity system seeks to capture the complexity of each site through a multi-criteria approach, bringing to the surface issues that remain unaddressed in conventional evaluation systems.

The SOL* is structured through the superimposition of sixteen layers, each corresponding to a distinct analytical criterion, including functionality, accessibility, natural and urban landscape, ownership regime, and socio-cultural significance. The interaction of these layers produces a composite visual identity that operates as a palimpsest, integrating material and immaterial aspects, historical strata, and contemporary dynamics. The symbolic language combines abstract forms derived from modern cartography with representational elements inspired by Renaissance maps, reinforcing the dual scientific and artistic nature of the representation.

The SOL* functions as a tool for revealing hidden problems, making visible critical conditions related to underuse, exclusion, environmental degradation, and the erosion of cultural identity. Furthermore, by enabling the comparison of multiple spa sites, it allows the identification of patterns, divergences, and emerging dynamics, contributing to a more comprehensive understanding of the field.

Overall, the paper argues that mapping can operate as an active medium of social awareness and spatial inquiry, provided that it moves beyond one-dimensional representation and incorporates multiple perspectives and narratives. The integration of scientific data with artistic practices enhances the communicative capacity of maps, enabling them to convey complex issues effectively and to foster a more critical and participatory understanding of space and the crises that shape it.



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THE IMPLEMENTATION OF THE ORIENTATION-TECHNIQUE BOTH IN THE AREAS OF THE FOREST-CONSERVATION AND WILDFIRE-SUPPRESSION

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Introduction: The specification of the exact onset spot of the wildfire, constitutes the most crucial factor in wildfire-suppression. In order to locate and announce a wildfire, observatories (Fire-Outpost) are used from where fire-safeguards are able to directly perceive the bursting out of fire in their designated area of protection.

Aim: The specification of the exact onset spot of a fire with greater precision through incorporating the orientation-technique via a sophisticated google earth application.

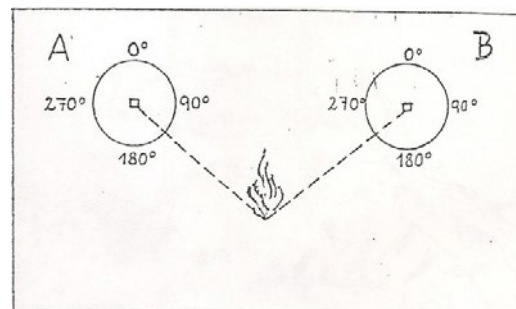
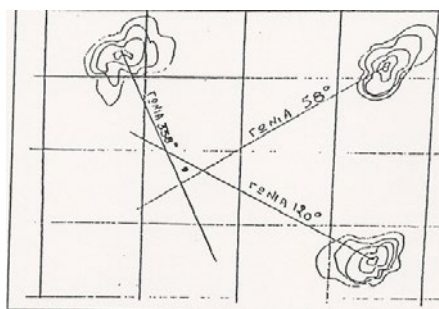
Materiel: The living work-force serving in PE.K.E. (Regional Operative Base - 199) together with the fire-safeguards as well as the inanimate such as compasses, computers, google earth map.

Method: A simulation of the onset-spot is carried out with a discrete point - construction (summit, building, telephone antenna) is signaled wirelessly from the Operative Base to the fire-safeguards. Each of them calculates the azimuth (degrees) of the spot in relation to his observatory. The specific degrees are declared to the Operative Base wirelessly again. The firefighter in PE.K.E.-199 draws in the google earth map straight lines where the start lines are the positions of the observatories and as for the angles these are equal to the degrees given by the fire-safeguards. Then he compares the cutting - points of the straight lines in comparison with the distinguishable point (claimed fire) in the google map and he calculates the divergence in metres.



Results: They are listed as an inset table for two (2) observatories out of a total of six (6), tested in the Summer 2015. Although there were discrepancies in the calculated azimuth from the fire-safeguards, the results are encouraging. The generated error is considered acceptable, according to the rules of orientation. As for the positive ones, these are the speed of information, the defining precision

of the onset - point and the reduction of the intervention time. The negative one is the difficulty of accepting this method by everyone.



Conclusion: The application had better be re-tested, the fire-safeguards should receive further training and we ought to improve it by introducing more précised devices of degrees - calculation, such as theodolite and the binoculars equipped with a compass. With this innovative technique, the role of the fire-safeguards is upgraded to the most critical task, which is for early detection of forest wildfires, their performance and efficiency are enhanced and ultimately improves the response of the mechanism wildfire-suppression as a whole. The huge advantage that arises from this application is the minimal operating cost, since fire-safeguards can be firefighters who work their working hours anyway (shift) and volunteers collaborating with the Hellenic Fire Corps.

ΠΑΡΑΡΤΗΜΑ - Πίνακας 1

ΠΥΡΟΦΥΛΑΚΙΟ 2 (Π2)

ΠΥΡΟΦΥΛΑΚΙΟ 4 (Π4)

Ημερομ. /Αξιμούθιο	23-7-15	7-8-15	25-8-15	20-9-15	A/A	23-7-15	7-8-15	21-8-15	12-9-15
Σημεία σκόπευσης (Αξιμούθιο πραγματικό)					Λαγκαδάς-Γήπεδο (6°)	8-10°	14°		10°
Εκκλησία παιδικό χωριό SOS (13°)	16°		18°		Καταφύγιο Κουρί (39°)	44°	46°		35°
Άρτεμις (86°)		83°	86°		Άγ. Βασίλειος (58°)		65°	60°	53°
Π4 (93°)	74°		105°		Παπαπασχάλη (171°)	184-188°	180°		180°
Λάναρη-κεραία (142°)		140-142°	140°		Π3 (185°)	190°	184-190°	185-190°	190°
Γήπεδο ΠΑΟΚ (214°)		210°		210°	Φάρος Αγγελοχώρι (233°)	230-240°	230-240°	245°	230°
Παλατάκι (219°)		216°		220°	Βανοστάσιο Φ/Α-κεραία (264°)	264°	262°	270°	260°
Μέγαρο μουσικής (221°)	212°		220°		Εκκλησία Γ.Ε.Χ.Α. (197°)			200°	190°
Φάρος Αγγελοχώρι (225°)		218°	213°		Λάναρη-κεραία (162°)			170°	160°
Μακεδονία Παλλάς (237°)		235°		236°					
Καυτατζόγλειο στάδιο (238°)	228°			238°					
Λευκός Πύργος (251°)		245°		246°					

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Σημειώσεις Δασοπροστασίας ΙΙ (μέρος Β) 3.Προσωπικές σημειώσεις από τις Σχολές Ορειβασίας της Ελληνικής Ομοσπονδίας Ορειβασίας Αναρρίχησης (Ε.Ο.Ο.Α.)



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ENHANCING LABORATORY SAFETY AWARENESS IN UNDERGRADUATE CHEMISTRY EDUCATION: EVIDENCE FROM A CASE-BASED STUDY IN AN EMERGING ACADEMIC DEPARTMENT

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Key words: Laboratory Safety, Student Risk Awareness, Hazard Perception Evaluation, Safety Education, Regulatory Compliance

Promoting awareness of laboratory safety represents a core element of undergraduate chemistry education, particularly within newly founded academic departments where safety cultures are still under development. In these settings, students typically possess limited prior laboratory experience, while safety procedures and infrastructure may not yet be fully established. Consequently, the development of a robust safety culture is critical at both the institutional and educational levels [1], [2]. This study examines laboratory safety awareness, knowledge, and behavioral attitudes among undergraduate chemistry students in a newly established department in Greece, with the objective of identifying key deficiencies and informing targeted educational actions.

The research was carried out at the Department of Chemistry of the Democritus University of Thrace (Kavala, Greece), which has been in operation since the 2019–2020 academic year. Data collection took place in 2024 through structured, anonymous questionnaires distributed to students engaged in teaching laboratories. The questionnaire comprised 32 closed-ended items organized into three sections: demographics and lifestyle characteristics, hazard recognition and safety-related attitudes, and laboratory safety practices. Safety awareness was evaluated using Likert-scale responses alongside knowledge-based questions consistent with the Globally Harmonized System (GHS) [3]. The dataset was analyzed using descriptive statistics, Spearman correlation analysis, and reliability assessment.

The findings indicate an overall satisfactory level of awareness regarding basic personal protective measures, with students generally demonstrating appropriate use of protective equipment and adherence to standard laboratory practices. However, important deficiencies were identified in hazard recognition and emergency response. While students showed adequate familiarity with certain hazard categories, understanding of fire-related risks was comparatively weaker, and responses related to fire management revealed uncertainty. Overall, preparedness in critical emergency situations appears limited.

The statistical analysis further suggests that safety awareness is influenced by both demographic and behavioral factors. Gender-related differences were observed, with female students tending to report higher compliance with personal protective practices. The level of study also played a significant role, with intermediate-level students demonstrating higher preparedness in specific safety domains compared to more advanced students, indicating potential gaps in continuous training. Age-related patterns imply that recent exposure to safety education may be more influential than accumulated experience. Additionally, lifestyle characteristics appear to contribute to safety-related behaviors, with certain habits being associated with either improved or reduced preparedness in emergency situations. These findings are consistent with previous research emphasizing variability in student safety awareness and the importance of structured safety education [4], [5]. The identified gaps in hazard recognition and emergency response highlight the need for systematic and continuous safety training, especially in newly established departments, while also underscoring the role of educational and behavioral factors in shaping compliance with safety protocols.

The study highlights the importance of incorporating structured, multi-level safety education into undergraduate chemistry programs, extending beyond theoretical instruction to include continuous, practice-based training. Suggested interventions involve recurring safety modules, experiential training, simulation-based activities, and routine safety evaluations. At the institutional level, additional support is required to improve laboratory infrastructure, ensure the availability of appropriate safety equipment, and implement dedicated safety management frameworks.

Despite being confined to a single department and employing a cross-sectional design, the study demonstrates that questionnaire-based methodologies can effectively evaluate safety awareness and detect educational gaps. The approach offers a practical and adaptable framework for enhancing laboratory safety education. Future investigations should prioritize longitudinal and multi-institutional designs to assess the sustained impact of safety interventions and the progression of safety culture within academic laboratory environments.

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REFRAMING LEADERSHIP AND MANAGEMENT ROLES IN CBRN CRISIS ENVIRONMENTS: A CONCEPTUAL AND OPERATIONAL PERSPECTIVE

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Keywords: Leadership, Crisis Management, CBRN threats, Roles, Team

Leadership and management are often discussed in tandem; however, in practice, they tend to capture different—though closely related—aspects of how organizations operate. This distinction becomes particularly visible in demanding environments such as crisis situations and Chemical, Biological, Radiological, and Nuclear (CBRN) incidents. Under such conditions, uncertainty, time pressure, and the potential threat to human life tend to magnify even small inefficiencies, making both leadership and management not simply relevant but essential. As contemporary research suggests, technical expertise alone rarely suffices; what is equally required is the ability to lead in an adaptive manner while maintaining a degree of structural coherence in how operations unfold [1, 2].

The notion of leadership can be traced back to the ancient Greek verb ἡγεῖσθαι, meaning “to guide” or “to lead.” This etymological perspective hints at something more nuanced than formal authority. Leadership, in this sense, is less about position and more about interaction—about how influence develops over time through trust, credibility, and, perhaps most importantly, shared intent. In high-risk settings such as CBRN response operations, this becomes more than a theoretical distinction. Personnel are frequently asked to act under pressure, often with incomplete or rapidly changing information, and sometimes at personal risk. In such moments, compliance alone is fragile; what tends to matter more is whether individuals understand—and accept—the purpose behind their actions [3].

For this reason, leadership extends well beyond simply setting direction. It involves maintaining morale, supporting resilience, and ensuring that ethical considerations remain present, even when urgency might suggest otherwise. Leaders, in these contexts, often find themselves balancing operational demands with the less visible—but equally important—task of stabilizing the human element of performance. Sustaining effectiveness under such conditions requires more than instruction; it requires the capacity to support adaptive responses in environments defined by uncertainty and risk [4]. At the same time, the relationship between leaders and team members does not remain fixed. In many cases, traditional hierarchies become less rigid, giving way—at least temporarily—to more fluid, expertise-driven forms of coordination. This tendency is particularly evident in multidisciplinary CBRN settings, where performance depends not only on technical proficiency but also on situational awareness and non-technical skills such as communication and teamwork.

Management, by contrast, follows a somewhat different logic. Derived from the Latin *manus* (“hand”), it reflects a more structured and execution-oriented perspective. Management is primarily concerned with planning, organizing, allocating resources, and monitoring outcomes. In CBRN environments, these functions are not merely supportive; they are foundational. Without clear procedures, reliable logistics, and coordinated systems of action, even highly capable teams may struggle to operate effectively. International frameworks, accordingly, tend to emphasize standardized processes and interoperability across agencies as key conditions for both efficiency and safety [2, 5].

In practice, managerial roles are rarely as stable as formal descriptions might suggest. Individuals often move between defined responsibilities and more situational roles, depending on immediate needs. This flexibility, while necessary, can introduce its own complications. Role ambiguity, for instance, may lead to hesitation or misaligned actions, particularly when time is limited. Similarly, role conflict—whether arising from competing expectations, multiple lines of authority, or simple overload—can place considerable strain on both individuals and teams. Such dynamics are not unusual in crisis environments and, if left unaddressed, may affect both decision-making and overall performance [1].

Under these conditions, balancing structure with adaptability becomes less of a theoretical ideal and more of a practical necessity. Managers are required to process continuously evolving information, communicate across organizational boundaries, and make decisions that are often both urgent and consequential. Alongside these roles, the function of the facilitator is increasingly recognized, particularly in multi-agency contexts. Rather than directing outcomes, facilitators tend to focus on how teams work—supporting communication, clarifying misunderstandings, and, in subtle ways, improving the quality of collective decisions.

Ultimately, leadership and management are better understood not as competing approaches but as complementary elements of the same system. Leadership contributes direction, meaning, and the human connection that sustains engagement, especially under pressure. Management, in turn, provides the structure and coordination necessary to translate that engagement into effective action. In high-risk environments such as CBRN response, it is this interplay—sometimes balanced, sometimes slightly uneven—that largely determines whether organizations can respond effectively, maintain continuity, and protect both their personnel and the wider public [2, 5].

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GREEN EXTRACTS DERIVED FROM GRAPE BY-PRODUCTS FOR APPLICATION IN HEALTH-PROMOTING FUNCTIONAL PRODUCTS

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Keywords: agro-industrial by-products, circular economy, grapes, functional products, sustainable bioactives

The increasing demand for sustainable and naturally derived bioactive compounds has intensified scientific interest in the valorization of agro-industrial by-products within the frameworks of green chemistry and the circular bioeconomy. Grapes and their processing residues -including pomace, seeds, skins, and stems- represent abundant yet underutilized sources of biologically active molecules with considerable nutritional, pharmaceutical, and cosmetic potential. The present study investigates the sustainable extraction, characterization, and functional evaluation of antioxidant amphiphilic bioactive compounds derived from by-products of the organically cultivated Greek red grape variety "Mavroudi". A solvent-efficient green extraction methodology was applied to recover target bioactives from grape processing residues, aiming to promote the transformation of agri-food waste streams into high-value functional ingredients [1].

The primary objective of this work is the valorization of grape by-products through environmentally friendly extraction and fractionation processes to obtain amphiphilic antioxidant compounds suitable for application in nutraceutical, dietary supplement, and cosmetic formulations. To achieve this objective, grape pomace-derived residues were subjected to a green extraction protocol compliant with current European Union regulations regarding sustainable processing technologies [1]. Extraction yield was determined in order to evaluate the efficiency and recovery performance of the applied methodology. Subsequently, the total phenolic content (TPC), total carotenoid content (TCC), and antioxidant activity of the obtained extracts were quantified using UV-Vis spectrophotometric methods. Antioxidant capacity was assessed through complementary assays including DPPH, ABTS, and FRAP, which collectively provide a comprehensive evaluation of radical scavenging potential and reducing activity. Specifically, the ABTS assay enables the detection of both hydrophilic and lipophilic antioxidant molecules, the DPPH assay primarily reflects lipophilic radical scavenging capacity, while the FRAP method evaluates the reducing power of the extracts by measuring their ability to reduce ferric ions, thus reflecting potential antioxidant activity in biological systems.

Further structural characterization of the extracted bioactive compounds was performed using attenuated total reflectance Fourier-transform infrared (ATR-FTIR) spectroscopy, which revealed characteristic functional groups associated with phenolics, polyphenols, flavonoids, and polar lipid constituents. Complementary UV-Vis spectral analysis confirmed the presence of conjugated chromophore systems within the extracts, indicating potential anti-UV and photoprotective properties

relevant for cosmetic and cosmeceutical applications. The photoprotective capacity of the extracts was further evaluated using the *in vitro* spectrophotometric method developed by Mansur et al. [2], which estimates the sun protection factor (SPF) based on absorbance measurements within the UVB region (290-320 nm).

In addition to antioxidant and photoprotective assessments, the biological functionality of the extracts was investigated through bioassays evaluating their anti-inflammatory and antithrombotic potential. These experiments were conducted using human platelet-rich plasma (hPRP) obtained from healthy donors. Platelet aggregation assays were performed to determine the ability of the extracts to inhibit platelet activation induced by two distinct agonists: Platelet-Activating Factor (PAF), a potent inflammatory mediator involved in thrombotic and inflammatory processes, and adenosine diphosphate (ADP), a classical agonist of platelet aggregation. This dual experimental approach enabled the investigation of the extracts' capacity to modulate platelet function through both PAF-mediated inflammatory signaling pathways and ADP-induced platelet activation mechanisms, as previously described by Tsoupras et al. [3].

Finally, potential challenges associated with the industrial exploitation of grape by-products -including raw material variability, stability of bioactive compounds, scalability of extraction processes, and economic feasibility- are also considered. Statistical analysis of experimental data was performed using the Shapiro-Wilk test to assess normality, while results are reported as minimum, maximum, and median values. Statistical significance was defined at a threshold of $p < 0.05$.

Overall, the findings highlight the substantial potential of grape processing residues as sustainable sources of multifunctional bioactive compounds exhibiting synergistic antioxidant, anti-inflammatory, and photoprotective properties. These results support the development of innovative functional products in the fields of nutraceuticals, functional foods, and cosmetic formulations. Moreover, the implementation of green extraction technologies contributes to a circular bioeconomy strategy by enabling the efficient valorization of agro-industrial waste streams into high-value bioactive ingredients with reduced environmental impact.

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CHILD PROTECTION IN CRISIS CONTEXTS: RETHINKING DATA GOVERNANCE AND GDPR IN EMERGENCY RESPONSE SYSTEMS

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Keywords: GDPR, Child Protection, Crisis Governance, Data Privacy, Emergency Management

In contemporary crisis environments, including natural disasters, armed conflicts, migration flows, and public health emergencies, the protection of vulnerable populations has become a central concern for governments and humanitarian actors. Among these groups, children represent one of the most at-risk populations, facing multilayered challenges that include exposure to adverse childhood experiences (ACEs) such as violence, neglect, forced displacement, loss of caregivers, and disruption of education, all of which have profound and long-term impacts on cognitive, emotional, and social development [1]. While the evidence base for child-focused public health interventions in crisis settings has grown in recent years, it remains limited in scope, geographically uneven, and insufficient in addressing critical areas such as long-term outcomes, sustainability, and the needs of children with disabilities [2]. Effective crisis response increasingly depends on coordinated, multi-agency interventions involving social services, healthcare systems, law enforcement, and humanitarian organizations, as well as on the rapid collection, processing, and sharing of personal data to ensure timely protection and support. However, this operational necessity raises significant concerns regarding the safeguarding of children's personal data within complex emergency contexts, particularly in light of evolving data protection requirements.

Despite the operational necessity of data sharing in crisis response, the European Union has established a comprehensive legal framework to safeguard children's personal data, grounded in both rights-based and risk-based approaches and supported by enforcement mechanisms. The General Data Protection Regulation (GDPR) operationalises these principles, recognising children as a particularly vulnerable group requiring enhanced safeguards, especially through consent mechanisms under Article 8 [3]. However, in emergency contexts, the application of these provisions often generates tensions between legal compliance and the need for rapid intervention. Fragmented age thresholds for consent and ambiguity in parental verification obligations further complicate cross-border coordination [4]. These challenges may delay critical decision-making and limit effective information sharing, revealing a governance gap between regulatory standards and the practical realities of crisis management.

This study aims to examine the intersection between child protection and data privacy within crisis contexts, focusing on the governance challenges introduced by GDPR in emergency response systems. It seeks to identify key legal, institutional, and operational barriers that affect the ability of stakeholders to share critical information while maintaining compliance with data protection principles. Additionally, the study explores how these challenges impact the overall effectiveness of crisis management and the

protection of vulnerable children.

The research adopts a qualitative policy analysis approach, drawing on European regulatory frameworks, official guidelines, and selected case-based examples from crisis situations involving child protection. Relevant GDPR provisions, including those related to lawful processing, data minimization, and the protection of vulnerable subjects, are examined in relation to real-world emergency response practices. The analysis also considers institutional dynamics and coordination mechanisms between public authorities and humanitarian actors, highlighting areas where ambiguity or fragmentation may arise.

The findings of this study suggest that while the GDPR provides essential safeguards for personal data, its current interpretation and implementation in crisis settings may hinder effective child protection efforts. The absence of clear operational guidelines and harmonized data-sharing protocols creates uncertainty among practitioners and limits coordinated action during emergencies. To address these challenges, this paper proposes the development of integrated governance frameworks that balance data protection with urgent response needs, including clearer legal interpretations, standardized inter-agency data-sharing mechanisms, and targeted professional training. By bridging the gap between legal requirements and operational realities, this research contributes to ongoing discussions on risk governance, crisis management, and human security. It highlights the need for adaptive policy approaches that enhance both data protection and the effectiveness of emergency response systems, ultimately supporting the development of resilient and responsive governance structures capable of addressing complex crisis scenarios.

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ANTIOXIDANT ACTIVITY AND AMPHIPHILIC BIOACTIVES IN GREEN EXTRACTS FROM FISH BY-PRODUCTS: A CIRCULAR ECONOMY APPROACH

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Keywords: fish by-products, antioxidant activity, phenolic compounds, carotenoids, amphiphilic extracts, circular economy

Fish is widely consumed and strongly recommended within the Mediterranean diet due to its high nutritional value and content of beneficial bioactive compounds. However, several fish parts, including heads, are commonly discarded as processing by-products, despite their potential nutritional and biochemical value. The valorization of these by-products represents an important research direction toward improving sustainability and supporting the principles of the circular economy. The present study investigates fish heads from four commonly consumed marine species (sardine, mackerel, anchovy, and horse mackerel) as potential sources of bioactive compounds.

The aim of this study was to perform a biochemical characterization of amphiphilic bioactives in extracts obtained from these fish by-products and to evaluate their antioxidant capacity. Following extraction using appropriate solvent systems, in accordance with EU legislations for food stuffs, the qualitative and quantitative determination of extraction yield, as well as total phenolic and carotenoid content, was carried out using the Folin–Ciocalteu method and gravitational and spectrophotometric techniques, respectively. Antioxidant activity was evaluated using three widely applied assays: DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), and FRAP (Ferric Reducing Antioxidant Power).

Additionally, UV-Vis and FT-IR spectroscopic analyses were employed to support the identification and characterization of the detected bioactive compounds. The results revealed notable differences among the examined species regarding extraction yield, total phenolic and carotenoid content. The extraction yield varied among species, with anchovy heads tending to present higher values, suggesting a potentially greater recoverability of bioactive compounds, although differences were not statistically significant. Anchovy heads exhibited the highest concentrations of these bioactive compounds, followed by mackerel and sardine, whereas the lowest concentrations were observed in horse mackerel heads.

These findings suggest a general trend indicating that fish species with higher lipid content tend to contain increased levels of amphiphilic compounds too, including phenolic bioactives and carotenoids.

Concerning antioxidant activity, the amphiphilic extracts demonstrated measurable activity in the DPPH and FRAP assays, which are primarily based on free radical scavenging and ferric ion reduction mechanisms, respectively. In contrast, no significant antioxidant activity was detected using the ABTS assay. This observation may be associated with the specific chemical composition of the extracts and the interaction of phenolic compounds with the mechanisms involved in the different antioxidant assays.

Spectroscopic analysis further supported these findings. UV-Vis spectra showed intense absorption peaks in the ultraviolet region, indicating the presence of phenolic compounds and carotenoids within the examined samples. Moreover, FT-IR spectra revealed characteristic functional groups consistent with these bioactive compounds. In particular, the detection of hydroxyl groups confirmed the presence of phenolic structures, while absorption bands corresponding to conjugated double bonds suggested the presence of carotenoids.

Overall, the present study demonstrates that fish heads represent a promising and underutilized source of natural antioxidant compounds, including phenolics and carotenoids. Although quantitative differences among species were observed, the qualitative presence of these bioactive compounds was common across all samples. The exploitation of such marine by-products may contribute to the development of sustainable strategies for waste reduction and resource valorization. Furthermore, these findings highlight the potential applications of fish by-products in the food, cosmetic, and pharmaceutical industries. Future research should focus on the isolation, identification, and functional characterization of individual bioactive compounds to further support the utilization of marine processing by-products within a circular economy framework.



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CIVIL-MILITARY COOPERATION IN CRISIS AND DISASTER GOVERNANCE IN THE WESTERN BALKANS

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Keywords: Civil-military cooperation, crisis management, Western Balkans, resilience, emergency response.

We cannot always say that civil-military cooperation has been an integral part of security systems as concepts. Over time, the need to deal with and resourcing emergency situations has also drawn attention to the fact that armed forces can be used and be effective in dealing with natural disasters and other forms of security challenges in addition to armed conflicts. The new security environment, although it may seem changing, only increases the need for civil-military cooperation, constituting a critical component in the effective management of crises and disasters, especially in regions exposed to complex security and environmental risks, without overlooking or bringing to attention the Western Balkans. We will stop to examine the role, impact, coordination and interaction of civil-military in strengthening national resilience and improving response capacities to various emergencies and disasters. Of course, a more pronounced focus will be on North Macedonia in the broader regional context, studying and analyzing existing institutional practices, operational experiences and legal issues that regulate cooperation between civil authorities and military structures.

Recent disasters and emergency situations in North Macedonia and the region show that much more work needs to be done in areas that facilitate civil-military cooperation and open up opportunities for both increasing human and logistical capacities as well as for the exchange of experiences and adaptations to face challenges that in emergency situations almost do not recognize administrative, legal or emotional boundaries for a successful confrontation. Forest fires, various floods, disasters like the one in Kocani and others taught us that in those cases this cooperation knows no boundaries and that success will depend primarily on cooperative capacities and not only on logistical ones.

The research adopts a qualitative approach, combining the analysis of national legislation, strategic documents and empirical knowledge derived from international projects and field exercises involving multi-agency coordination. Particular attention is paid to mechanisms developed through participation in European Union Civil Protection initiatives, NATO-supported programs and cross-border cooperation projects.

The study contributes to the ongoing discourse on crisis governance by providing policy-oriented recommendations aimed at improving coordination models and strengthening resilience in the Western Balkans. It also highlights the importance of integrating security and disaster risk management frameworks in addressing contemporary multidimensional threats.



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COMPUTATIONAL SYSTEM DYNAMICS FRAMEWORK USING STELLA FOR MODELING CHEMICAL ACCIDENTS IN AQUATIC ECOSYSTEMS

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Keywords: System Dynamics, STELLA, Aquatic Ecosystems, Chemical Accidents, Environmental Modelling.

Aquatic ecosystems throughout the Mediterranean basin are subject to escalating environmental risks attributable to the intensification of maritime transport operations and the expansion of coastal industrial infrastructure involving hazardous chemical substances. The inadvertent release of such substances constitutes a significant threat to ecosystem integrity, inducing disruptions in water quality, biodiversity composition, and overall ecological stability. The processes underlying such disturbances are characterised by intricate interactions among physical transport mechanisms, chemical transformation pathways, and biological response dynamics, thereby necessitating the application of advanced computational methodologies for their systematic analysis.

The present study proposes the development of a computational framework grounded in System Dynamics methodology and implemented within the STELLA modelling environment, with the objective of simulating the spatiotemporal evolution of chemical accidents in aquatic ecosystems. The proposed model is structured upon stock–flow architectures, enabling the formal representation of key state variables, including pollutant concentration, dispersion dynamics, natural attenuation mechanisms, and ecosystem response over time. The System Dynamics paradigm has been extensively employed in environmental modelling and water resource management, demonstrating considerable efficacy in the representation of nonlinear environmental processes and feedback-driven system behaviour [1][2].

The methodological approach adopted in the present study is informed by prior applications of System Dynamics in aquatic environments, with particular reference to coastal lagoon systems. The foundational work of Gamito [3] established the applicability of STELLA as a modelling instrument for the simulation of toxic disturbance effects in lagoon ecosystems, demonstrating that stock–flow representations can effectively capture pollutant dynamics and ecological response within computationally tractable yet scientifically rigorous models. Furthermore, System Dynamics approaches have been applied in the context of water pollution incidents and environmental risk assessment, substantiating their utility in the representation of complex environmental processes and their value as an analytical basis for informed decision-making [4].

While extant research has contributed significantly, the application of System Dynamics modelling has been largely confined to specific ecosystem categories, most notably coastal lagoons, without comprehensively examining the potential of STELLA as a generalised modelling instrument applicable

to diverse aquatic environments. In this context, the present study is directed towards extending the scope of System Dynamics modelling to a broader spectrum of water ecosystems, encompassing lacustrine, riverine, estuarine, and coastal marine environments. This extension necessitates the systematic adaptation of model structures to accommodate differences in hydrodynamic behaviour, pollutant transport mechanisms, and the ecological sensitivity characteristic of each ecosystem type.

A series of simulation scenarios is developed to investigate system behaviour under varying environmental conditions and disturbance intensities. Through comparative analysis conducted across multiple ecosystem types, the study evaluates the transferability and scalability of the proposed modelling framework. Particular analytical emphasis is accorded to the capacity of the model to represent nonlinear response dynamics, temporally delayed system reactions, and feedback mechanisms that govern pollutant attenuation and the trajectory of ecological recovery.

The principal contribution of the present work resides in the systematic extension of the STELLA-based System Dynamics approach beyond its conventional application domain. Through demonstrating the methodological adaptability of the framework across heterogeneous aquatic ecosystems, the study establishes STELLA as a flexible and scalable instrument for environmental modelling and impact assessment. The proposed framework constitutes a foundation for prospective research endeavours directed towards the development of more comprehensive predictive models for the analysis of chemical accident impacts and the advancement of scientific understanding of environmental system behaviour under acute anthropogenic stress conditions.

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A MULTI-OBJECTIVE INVENTORY ROUTING FRAMEWORK FOR RURAL FREIGHT LOGISTICS

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Keywords: inventory routing, rural freight, multi-objective optimization, logistics, supply chain

Rural freight mobility and logistics face persistent challenges, including inadequate road infrastructure, high transportation costs, safety risks, tolls at link access points, and dispersed demand. Traditional inventory routing models often fail to address these complexities, especially in rural contexts where alternative routing options and integrated in-haul/backhaul operations are essential for improving efficiency and reducing empty miles. In many rural regions, limited connectivity, lower road quality, and longer travel distances further increase operational uncertainty, making it difficult to design efficient and reliable freight distribution systems. These challenges highlight the need for advanced modeling approaches that can capture both operational and network-level characteristics of rural transportation systems.

This study proposes a bi-objective mathematical model for the inventory routing problem in rural logistics, incorporating multiple routing attributes (transportation costs, risks, link-access tolls, and distances) and inventory dynamics (integrated in-haul and back-haul visits). The model aims to minimize total logistics costs and transportation risk while balancing operational expenses, safety, and resilient network performance. The formulation considers multi-period planning, vehicle capacity constraints, and customer demand satisfaction, ensuring that routing and inventory decisions are jointly optimized rather than treated separately. This integrated perspective improves coordination between distribution and pickup operations, which is particularly valuable in rural logistics systems.

In this study, risk is defined as a composite measure that includes both accident risk and critical link-based resilience risk. Accident risk is derived from crash data along rural road links connecting distribution nodes, while resilience risk captures the vulnerability of the network to disruptions. This is achieved by identifying critical links representing the top 5% of the most important links based on freight flow analysis and assigning higher risk to routes that depend on these structurally significant components. This formulation enables the model to generate safer and more resilient routing decisions by avoiding both high-accident routes and critical links whose failure would significantly impact network performance.

Additionally, the model allows the selection among multiple alternative routes between nodes, which is particularly important in rural networks where route redundancy is limited. By integrating multi-attribute decision-making within a multigraph structure, the model captures the trade-offs between

cost, safety, and resilience more effectively than traditional single-objective approaches. This enhances the flexibility of routing strategies and supports more informed decision-making for logistics planners. Furthermore, the model structure can be adapted to incorporate additional attributes such as environmental impacts or service reliability, making it suitable for broader applications in sustainable transportation planning.

A real-world case study involving Walmart distribution centers in Macclenny, Baker County, Florida, and several rural Supercenters is conducted to validate the model. A modified Non-Dominated Sorting Genetic Algorithm II (NSGA-II) is developed and compared with CPLEX for solution efficiency across small- and large-scale problem instances. The proposed algorithm incorporates tailored operators to improve convergence and maintain solution diversity across the Pareto front. The comparison demonstrates the effectiveness of the metaheuristic approach in handling complex, large-scale rural logistics problems where exact methods become computationally expensive.

Results indicate that the proposed approach outperforms classical methods and improves routing decisions in rural logistics systems. The findings demonstrate that incorporating risk and resilience into routing decisions can significantly enhance network performance while reducing operational costs. Overall, this study highlights the importance of developing resilient, multi-attribute, multi-route network structures in rural logistics optimization and provides a practical framework for supporting data-driven decision-making in rural freight transportation systems.

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AI-INTEGRATED IONIC LIQUID-BASED SENSING FOR REAL-TIME DETECTION OF HAZARDOUS SOLVENT VAPORS IN INDUSTRIAL ENVIRONMENTS

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Keywords: ionic liquids, molecular interactions, gas sensing, artificial intelligence, acetonitrile

Ensuring safety and uninterrupted operation in sensitive industrial environments requires reliable systems for the early detection of hazardous chemical releases. Ionic liquids (ILs) are a class of molten salts with negligible vapor pressure, high thermal stability, and tunable physicochemical properties, which make them promising materials for chemical sensing applications. Their structure can be adjusted through the selection of cation–anion combinations, enabling control over polarity, viscosity, and interactions with target analytes. In this context, the development of highly sensitive, selective, and real-time sensing platforms is of critical importance[1]. This study proposes a sensing framework that combines ionic liquid (IL)-based sensors with artificial intelligence (AI) for real-time detection of solvent vapors, focusing on acetonitrile as a representative industrial pollutant. Imidazolium-based ionic liquids are chosen for their adjustable properties and strong interactions with polar molecules.

Ionic liquid-based systems have demonstrated strong potential in electrochemical gas sensing applications, particularly due to their tunable conductivity and interaction with gaseous analytes, supporting their suitability for sensing applications[2], [3]. The approach focuses on the use of a single ionic liquid phase as the sensing medium, with properties that can be adjusted through the choice of cation–anion combination. In this study the framework considers a range of candidate ILs selected based on interaction strength with polar vapors, and stability under operating conditions. This allows flexibility in the design while maintaining a clear selection strategy.

At the molecular level, the sensing mechanism is governed by the absorption of acetonitrile into the ionic liquid phase. This process is driven by dipole–ion interactions between the polar vapor molecules and the ionic species of the IL. The incorporation of analyte molecules into the IL disrupts the local ionic environment and modifies ion mobility within the liquid structure. These microscopic changes are directly reflected in macroscopic electrical conductivity variations, which form the basis of the sensing signal[4].

The conductivity response is particularly suitable for continuous monitoring due to its fast response time and compatibility with electronic readout systems. The relationship between analyte concentration and conductivity variation provides a direct and quantifiable sensing output[5]. To improve reliability in complex environments, multi-sensor configurations can be employed, where different ionic liquids generate partially overlapping response patterns, enhancing selectivity and reducing interference effects.

Sensor data are processed through a structured workflow that includes signal preprocessing, noise filtering, and feature extraction. Extracted features include temporal response behavior, signal intensity changes, and recovery dynamics. These parameters are then used as inputs for artificial intelligence-based models. Machine learning algorithms are implemented to classify chemical species, estimate vapor concentration levels, and detect anomalies relative to baseline operating conditions. Supervised learning approaches enable accurate classification of known vapors, while unsupervised techniques support detection of unknown or unexpected events.

To further support the sensing mechanism, molecular-level understanding of ion mobility and structural rearrangements within ionic liquids is considered. Variations in ion transport properties induced by analyte absorption provide a physical explanation for the observed conductivity changes. This link between molecular behavior and macroscopic signal response strengthens the interpretability of the sensing system and supports rational selection of ionic liquids for optimized performance.

The proposed framework is designed for continuous real-time operation, where conductivity signals are continuously recorded and analyzed. AI-based processing enables dynamic interpretation of incoming data, allowing real-time risk assessment, early warning generation, and potential automated response actions. This integration of IL-based sensing and AI-driven analytics enhances system adaptability in rapidly changing industrial environments.

Overall, the proposed approach combines the tunable properties of ionic liquids with advanced data-driven intelligence to form a flexible and scalable sensing platform. The framework provides a foundation for future experimental validation and optimization, with potential applications in industrial safety monitoring, environmental hazard detection, and chemical process control systems.

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CRISIS GOVERNANCE AND LEADERSHIP UNDER PRESSURE: DECISION-MAKING DYNAMICS IN BARACK OBAMA'S ADOPTION OF THE AMERICAN RECOVERY AND REINVESTMENT ACT (ARRA) OF 2009

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Keywords: Crisis governance, Leadership under pressure, Decision-making theory, Barack Obama, American Recovery and Reinvestment Act (ARRA) 2009.

This paper examines crisis governance and leadership under pressure through the lens of Barack Obama's decision to adopt the American Recovery and Reinvestment Act (ARRA) of 2009[1], focusing mainly on the decision-making process rather than the detailed design or implementation of the act itself. Its central aim is to analyze how a severe systemic crisis reshaped the president's choice environment and how individual leadership traits interacted with structural imperatives to produce a high-stakes policy decision. By treating the ARRA decision as a bounded case study, the paper investigates leadership-level decision dynamics and links them to broader theoretical frameworks, including Decision-Making Theory, realism and the principle of self-help (Thucydides) and trait-based leadership analysis. In doing so, it situates Crisis Governance and Leadership Under Pressure as intersecting domains through which both agency and structure can be jointly examined.

The global financial crisis of 2007–2009 created a context of acute uncertainty, compressed timelines, and heightened perceptions of systemic risk. At the outset of his presidency, Obama faced a rapidly deteriorating economic environment marked by financial instability, rising unemployment, and declining output. Under such conditions, the conventional policy cycle was significantly shortened, and the range of viable alternatives narrowed. Decision-Making Theory conceptualizes such situations as characterized by bounded rationality, where leaders must choose among imperfect options under constraints of limited information, cognitive load, and time pressure. The ARRA decision exemplifies this dynamic: rather than optimizing policy along ideological lines, the administration prioritized measures capable of averting systemic collapse.

From a realist perspective, the decision to adopt the ARRA can be interpreted through the principle of self-help, rooted in the classical tradition associated with Thucydidean thought[2]. Faced with an internal economic crisis that threatened domestic stability and international standing, the United States acted to preserve its structural capacity and relative power position. In this view, the stimulus package functioned not only as an economic intervention but also as a strategic measure to maintain state resilience and legitimacy. The adoption of large-scale fiscal expansion reflects a realist logic in which survival imperatives override ideological preferences or normative constraints. Confronted with the risk of prolonged recession or systemic breakdown, the state mobilized its own resources to stabilize

core functions, illustrating how crisis governance often entails decisive and extraordinary action under conditions of uncertainty.

Complementing this structural interpretation, the paper incorporates a trait-based analysis of Obama's leadership[3] to assess how individual characteristics shaped the decision-making process[4]. Trait Theory emphasizes that leaders' cognitive styles, emotional dispositions, and behavioral tendencies influence how they interpret problems, evaluate risk, and select among alternatives. Obama's leadership profile—characterized by deliberation, analytical rigor, and emotional composure—was particularly salient in a crisis context requiring measured judgment. His reliance on expert consultation, systematic evaluation of policy options, and preference for reasoned communication reflects high cognitive complexity and a commitment to institutional legitimacy. At the same time, his decision to endorse a large-scale and politically contentious stimulus indicates a capacity for calculated risk-taking and strategic assertiveness. This combination suggests a leadership style capable of balancing caution with decisive action, a critical requirement in crisis conditions.

The paper integrates these perspectives into a unified analytical framework that captures both structural constraints and individual agency[5]. It conceptualizes crisis leadership as a process of selecting among constrained alternatives under high stakes and limited time, while simultaneously constructing a legitimizing narrative for extraordinary policy measures. The ARRA decision is examined along two principal axes: first, as an expression of realist self-help behavior aimed at preserving state stability and power; and second, as an outcome shaped by the specific traits and decision style of the president. This dual approach enables a more comprehensive understanding of crisis governance, bridging systemic and leader-centric explanations.

The analysis suggests that effective crisis governance depends on the ability to rapidly synthesize complex information, maintain coherence in decision structures, and articulate a clear rationale for action under uncertainty. By integrating realism with trait-based leadership analysis, the paper advances a nuanced understanding of crisis governance as a phenomenon shaped by both structural imperatives and individual agency, using the ARRA decision as a concrete empirical case through which these dynamics are examined.

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TRANSITIONING GREEK PUBLIC PROCUREMENT FROM GREEN CRITERIA TO ESG INTEGRATION: A MULTI-CRITERIA EVALUATION FRAMEWORK

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Keywords: Public Procurement, ESG Integration, Green Public Procurement, Sustainable Governance, Multi-Criteria Evaluation Framework

Public procurement is a central instrument of public policy, shaping not only economic efficiency but also sustainability outcomes, market behavior, and institutional performance. In the European context, Green Public Procurement (GPP) has become an established mechanism for integrating environmental considerations into public contracting processes. However, the transition toward a fully integrated Environmental, Social, and Governance (ESG) approach remains uneven across Member States, particularly in public administrations where procurement practices continue to emphasize cost efficiency and procedural compliance rather than multidimensional value creation.

Greece represents a relevant case for examining this transition, as environmental criteria have been progressively incorporated into procurement procedures, largely reflecting European regulatory alignment. Nevertheless, social and governance dimensions remain limited and insufficiently operationalized within tender evaluation processes. In parallel, the assessment of contractors remains predominantly focused on technical and financial eligibility, without systematic consideration of broader ESG-related performance or risk profiles. This creates a dual gap in procurement systems: limited integration of sustainability criteria and insufficient evaluation of contractor reliability beyond formal compliance requirements.

This paper examines the transition of Greek public procurement from predominantly green criteria toward full ESG integration, incorporating both the public authority and contractor perspectives. It argues that environmental considerations alone are insufficient to support resilient and strategically effective procurement systems, particularly in contexts where public value creation depends on both effective supplier selection and the long-term performance of contractors.

To address this gap, the study proposes a Multi-Criteria Evaluation Framework for ESG integration in public procurement. The framework conceptualizes procurement as a dual-level governance process that evaluates both tender requirements and contractor capability through an integrated ESG lens, extending beyond price and technical specifications to include environmental, social, and governance dimensions.

Methodologically, the study adopts a qualitative policy analysis combined with a comparative review of European procurement practices. It draws on selected Greek procurement cases and established EU

approaches to identify structural patterns in ESG integration and contractor assessment, highlighting key governance and risk-related gaps.

The findings indicate that while environmental criteria are increasingly embedded in Greek procurement processes, social and governance dimensions remain underdeveloped and inconsistently applied. Furthermore, contractor evaluation practices remain largely compliance-based, with limited incorporation of ESG-related performance indicators. This results in a fragmented approach that restricts the capacity of procurement systems to function as strategic tools for risk management, accountability, and sustainable value creation.

The paper contributes to the literature on sustainable public procurement by proposing a transition-oriented framework that integrates both institutional and contractor-level perspectives. It reconceptualizes procurement as a strategic governance mechanism linking public sector objectives with contractor performance and responsibility, thereby enhancing transparency, resilience, and public value creation in Greek procurement systems.



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RESILIENCE ASSESSMENT TOOL FOR PORT PLANNING

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Keywords: Port resilience, integrated hybrid port modeling, resilience quantification, Hurricane Matthew, maritime transportation systems.

US ports and container/intermodal terminals are critical links in the marine transportation system. Disruption at a port can have a crippling economic effect in the coastal zone as well as the rest of the nation. Port stakeholders have a vested interest in the long-term function and viability of ports, but no standardized measures for performance or resilience exist for ports.

The goal of this research is to demonstrate the utility of a predictive port resilience assessment tool. The developed tool encompasses a microscopic traffic simulation model (VISSIM) based hybrid multimodal analyses of port operations and provides a quantifiable assessment of resilience. The application of this tool is shown on six ports in the Southeast US. The waterside port simulation models were developed using vessel automatic identification system data and programmed within a VISSIM simulation of landside operations.

This hybrid modeling approach was used to visualize vessels and allow them to interact in both time and space with each other and landside infrastructure. Local and regional resilience was quantified through the analysis of time-dependent resilience plots and used as a performance measure in this study. The utility of the predictive port resilience assessment was demonstrated in response to Hurricane Matthew (2016).

However, the novel procedure described herein can be applied to any port hazard. This research grows the understanding of the regional consequences of hurricane events and enhances the knowledge in the development of a stakeholder-focused tool to assess resilience.



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DEVELOPMENT OF A COMPUTATIONAL FRAMEWORK FOR EARLY WARNING AND COMMUNICATION REGARDING CHEMICAL ACCIDENTS IN AQUATIC ECOSYSTEMS

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Keywords: aquatic ecosystems, chemical accidents, prediction, early warning, communication

Chemical accidents in aquatic ecosystems constitute critical environmental emergencies, capable of generating immediate and wide-ranging adverse consequences for public health, water resource safety, and ecosystem functioning. The inherently dynamic and frequently nonlinear behaviour of pollutants in aquatic environments, compounded by uncertainty regarding the source, quantity, and physicochemical properties of the substances released, renders response time a determinative factor in the mitigation of environmental impacts. In this context, the development and deployment of early warning models represent a fundamental prerequisite for the effective management of such incidents.

Not with standing considerable advances in specialised monitoring and analytical technologies, prevailing practice is frequently characterised by data fragmentation and an absence of integrated forecasting and communication mechanisms. The extant literature establishes that effective early warning for environmental events necessitates the integration of multi-source data streams and the continuous operation of dynamic models capable of supporting real-time predictive functions. Moreover, delays in the identification and dissemination of risk assessments may substantially exacerbate the consequences of an incident, particularly where critical infrastructure — such as potable water supply networks — is implicated [1].

The present study addresses the necessity of developing a computational framework incorporating specialised early warning models for chemical accidents in aquatic ecosystems. The proposed framework is structured upon a multi-level architecture comprising: (a) a real-time data acquisition module, (b) a data integration and quality assurance module, (c) an analysis and forecasting layer, (d) an operational support layer, and (e) a targeted communication layer.

Within this architecture, the forecasting layer occupies a central analytical function, integrating pollutant dispersion models, hydrodynamic models, and anomaly detection algorithms. These models assimilate data from sensor networks, meteorological and hydrological parameters, and the physicochemical characteristics of the substances involved, with the objective of assessing the spatiotemporal evolution of the incident and anticipating the arrival of contaminants in areas of ecological or operational sensitivity. This integration facilitates a transition from a reactive to a proactive paradigm in environmental risk management.

The proposed framework additionally incorporates mechanisms for automated alert generation, predicated upon predefined threshold values and dynamic risk assessments. The operational effectiveness of early warning systems is contingent, however, not solely upon the accuracy of the underlying models, but equally upon the capacity to communicate results to relevant stakeholders in a timely and comprehensible manner. In this regard, the establishment of structured communication channels and the elaboration of differentiated messaging for distinct user categories constitutes a determinative condition for system efficacy [2].

The incorporation of principles drawn from science communication and risk communication into the design of the framework is of considerable methodological importance. The translation of complex scientific outputs — including predictive scenarios, probability estimates, and uncertainty quantification — into precise, comprehensible, and operationally actionable communications represents a critical component of an effective response strategy. The proposed framework is designed to support differentiated communication directed at multiple audiences, encompassing scientific experts, civil protection authorities, and the general public, thereby fostering institutional trust, adherence to protective guidelines, and the overall resilience of socio-ecological systems.

The contribution of such a computational framework to civil protection operations is multidimensional. It enhances operational preparedness through the timely identification of emerging risks and the provision of an evidence-based foundation for decision-making. Concurrently, it serves to reduce the exposure of both populations and ecosystems to hazardous substances through the early activation of prevention and mitigation protocols. Furthermore, the framework promotes enhanced coordination across administrative levels and operational agencies, thereby improving the overall effectiveness of the emergency response. The development of integrated early warning models embedded within a coherent computational framework for information management and risk communication represents a scientific and policy priority in addressing chemical accidents in aquatic ecosystems. This approach supports the transition towards civil protection systems characterised by greater resilience and adaptive capacity, commensurate with the scale of contemporary environmental challenges.

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THE ANHARMONIC OSCILLATION AS A FRAMEWORK FOR UNDERSTANDING AND PREDICTING CHEMICAL ACCIDENTS IN AQUATIC ECOSYSTEMS

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Keywords: Anharmonic oscillation, aquatic ecosystems, chemical accidents, prediction

The concept of anharmonic oscillation, well-established within the domains of physics and physical chemistry, constitutes a compelling theoretical framework for the characterisation of nonlinear behaviour in complex systems. In contrast to the idealised harmonic oscillator, in which restoring forces vary linearly with displacement, anharmonic systems exhibit nonlinear force–displacement relationships, resulting in amplitude-dependent frequencies, asymmetric potential energy surfaces, and the emergence of critical thresholds and abrupt dynamic transitions [1]. Although primarily applied to molecular vibrations and spectroscopic analysis, this framework affords significant interpretive and predictive value when extended to environmental systems, particularly in the context of chemical accidents in aquatic ecosystems.

Aquatic ecosystems are inherently nonlinear systems governed by tightly coupled biogeochemical processes, feedback mechanisms, and threshold dynamics. Chemical accidents of diverse origin — including industrial spills, agricultural runoff surges, and wastewater discharge failures — may elicit disproportionate ecological responses relative to the magnitude of the initial perturbation. This behaviour exhibits a marked correspondence with that of anharmonic systems, wherein relatively modest increments in energy input may precipitate qualitatively distinct system states [2]. The introduction of nutrients or toxic substances may initially be attenuated by intrinsic ecosystem resilience; however, once a critical threshold is exceeded, rapid eutrophication, hypoxia, and mass mortality events may ensue — exemplifying conditions under which linear approximations systematically fail to capture the full complexity of system dynamics.

At the molecular level, anharmonicity governs the behaviour of chemical bonds under stress conditions, influencing reaction kinetics, bond dissociation energetics, and pathways of energy redistribution. In the environmental context, these phenomena manifest as nonlinear reaction rates, particularly under conditions of elevated pollutant concentration or fluctuating temperature and radiation regimes. The scientific significance of investigating such dynamics resides in the enhancement of predictive capacity. Conventional environmental models frequently rely upon linear or weakly nonlinear assumptions, which systematically underestimate the probability and severity of abrupt ecological transitions in accident scenarios. By incorporating anharmonic principles, a more rigorous representation of threshold effects, hysteresis, and regime shifts becomes attainable. This consideration acquires particular relevance

given the intensifying pressures of climate change and escalating anthropogenic activity, which amplify system variability and drive ecosystems progressively towards the boundaries of dynamic instability.

Numerical simulation constitutes a methodologically robust avenue for the investigation of these phenomena. Through the integration of nonlinear differential equations, stochastic perturbation terms, and reaction–diffusion dynamics, computational models can effectively replicate the behaviour of aquatic systems across a range of chemical stress scenarios. Techniques such as finite element analysis, agent-based modelling, and Monte Carlo simulation facilitate the systematic exploration of parameter spaces for which closed-form analytical solutions are not obtainable. Furthermore, the coupling of hydrodynamic models with biogeochemical modules enables spatially resolved predictions of contaminant dispersion and ecosystem response. Calibration and validation against empirical datasets further enhance the reliability and generalisability of such models [3].

From the perspective of civil protection and environmental policy, the implications of this analytical approach are considerable. Enhanced modelling of nonlinear dynamics is capable of underpinning early warning systems through the a priori identification of critical state thresholds [4]. Scenario-based simulations can inform risk assessments, contingency planning, and the allocation of resources in emergency response contexts. In particular, the prediction of conditions under which a pollutant discharge may induce oxygen depletion provides a scientifically grounded basis for the formulation of rapid intervention strategies [5]. The integration of such models into decision-support systems further strengthens the interface between scientific expertise, policy formulation, and operational agency response.

The analytical interpretation of chemical accidents in aquatic ecosystems through the theoretical framework of anharmonic dynamics affords both conceptual rigour and practical utility. This approach establishes a coherent link between molecular-scale physicochemical processes and ecosystem-level response dynamics, providing a scientifically robust foundation for the development of advanced predictive methodologies. Future research endeavours should be directed towards the refinement of computational models, the expansion of high-resolution environmental monitoring networks, and the promotion of interdisciplinary collaboration aimed at translating theoretical advances into operationally applicable strategies for environmental protection and ecological resilience.

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PREPARATION AND CHARACTERIZATION OF PLA/CNF BIOCOMPOSITES FOR SUSTAINABLE ADDITIVE MANUFACTURING

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Keywords: PLA, cellulose nanofibers, biocomposites, FDM 3D printing, sustainable polymers

Plastic is essential in present-day society, from everyday uses and commodities to industrial applications. However, there has been growing environmental concern surrounding petroleum-derived materials, since their production requires a considerable amount of energy and results in the emission of hazardous secondary compounds. Moreover, their improper disposal can release numerous particles that infiltrate all ecosystems [1–3]. Thus, the need for sustainable alternatives is crucial, such as bio-based, biodegradable polymers. Specifically, polylactic acid (PLA), one of the most well-known bioplastics, is obtained by the polymerization of lactic acid derived from renewable biomass. It is biodegradable, biocompatible, and possesses high mechanical strength, tensile strength, and elasticity [3]. In contrast, its low flexibility, limited thermal resistance, and other characteristics can restrict its use. Therefore, the addition of natural reinforcements, such as cellulose, can develop biocomposites with enhanced functional properties, especially mechanical and thermal characteristics. To obtain these composites, techniques such as melt mixing and solvent casting can be employed, followed by additive manufacturing methods used to shape the material and fabricate the corresponding fused filament. Therefore, a wide range of improved products can be developed, including antibacterial food packaging, disposable cutlery, biomedical components such as drug delivery systems and biodegradable implants, scaffolds for tissue engineering, and overall biodegradable and environmentally friendly 3D-printed objects [2, 4-5].

In the present experimental procedure, a biocomposite of (PLA) and cellulose nanofibers (CNF) at a ratio of 1 wt% was produced using various pretreatment methods to evaluate how the homogeneity of the composite, and consequently its mechanical properties, are affected. One method involved the preparation of an aqueous suspension. Briefly, 1.5 g of CNF was dispersed in deionized water under continuous magnetic stirring at 70 °C. One third of the suspension was isolated and combined with 49.5 g of PLA to maintain a CNF ratio of 1 wt%. The mixture was homogenized and then dried to obtain the final composite material.

An emulsion-based blending approach was also utilized to produce PLA/CNF composites. PLA (10 g) was first dissolved in chloroform, while 0.5 g of CNF was dispersed in water to form the organic and aqueous phases, respectively. The two phases were mixed under stirring to form an emulsion, followed by solvent evaporation. Subsequently, the additional amount of PLA needed to achieve the desired

wt% ratio was added, together with acetone. The mixture was finally subjected to ultrasonication and thermal treatment.

Biocomposites produced by both methods were successfully used for the extrusion of a continuous filament with a diameter of 1.75 mm, which is required as input material for fused deposition modeling (FDM). Compressive test samples were then printed using FDM for the assessment of the mechanical properties of the composites. The mechanical behavior was evaluated according to ASTM D695 “Standard Test Method for Compressive Properties of Rigid Plastics”, while the structure and intermolecular interactions were investigated by X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR). The results showed that processing route strongly influenced composite homogeneity and final performance. The aqueous-suspension route supported better filler dispersion and more stable filament formation, while the emulsion-based route offered an alternative route for combining hydrophilic CNF with hydrophobic PLA through interfacial mixing. In the XRD patterns, changes in peak intensity and peak broadening indicated alterations in PLA crystallinity and the presence of CNF-related structural contributions, while FTIR confirmed the coexistence of the characteristic functional groups of both PLA and CNF, with no evidence of chemical degradation during processing. The compressive testing results revealed that the processing method affected the compressive load and compressive stress at maximum load, reflecting differences in filler distribution, interfacial adhesion, and internal defects within the printed specimens.

The results obtained indicate the success of the production of PLA/CNF biocomposites using simple and scalable methods of processing and conversion to filaments for use in the FDM process. The production of biocomposites consisting of renewable resources is indeed an interesting approach that allows creating more sustainable products with increased structural stability and enhanced mechanical properties. These biocomposites are of significant relevance for use in eco-friendly packaging, disposable items, medical equipment, and 3D-printing technologies.

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FROM WASTE TO VALUE: SUSTAINABLE PROCESSING OF POMEGRANATE BY-PRODUCTS VIA GREEN EXTRACTION AND THEIR ANTITHROMBOTIC ACTIVITY

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Keywords: Pomegranate by-products, green extraction, antioxidants, phenolic compounds, antithrombotic activity, anti-inflammatory activity.

Pomegranate processing generates significant quantities of by-products, mainly peel and pomace, which are often discarded despite their high content of biologically active compounds. The valorization of these agricultural residues through environmentally friendly approaches is increasingly important within the framework of sustainable development and circular economy strategies. The present study investigates the recovery of bioactive compounds from pomegranate peel and pomace using green extraction methodologies and evaluates their antioxidant and bioactive potential.

The extraction procedures were designed to minimize solvent toxicity and energy consumption while preserving the integrity of sensitive phytochemicals. Mild extraction conditions were applied in order to ensure the recovery of natural compounds with minimal environmental impact [1]. The obtained extracts were evaluated for their total phenolic content, carotenoid concentration, and antioxidant capacity using widely established in vitro assays, including ABTS, DPPH, and FRAP methods. In addition, UV–Vis and ATR-FTIR spectroscopic analyses were performed to investigate the structural characteristics and functional groups of the extracted compounds.

The results demonstrated that both pomegranate peel and pomace are rich sources of phenolic compounds, which are strongly associated with antioxidant activity [2]. Pomace extracts exhibited particularly high phenolic density despite the relatively lower extraction yield commonly observed in green extraction techniques. This finding suggests that pomace retains a substantial amount of soluble and bound phenolics after juice production and therefore represents an important source of valuable bioactive molecules. Peel extracts also presented considerable phenolic concentrations, which can be attributed to the abundance of hydrolyzable tannins and related compounds located in the external tissues of the fruit. The preservation of these compounds under mild extraction conditions indicates that green extraction methods can effectively recover antioxidants without the use of harsh chemical treatments.

Carotenoid analysis revealed the presence of lipophilic antioxidant compounds in both peel and pomace extracts, with higher concentrations detected in the peel samples. This observation is consistent with the biological role of the peel as a protective layer against oxidative and environmental stress. Although

carotenoids are generally more difficult to recover under low-intensity extraction conditions, their successful extraction confirms the efficiency of the applied methodology. In contrast, lower carotenoid concentrations in pomace may be associated with the retention of hydrophobic compounds within the fiber-rich matrix.

The antioxidant activity assays demonstrated strong radical scavenging activity and reducing capacity for all extracts examined. The results obtained from ABTS, DPPH, and FRAP assays showed similar trends and were positively correlated with the measured phenolic content [3]. Minor differences among the assays can be explained by variations in reaction mechanisms and assay sensitivity toward different antioxidant classes. Nevertheless, the overall findings confirm that extracts obtained through green methodologies retain significant biological functionality and may therefore be suitable for applications requiring natural antioxidant agents.

Spectroscopic analysis further supported the chemical characterization of the extracts. UV–Vis spectra displayed characteristic absorption bands associated with conjugated phenolic structures, while ATR-FTIR spectra revealed the presence of hydroxyl (–OH), carbonyl (C=O), and aromatic functional groups typical of polyphenols and other plant-derived bioactive compounds. The combined use of spectroscopic and biochemical analyses provided a comprehensive evaluation of the molecular profile of the extracts.

Overall, this study highlights the potential of pomegranate peel and pomace as sustainable sources of natural antioxidants and bioactive compounds. The successful application of green extraction techniques supports the development of environmentally responsible processing strategies and contributes to the reduction of agro-industrial waste. Furthermore, the recovered extracts may have potential applications in food, nutraceutical, cosmetic, and pharmaceutical products, where natural bioactive ingredients are increasingly preferred over synthetic additives.

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INNOVATIVE PORPHYRIN – BASED PHOTOCATALYSTSON 3D – PRINTED STRUCTURES FOR RAPID WATER DECONTAMINATION

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Keywords: Porphyrin, 3D-printing, Photocatalysis, Organic pollutant degradation, Natural Disasters

The global rise in environmental degradation, amplified by the increasing frequency and severity of natural disasters, has made the development of efficient water purification systems a crucial priority for disaster management and recovery. Natural disasters like floods, hurricanes, and earthquakes often damage existing water infrastructure, leading to the rapid contamination of local water sources with hazardous industrial dyes, chemical pollutants, and pathogenic bacteria. In the immediate aftermath of such events, the lack of potable water poses a serious secondary threat to public health. Therefore, there is a critical need for modular, rapidly deployable, and highly efficient decontamination technologies that can function under various environmental conditions. [1]

Photocatalysis represents a promising and sustainable method for the decomposition of contaminants in water by employing light energy for chemical degradation. The fundamental mechanism of photocatalysis involves transferring energy from a light source to a photocatalyst, which excites electrons from the valence band to the conduction band. This process generates photo-induced electron and hole pairs that participate in advanced oxidation reactions, producing highly reactive oxygen and hydroxyl radicals. These radicals can partially or fully mineralize organic pollutants, such as synthetic dyes and pharmaceutical residues, into harmless byproducts like water and carbon dioxide. [2]

Porphyrins have emerged as highly effective photosensitizers in these degradation applications due to their exceptional light-harvesting properties and adaptable chemical structures [3],[4]. However, a significant challenge in utilizing porphyrins in homogeneous liquid phases is their tendency to self-assemble, which can reduce reactivity and complicate post-treatment recovery. To address these limitations, it is essential to immobilize porphyrins onto solid supports. By attaching these molecules onto stable substrates, their structural stability is preserved, and their photocatalytic efficiency is enhanced. Additionally, immobilized systems facilitate the easy separation of the catalyst from the treated water—an important feature, especially in disaster-impacted localities where complex filtration equipment may not be available.

The integration of three-dimensional (3D) printing technology introduces an innovative approach to design these solid supports. As an additive manufacturing technique, 3D printing enables the precise fabrication of complex geometries with a high specific surface area. In the context of disaster management, 3D printing allows for the flexible production of custom-engineered photocatalytic reactors and structures (using Fused Deposition Modeling (FDM) or Stereolithography (SLA) methods) that are lightweight, portable, and optimized for maximum light exposure. By creating structures with large external surfaces, it is possible to maximize the deposition of porphyrin photosensitizers, significantly increasing the rate of pollutant degradation.[5]

In this research, various porphyrins, including H_2TPP and $H_2TPP(NH_2)_4$, were deposited onto 3D-printed structures to evaluate their performance in water decontamination. The reactivity of these functionalized structures was tested against several complex organic dyes—such as Methylene Blue, Reactive Black 5—under visible light irradiation. The results demonstrated significant potential for disaster response applications. Notably, the $H_2TPP(NH_2)_4$ porphyrin exhibited exceptional efficiency, achieving complete degradation of Methylene Blue in just 100 minutes.

This study highlights the collaboration between advanced chemical engineering and modern manufacturing as a vital role for future disaster resilience. The ability of these 3D-printed photocatalytic reactors to eliminate harmful dyes and potentially neutralize pharmaceutical contaminants and bacteria provides a flexible solution for emergency water treatment. By offering a scalable and efficient means of depollution, this technology can play a vital role in natural disaster management, ensuring that affected populations have access to safe, clean water during the most critical stages of a crisis. Future research will focus on real world application of these reactors and their effectiveness against a broader spectrum of disaster related environmental pollutants.

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BEYOND SKILLS: META-COMPETENCES FOR EDUCATORS IN CONTEXTS OF DISRUPTION, DRR, AND RESILIENCE

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Keywords: meta-competence; educator formation; adaptive expertise; resilience; disruption-sensitive education

Competence-based teacher education has shaped reform agendas for several decades, but its practical and conceptual limits are now difficult to ignore. Implementation has often been uneven, with some competences becoming embedded in institutional policy and practice while others remain marginal or difficult to translate into programmes [1]. At the same time, competence frameworks can encourage a tick-box logic when they multiply indicators without asking how teachers exercise judgement, responsibility, and educational wisdom in concrete situations [2]. This tension becomes sharper in contexts of disruption, disaster risk reduction (DRR), and resilience, where educators are not simply asked to perform pre-defined tasks. They are asked to interpret unstable conditions, work with vulnerability, make ethically defensible decisions, and continue teaching when routines are interrupted. This paper argues that the concept of meta-competences offers a more suitable language for this problem. Meta-competences are understood here as higher-order capacities that allow professionals to learn, adapt, anticipate, and create, rather than merely prove that they can perform a specified competence [3]. They are not used as a softer name for “soft skills,” nor as a vague umbrella term. In this paper, they refer to the capacities that enable educators to mobilise, connect, and further develop other competences when a situation is novel, uncertain, emotionally demanding, or poorly scripted in advance. The argument also draws on research on adaptive expertise in teacher education. This literature suggests that professional preparation should not stop at routine competence. It should cultivate teachers who can reason flexibly, attend to context, revise action, and learn from practice as conditions change [4]. Recent DRR education research points to a similar need. Although policy attention and curricular experimentation have increased, implementation remains fragmented, with limited subject integration, weak alignment with emerging pedagogies, and insufficient use of cultural, local, and indigenous knowledge [5]. Taken together, these debates suggest that educator formation needs a framework that explains how expertise, judgement, care, and action are connected under pressure.

The paper develops such a framework through the PATH of Environmental and Disaster Education strand of an international postgraduate initiative linking Greece and Canada within the MSc “Resilience, Risk, Crisis, Emergency Management, and Homeland Security.” The Environmental and Disaster Education Path is not presented here as a descriptive curriculum inventory. It is used as an analytical setting in which a set of meta-competences for disruption-sensitive education can be made explicit. The

framework is developed through conceptual synthesis across four bodies of work: competence-based teacher-education debates, meta-competence theory, adaptive-expertise research, and DRR-education implementation studies. The proposed set is therefore not exhaustive. It is offered as a structured contribution to curriculum design, programme review, and professional development.

Six meta-competences are foregrounded. The first is systems-aware situational understanding: the capacity to read educational situations through the interaction of ecological, institutional, social, cultural, and infrastructural conditions. The second is judgement under uncertainty: the ability to make defensible decisions without hiding behind false certainty or purely procedural responses. The third is adaptive pedagogical reasoning: the capacity to redesign teaching, participation, and assessment when circumstances change. The fourth is relational-ethical responsiveness: the ability to build trust, recognise vulnerability without reducing learners to it, and support psychologically safer learning environments. The fifth is policy-to-practice mediation: the capacity to translate international agendas, institutional rules, school realities, and classroom decisions into each other. The sixth is reflexive intervention design: the ability to plan, justify, implement, evaluate, and revise educational action while taking account of constraints, unintended effects, and stakeholder perspectives.

The contribution of the paper is to move beyond the familiar question of which additional competences educators should acquire. Its concern is what should organise professional action when disruption becomes part of educational life rather than an occasional emergency. A meta-competence perspective does not reject competence-based education. It asks where competence is insufficient. For disruption-sensitive education, this distinction matters. Educators need more than expanded lists of indicators. They need the capacity to connect systems understanding, adaptive reasoning, ethical responsiveness, and reflexive intervention in real situations. The paper therefore proposes a theoretically grounded and transferable framework for postgraduate educator formation at the intersection of disruption, DRR, and resilience.

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UTILIZATION OF PROJECT METHOD FOR TEACHING INTERMOLECULAR AND INTRAMOLECULAR FORCES

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Keywords: Project method, multiple choice, fill-in-the-blank questions, word search puzzles, crossword puzzles.

The purpose of this work is to find and evaluate modern and innovative ways of teaching Chemistry, with the aim of increasing students' interest in Chemistry and in general, the sciences. Chemistry, although a fundamental science, is often considered by many to be "difficult", full of abstract concepts and complicated formulas, which discourage students, resulting in them moving away without realizing that behind these apparently difficult symbols, there is a very beautiful science hidden, with everyday applications and discoveries that shape the world.

Chemistry is a very vast world, this specific work focuses on a very fundamental and interesting chapter, intramolecular and intermolecular forces. Understanding these concepts is essential, because they explain many phenomena, including the physicochemical properties of substances, chemical reactions, solubility and in general how atoms and molecules are held together. However, these concepts often cause confusion among students as they are microscopic structures and interactions that challenge the imagination. Beyond that, learning of intermolecular and intramolecular forces should take place in a student-centered way, that is, encouraging the student to actively participate in the teaching method. It is considered important to connect concepts with examples from daily life and to perform experiments that will help the student to understand intramolecular and intermolecular forces in depth and not to rely on a one-dimensional theoretical approach that will simply teach them superficial things. Furthermore, the integration of students into groups and their participation in a project promotes cooperation and teamwork, while at the same time helping them to understand the theory even more through personal research. In addition, closed-ended exercises, such as multiple choice, matching, true-false, fill-in-the-blank questions, word search puzzles, crossword puzzles, are useful assessment tools.

Teaching Chemistry in traditional ways is often limited to memorizing formulas and concepts. This results in students presenting gaps in many parts of the theory but also having difficulty connecting their knowledge to everyday life. From the above, it is considered necessary to approach the teaching of Chemistry in a more innovative and modern way, as classical methods are often unable to keep the students' interest intact and explain the concepts to them so they can comprehend. For that reason, the paper focuses on the analysis of modern methods of approaching the subject, proposing ways that will make the teaching of Chemistry more understandable, interactive and attractive for students.

The project is an innovative teaching approach for the Chemistry lesson, which enables students to actively participate in learning, thus developing very useful skills. More specifically, students take an active role in the educational process, research and apply theory in practice and are not simply passive recipients of information (Prince, 2004). Projects for the Chemistry lesson most often include experiments, simulations and applications in everyday life. In particular, students understand the connection that chemical bonds, intramolecular and intermolecular forces, dipole moment and solubility have with everyday life and the objects around them, making learning effective and experiential (Johnson & Johnson, 1999). Projects also contribute significantly to the development of critical and scientific thinking, necessary for understanding Chemistry in depth (Hofstein & Lunetta, 2004). Specifically, projects require students to search for information, evaluate data and draw conclusions. Finally, projects are usually done in groups. Thus, students learn to collaborate and develop communication skills, important for both learning and social development (Duran et al., 2006).

In conclusion, Project method is the bridge between theory and its visual representation, offering both the student and the teacher a great way to present and understand knowledge in a pioneering and innovative way. The present work highlighted the importance of innovative and student-centered teaching approaches in the understanding of intramolecular and intermolecular forces. Through the combination of theoretical analysis, educational experiments, digital tools and project-based learning, students are encouraged to actively participate in the learning process and connect abstract chemical concepts with everyday phenomena.

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THE SIGNIFICANCE OF VIDEO RECORDED EDUCATIONAL EXPERIMENTS IN THE INSTRUCTION OF THE REFRACTIVE INDEX

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Keywords: refractive index, video recorded educational experiments.

This paper deals with the teaching of the concept of refractive index in the context of Science Education, with the aim of understanding the factors that influence student learning and exploring contemporary and innovative pedagogical methods that can enhance the educational process. This topic was chosen because of the particular importance of optics in understanding fundamental physical phenomena, but also because of the frequent misconceptions that students of all levels have about the path of light, refraction and the refractive index. Teaching this topic is a pedagogical challenge, as it requires both abstract thinking and an experimental approach, while at the same time offering rich opportunities for the use of digital tools, virtual simulations and experiential activities.

The study and teaching of optical phenomena, and in particular the refractive index, are a fundamental part of modern science education. The theoretical and pedagogical framework that guides the work is linked to the modern concept of inquiry-based learning, which promotes active student participation and the development of critical thinking skills. More generally, the choice of topic arose from the observation that many students find it difficult to understand how and why light changes direction and speed when it enters different materials, while there is often confusion around concepts such as optical density, refraction, dispersion and their relationship with the refractive index. At the same time, developments in new technologies, the integration of virtual laboratories and the use of innovative teaching and assessment methods have created a need to examine how the teaching of the refractive index can be made more effective, participatory and adapted to the needs of modern educational reality.

Video recorded educational experiments are an important tool for enhancing teaching, supporting research, and improving the learning experience. They allow students to watch practical demonstrations repeatedly, reinforcing understanding and bridging the gap between theory and practice, and are particularly useful for those who miss live sessions or need to review material (Bos et al., 2016). At the same time, they provide systematic data that help educators and researchers evaluate teaching methods, improve strategies, and design curricula. By observing experiments, students develop critical thinking, problem-solving skills and a scientific approach, observe causal relationships and actively participating in data analysis and hypothesis testing. In addition, access to recorded experiments offers flexibility in learning, supports different learning paces and styles, and allows educators to disseminate effective techniques and innovative strategies (Bos et al., 2016). Overall, video recorded educational

experiments enhance understanding, critical thinking, accessibility to learning, and provide valuable data for teaching improvement and educational innovation.

Video recorded educational experiments offer unique added value to the understanding of the refractive index, as they allow the observation of details that are often overlooked during live laboratory experiments. Techniques such as slow motion make it possible to carefully analyze the path of light in complex systems, while the use of digital measurement tools on the video recorded educational experiments helps to accurately link optical data with mathematical calculations. In addition, the ability to project experiments that highlight the dispersion of light in a prism provides impressive visual evidence that the refractive index depends on color, leading to a more comprehensive and multidimensional understanding of the nature of light.

Through concept maps, the trainees will understand the connection between seemingly different phenomena (such as rainbows and optical fibres) under the common concept of the refractive index. By observing impressive phenomena (e.g. the disappearance of a glass), learners will become aware of the beauty of physics and the value of accuracy in experimental measurements. Through image commentary and experimental angle measurement, trainees will understand how a change in the medium of propagation affects the direction of light. They will be able to calculate the refractive index using trigonometric formulas. Working in teams to adjust the laser beam and take measurements promotes effective communication, respect for colleagues' opinions and the distribution of roles.

Overall, the paper concludes that teaching the concept of refractive index can be more effective when based on multimodal teaching approaches that combine theoretical analysis, experimental investigation, collaborative learning and the use of digital tools. The combination of these elements not only leads to a better understanding of the phenomenon of refraction, but also to the creation of a learning environment that fosters creativity, initiative and scientific thinking in students.

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INNOVATIVE TEACHING AND ASSESSMENT METHODS FOR THE TOPIC OF SINGLE DISPLACEMENT CHEMICAL REACTIONS

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Keywords: chemical reactions, concept map, Multiple-choice questions, Quizlet Blast.

The purpose of the following procedure is to transform learning from a monotonous and impersonal process into an engaging and enjoyable experience. This approach helps students recognize the beauty and interest of science. Additionally, the interactive nature of the activities presented in this work fosters students' familiarity with chemical phenomena and deepens their understanding, thereby avoiding rote learning - a common modern educational challenge.

Single displacement reactions constitute a fundamental topic in the study of inorganic chemistry and are central to the teaching of chemical reactions in schools. Understanding them requires the integration of knowledge related to the reactivity of elements, the electrochemical series, and redox processes, concepts that are often presented to students as isolated and abstract pieces of information. The result is the development of misconceptions and an inability to predict the outcomes of chemical phenomena, particularly when these are linked to experimental observations.

The focus of this work is the systematic study of teaching single displacement reactions through the lens of contemporary science education pedagogy. In modern education, traditional lecture-based teaching often falls short in developing skills such as critical thinking, creativity, and collaboration. Innovative teaching methods aim to transform the classroom into an active and participatory learning environment, where students become the protagonists of knowledge. Innovative teaching methods do not merely focus on the delivery of knowledge; they encourage active participation, autonomy, and the development of skills that can be applied both at school and in everyday life. Their success depends on appropriate infrastructure, continuous teacher training, and systematic evaluation of the learning process, ensuring that teaching becomes a tool for developing well-rounded and reflective students. The study examines both the theoretical content of the topic and the pedagogical practices that can be applied to teach it in the school environment. Special emphasis is placed on the role of the experimental process, inquiry-based learning, and the use of digital and interactive tools, which support the development of conceptual understanding. Finally, educational experiments, virtual laboratories, and interactive assessment tools are proposed and analyzed, aiming to enhance experiential learning and cultivate both scientific and social skills.

The analysis conducted leads to the conclusion that effective teaching of single displacement reactions

cannot be limited to the symbolic representation of chemical equations. Instead, it requires connecting the macroscopic level (experimental observations) with the microscopic and symbolic levels of chemistry. The use of experiments, virtual laboratories, and organized project-based activities is shown to significantly reduce conceptual difficulties and stimulate students' critical thinking.

The findings of this work highlight that active student participation, the integration of theory with experimental practice, and the use of modern educational technologies are decisive factors for effective chemistry instruction. When teaching single displacement reactions is organized with pedagogical planning and appropriate instructional tools, a challenging and abstract topic can be transformed into a meaningful learning experience that fosters scientific thinking, critical reasoning, and a positive attitude toward the natural sciences.

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GUIDING PRINCIPLES FOR IMPROVING THE ETHICAL CULTURE OF LAW STUDENTS

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Keywords: Legal field, Legal culture, Legal responsibility, Ethical culture, Guiding principles.

Introduction: Contemporary societies are going through predictable period in which issues related to ethics, academic integrity, and professional culture end up creating a strong belief in students' behavior that, in the absence of rules and principles regarding these components, there is a possibility that they will fail to achieve a legal culture [1].

The same is true for law students, who can deepen their knowledge so as to develop specific rules and principles of good conduct, which will be reflected in their subsequent professional activity. Thus, ensuring an adequate framework of ethical rules and values of academic integrity could create a guarantee that their behavior will be focused mainly on increasing their ethical culture, on the one hand, and legal culture, on the other hand.

Considering these aspects, the doctrine in legal studies has emphasized that, currently, a special interest from the academic environment should be given to the idea of whether the rules of ethics in the law curriculum are an essential or an incidental component [2]. The interest in this issue is all the greater as ethics are frequently violated by law students and, these circumstances, create serious concern about how well they understand the role of such rules and principles in their professional careers [3].

Objectives: This paper aims to provide a useful analysis of guiding principles in situations that could contribute to increasing the ethical culture of law students. In this regard, some relevant cases were analyzed. These refer to the principle of ethical behavior, the principle of academic integrity, as well as the principle of legal responsibility. All of these form a kind of guiding principles that should be imperatively taken into account by law students and adhered to accordingly.

Methodology: In order to achieve the above-mentioned objectives, a conceptual study of the research activity was carried out through theoretical mechanisms of activity analysis, deepening the theoretical framework in an interdisciplinary context. On the one hand, the approach focused on the ethical behavior that law students should characterize and, on the other hand, on the legal aspects that certainly enhance their ethical culture.

Conclusions: At the end of the research activity, a series of conclusive results were formulated. They particularly emphasized that, within academic activities, the status of law students is characterized by their awareness that rules and provisions of ethics and academic integrity should enhance ethical

culture [4]. Moreover, these aspects also form a framework defined by pertinent guiding principles regarding ethical culture, which cannot be improved by avoiding ethical rules and legal provisions. This means that, in the absence of adequate ethical rules and legal provisions that characterize the behavior of law students, it is impossible to achieve an ethical culture [5].

At the same time, the results of the present study also highlighted the fact that the ethical culture of law students is strongly linked to certain innovative guiding principles, accepted even within a limiting framework that imposes fair professional activity.

Consequently, the professional responsibility is stated as a principle of ethics which obliges law students adhere to a set of values, as guiding principles, which particularly characterize ethical culture, legal culture and, finally, professional culture.

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REGULATORY CONFLUENCE IN CRISIS GOVERNANCE: ARCHITECTING INTEROPERABLE INFORMATION SYSTEMS FOR EU CIVIL PROTECTION THROUGH THE CONVERGENT FRAMEWORK OF AI ACT, GDPR, AND NIS2 COMPLIANCE

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Keywords: AI Act, civil protection, crisis governance, GDPR, interoperability.

The European Union has reshaped digital governance with three key regulations:

- 1.General Data Protection Regulation (GDPR)
- 2.Network and Information Systems Directive 2 (NIS2)
- 3.Artificial Intelligence Act (AI Act).

Each one tackles a different pillar such as data privacy, cybersecurity resilience, and algorithmic accountability and leading to a complex, convergent environment for crisis management systems. This paper explores the regulatory confluence paradox in EU civil protection, where organizations must rapidly share data to improve situational awareness while also sticking to data minimization, rigorous risk assessments, and strict transparency rules.

The 2024-2025 Santorini-Amorgos seismic sequence makes a compelling case study. In this situation, volcano and tectonic activity was tracked by 23 seismic stations, coordinated by groups like the National Observatory of Athens and Aristotle University of Thessaloniki. These stations captured real-time seismic data that, incidentally, included personal location information while triggering GDPR concerns because such granular data could reveal individuals' whereabouts. High-risk AI systems used for hazard prediction brought in AI Act requirements for conformity checks and explainability. Among all those procedures, NIS2 demanded robust cybersecurity for interconnected institutional networks. This situation exposed interoperability challenges like technical, semantic, organizational, legal, and political ones as Novakouski and Lewis described.

At the heart of this case everything lies with the struggle to balance GDPR's strict purpose and minimization principles with the need for speed and data volume in emergency response. Furthermore, it becomes complicated by NIS2's tight incident reporting deadlines (24-72 hours) and the AI Act's oversight of high-risk systems. Fragmented governance resembling Tiao-Kuai administrative tensions can slow down responses. The paper suggests a convergent framework, aiming to turn overlapping regulatory demands into unified enterprise architectures.

The framework centers on multi-level governance using Memoranda of Understanding (MoUs) and Service Level Agreements (SLAs) to bring together data protection authorities, Computer Security Incident Response Teams (CSIRTs), and civil protection agencies. MoUs synchronize incident timelines,

lay out data-sharing protocols (think tiered access: public, need to know, anonymized), and pre-authorize crisis data processing under GDPR Article 6 (legal obligation/vital interests). On the technical-semantic side, shared ontologies map EDXL/OGC standards to Common Data Elements, supporting information brokers to enable push-pull exchange.

Pre-authorized protocols build in evidence that generate workflows, automating audit trails by using policy as code for compliance parameters. These connect with Machine Learning Operations (MLOps) platforms like GitHub and Splunk, giving traceability without sacrificing speed, and tying together AI Act documentation with GDPR accountability. Organizational interoperability lines up with Incident Command System phases, and the policy layer uses linked data to flag when requirements across regulations are satisfied.

Implementing all this follows several stages:

1. Build the foundation (MoUs, stakeholder mapping)
2. Harmonize approaches (interpretation memos, semantic assets)
3. Run sandbox trials
4. Deploy (training, monitoring)
5. Adapt and review with simulations.

Regulatory sandboxes modeled on the Interoperable Europe Act help test integration with legacy systems, tackling vendor lock-in and telemetry gaps with no operational risk.

Still, legacy systems often lack proper logging and deal in a mishmash of formats, so adapters are needed for parallel paths and some focused on fast alerts, others on audit logs. Adaptive governance tackles these challenges through ongoing monitoring, living playbooks, and cross-sector exercises that keep pace with evolving EDPB and ENISA guidance.

The conclusions point to regulatory convergence as a design priority and instead of constraints, the synergy across GDPR, NIS2, and the AI Act actually builds more resilient architectures. By embedding compliance into workflows, EU civil protection produces systems that are interoperable and accountable, putting lives first, without sacrificing regulatory standards. Looking forward, developing readable ontologies by machines and comparative studies across sectors will help refine future roadmaps.

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HOW DID COVID 19 ERODE THE HUMAN CAPITAL AND WHAT IS THE ROLE OF STATES IN REVERSING THE EFFECTS OF THE PANDEMIC ON NEW GENERATIONS

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Keywords: Pandemic, COVID-19, crisis, Human capital, COVID-19 effects/consequences, response

Pandemics, inherent to human nature, have long scarred human history, leaving an indelible mark and decisively influencing the shaping of future generations. Pandemics constitute crises, as they embody elements of ambiguity, uncertainty, and urgency; furthermore, the extent of their impact can never be accurately determined at the outset. A reasonable period of time must pass before their consequences can become fully perceptible, measurable, and, by extension, manageable.

This paper examines the adverse effects of the COVID-19 pandemic crisis on all fundamental aspects of human life, specifically focusing on human capital, and more particularly on children and youth. This new generation is called upon to move forward and face future challenges by overcoming the hardships caused, while also carrying forward the useful conclusions and tools that emerged from this severe global pandemic.

Addressing these adverse effects requires targeted actions, political will, and the extensive use of all technological means. The purpose of every beneficial measure or action should not be limited to remediation; it must also function preventively to avert a similar future crisis. In the first chapter of this paper, the concepts of “pandemic” and “crisis” are discussed, focusing on the COVID-19 pandemic crisis. Subsequently, the second chapter analyzes the concept of human capital and how it is built. The third chapter provides a detailed description of the crisis’s impact on physical and mental health, education, and labor. Finally, the fourth chapter outlines the methods that can contribute positively toward remediating the adverse consequences of the pandemic.

According to recent studies, such as the World Bank report, COVID-19 and the pandemic crisis triggered a massive erosion of human capital at critical moments in the life cycle, derailing development for millions of children and youth, particularly in low- and middle-income countries. Analysis of global data on young people who were under 25 at the start of the pandemic highlighted the impact of the pandemic on young people at key developmental stages: early childhood (0-5 years), school age (6-14 years) and youth (15-24 years). It was revealed that today’s students could lose up to 10% of their future earnings due to the educational disruptions caused by COVID-19 and that the cognitive deficit of today’s toddlers could be translated into a 25% drop in their earnings when they become adults.

Human capital - the knowledge, skills and health that people accumulate over their lifetime - is the key to unlocking a child’s potential and enabling countries to achieve resilient recovery and strong future

growth. However, the pandemic has closed schools and workplaces and disrupted other essential services that protect and promote human capital, such as maternal and childcare and job training. Due to the pandemic, preschool children lost a lot of their preschool education and experienced a lot of food insecurity during the pandemic. In addition, school-age children lost, on average, about thirty-two days of learning for every thirty days of school closures. This is because school closures and ineffective distance learning measures taken, made students miss out on learning and also forget what they had already learned. As a result, learning poverty has further increased. In addition, COVID-19 has dealt a heavy blow to youth employment. It is estimated that at the end of 2021, 40,000,000 people did not enter the labor market due to the pandemic, exacerbating youth unemployment trends. Also, youth earnings shrank by 15% in 2020 and 12% in 2021.

The window for addressing delays in human capital accumulation is small, as gaps in the early stages of the life cycle tend to widen over time. Without long-term targeting, the pandemic will further deepen poverty and inequality.

In this frame, this study focuses on policy options available in order to reverse the consequences of the pandemic on today's youth, underlining the priority of the issue for the future development of all countries. Given that today's under-25s, those most affected by the erosion of human capital, will make up more than 90% of the most productive-age workforce in 2050, reversing the impact of the pandemic on them and investing in their future should be a top priority for governments. Otherwise, these groups will represent not just a lost generation, but rather many lost generations.



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ASSESSING THE ACCESSIBILITY OF TRANSPORTATION EMERGENCY MANAGEMENT FOR PERSONS WITH DISABILITIES: A CANADIAN CASE

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Keywords: Accessibility, Disability, Emergency, Resilience, Governance

This presentation reports findings from a national research project examining the accessibility of emergency management within Canadian federally regulated transportation systems. The project considers whether emergency management measures account for the diverse ways persons with disabilities experience emergency situations, and whether gaps in accessibility contribute to heightened risk during emergencies. The research demonstrates how governance, standards, emergency technologies, education and training, and operational practices intersect to shape accessibility outcomes in transportation emergencies. Attention is given to how misalignment across these domains produces systemic risk for persons with visible and nonvisible disabilities, especially those with cognitive disabilities.

Grounded in the social model of disability, the study conceptualizes disability as arising primarily from societal barriers rather than individual impairment [1]. From this perspective, exclusion reflects failures in governance, infrastructure design, communication systems, and workforce training embedded within emergency management. The study considers barriers affecting persons with various types of disabilities, with particular emphasis on persons with cognitive disabilities as an understudied and underserved group in emergency management research and practice [2].

Cognitive disability denotes a disadvantage associated with variations in cognitive functioning relative to commonly accepted expectations, with individuals showing diverse strengths and limitations that may be temporary or lasting and change over time [3]. Transportation emergency situations may further exacerbate cognitive barriers due to complex layouts and time-sensitive environments, increasing cognitive load and stress. These factors may limit an individual's ability to recognize danger, understand instructions, interpret environmental cues, and take protective action [4].

To examine these issues, the project reviews both proactive emergency management measures. The research draws on Canadian and international scholarly and grey literature, legislative and standards

analyses, outreach to emergency managers, and consultations with persons with disabilities.

Project Findings: Accessibility Gaps and Implications for Inclusive Resilience. The study identifies systemic accessibility gaps across Canadian emergency management and practices in transportation, reflecting broader weaknesses in governance, preparedness, and system design. Accessibility is most often addressed as an individual accommodation rather than embedded as a core design and security requirement across the emergency management lifecycle.

First, the findings highlight inconsistent governance, accountability, and leadership for accessibility in emergency planning. Responsibilities for accessible emergency management are fragmented across agencies and operators, resulting in uneven integration into security planning, standards, and oversight mechanisms. Meaningful involvement of persons with disabilities in emergency planning, exercises, and evaluation remains limited. Findings recommend the implementation of inclusive codesign strategies to improve accessibility and safety. **Second**, preparedness and education measures—including traveller information and staff training—are insufficiently tailored to diverse functional needs. Emergency preparedness resources are uneven in quality and accessibility, particularly for persons with cognitive, sensory, or communication-related disabilities. Staff training on accessible emergency response is inconsistent and often lacks focus on invisible disabilities, stress responses, and respectful assistance. Exercises and drills rarely test a broad range of disability-related scenarios, limiting systems' readiness. **Third**, communication emerges as a central crosscutting barrier. Emergency information is frequently delivered through single channel, security driven, or cognitively complex formats that are difficult to interpret under stress. Findings emphasize the need for plain language, multimodal, and redundant communication and alert systems that support cognitive and sensory accessibility across preparedness and response. **Fourth**, the built environment and wayfinding systems often undermine safe evacuation and sheltering. Emergency routes may be inaccessible, overly complex, or poorly differentiated from everyday circulation, while emergency signage frequently fails under degraded sensory or lighting conditions. The study identifies the need for intuitive wayfinding, accessible shelter-in-place options, and design approaches that anticipate diverse needs during emergencies. **Finally**, incident response and continuous improvement processes lack systematic attention to disability experiences. Staffing, surge capacity, feedback mechanisms, and reviews rarely incorporate accessibility metrics, limiting organizational learning and long-term resilience. **Collectively**, these findings demonstrate that inclusive transportation emergency management requires a shift from ad hoc accommodation toward proactive, evidence informed accessibility embedded across governance, security, technology, education, and operational practice. Such integration is essential to reducing risk and strengthening resilient transportation systems for all.

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ETHICS IN PUBLIC HEALTH EMERGENCIES AND DISASTER MANAGEMENT

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Keywords: Public Health Emergencies, Disaster Ethics, Ethical Decision-Making, Health Systems Resilience, Disaster Preparedness and Response

Public health is a fundamental collective and political function aimed at preventing, protecting, and promoting health at the population level. In the modern global environment, increasing threats such as pandemics, climate change, natural and technological disasters and social inequalities highlight the preparedness and resilience of health systems as critical components of public health. Public health emergencies are characterized by high levels of uncertainty, time pressure, and limited resources, requiring immediate, coordinated, and cross-sectoral responses. At the same time, they create an environment in which technical and organizational decisions coexist with complex and often conflicting ethical dilemmas [1].

The concept of a public health emergency refers to events that seriously threaten population health and require immediate and coordinated action, such as epidemics, natural disasters, and humanitarian crises. It is distinguished from the concept of a disaster, which exceeds a community's capacity to respond using available resources [2]. The extent and severity of impacts depend not only on the event itself but also on the vulnerability and response capacity of societies. Vulnerability encompasses both material and social dimensions, while the increasing frequency and complexity of crises intensify their overall impact [2].

Despite the existence of international frameworks and guidelines developed by public health and humanitarian organizations (WHO, UNDDR, IHR, CRED), disaster management remains predominantly operational, biomedical, or normative in its approach. Although some frameworks incorporate ethical principles [3,4], these often remain at a theoretical level and are not translated into clear and applicable decision-making tools. The absence of a unified and operational ethical framework creates significant challenges both in practice and in ensuring fairness and transparency [1].

The international literature demonstrates that ethical dilemmas in disaster settings are largely recurrent and predictable, manifesting at two interrelated levels: the macro level and the micro level. At the macro level, challenges are associated with the institutional and socio-political context. Factors such as lack of transparency in decision-making, inadequate organization of humanitarian assistance, social and economic inequalities, and media influence contribute to conditions of unequal access to services, misallocation of resources, and violations of fundamental rights. Furthermore, the absence of clear and applicable guidelines hampers coordination and effective response [1].

At the micro level, healthcare professionals and frontline workers face intense ethical dilemmas on a

daily basis. Triage, particularly in mass casualty situations, requires decisions often based on utilitarian criteria, namely the maximization of overall benefit. However, such decisions may conflict with the principle of equality or respect for the intrinsic value of each individual. At the same time, questions arise regarding the limits of the duty of care, especially when professionals are required to place their own health or safety at risk, as in cases of epidemics or armed conflict [1].

Furthermore, maintaining confidentiality and privacy is often challenging in disaster settings, where conditions are unstable and infrastructure is limited. The need for rapid decision-making may lead to paternalistic approaches, with reduced patient autonomy and inadequate informed consent processes [1]. The lack of specialized training in disaster medicine and ethical decision-making increases the risk of errors and exacerbates the moral and psychological burden on professionals [4].

Decision-making in such contexts is often based on empirical or intuitive approaches due to the absence of standardized and validated ethical tools. This may result in inconsistencies, value conflicts, and reduced public trust in authorities [4]. Ethical issues are not limited to immediate life-and-death decisions but extend throughout the entire disaster management cycle, from preparedness and response to recovery, and are closely linked to broader political and social dynamics, where macro-level factors directly influence micro-level decisions.

Preparedness and response planning constitute a comprehensive process covering the entire crisis cycle, including mitigation, preparedness, impact, response, and recovery phases [2]. This process is based on an “all-hazards” approach and requires strong institutional frameworks, effective governance, coordination, and community engagement [5]. The experience of the COVID-19 pandemic has further highlighted the need to strengthen public health systems and integrate ethics into governance, policy design, and education [5]. The contemporary approach is shifting from a narrowly biomedical model toward a more holistic and socially oriented model that takes into account inequalities and the social determinants of health.

In conclusion, ethics constitutes an integral and functional component of emergency and disaster management. The development and implementation of unified, cross-sectoral, and practically applicable ethical frameworks, combined with enhanced professional education and preparedness, are essential for ensuring fair, consistent, and effective decision-making. Such efforts directly influence the survival, well-being, and trust of affected populations. The systematic integration of ethics into the design and implementation of public health policies can strengthen transparency, accountability, public trust, and the resilience of health systems in the face of contemporary global challenges [1].

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RESILIENCE OF CONCRETE WITH EXPANDED POLYSTYRENE FROM MARINE WASTE IN CHEMICALLY AGGRESSIVE ENVIRONMENTS

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Keywords: concrete with expanded polystyrene, chemical attack, capillary water absorption, mechanical behaviour, chemical durability

The construction sector is facing increasing pressure to reduce its environmental footprint, particularly due to the extensive use of natural aggregates in concrete production, which contributes to the depletion of natural resources and raises significant environmental concerns. This issue is further intensified by the growing demand for construction sand, a key component of concrete, whose extraction from riverbeds and coastal areas leads to severe environmental impacts, including ecosystem disruption, biodiversity loss and deterioration of water quality. It is estimated that approximately 50 billion tones of sand are consumed annually, exceeding the natural replenishment rate and highlighting the urgent need for sustainable alternatives. [1]

Expanded polystyrene (EPS) is a polymer that has attracted considerable interest due to its low density, lightweight structure, good thermal insulation properties and adaptability to various applications. These characteristics have led to its widespread use, especially in construction and packaging, resulting in continuously increasing production rates. However, despite its advantageous properties, EPS poses considerable environmental impacts at the end of its life cycle, as it is non-biodegradable and tends to accumulate in landfills and aquatic systems. [2]

In order to address those critical challenges, the partial replacement of natural aggregates in concrete mixtures with recycled EPS has attracted the interest of researchers, as its great properties make it a promising lightweight aggregate substitute, contributing simultaneously to effective waste management and conservation of natural resources. [3]

Nevertheless, existing studies mainly focus on the mechanical and physical properties of cementitious materials incorporating EPS. This study focuses on the development, performance and resilience of concrete composite materials with marine waste expanded polystyrene. Natural aggregates at a range between 4-8 mm were substituted with EPS particles at levels of 0%, 30%, 50%, 70% and 90%. The behavior of the samples in chemically aggressive environments was studied through aqueous solutions of sulfuric acid, sodium sulfate and sodium chloride. The investigation was conducted at intervals of 7, 28 and 56 days. The mechanical performance and transform phenomena of the samples were investigated through flexural strength and capillary water absorption tests.

The results have indicated that although a reduction in initial strength was observed with the utilization

of EPS, several specimens incorporating EPS performed better than conventional concrete in terms of strength development in aggressive environments. Furthermore, a clear correlation between the flexural strength measurement and capillary absorption shows that increased porosity is directly associated with the decrease in strength. In addition, X-Ray Diffraction (XRD) analysis, provided valuable insight into the microstructural evolution of the specimens, revealing changes in their crystalline structure. These results highlight the complex interaction between porosity development and long-term durability performance of EPS-modified concrete in various chemically corrosive conditions, aligning with current efforts toward sustainable resource management and resilient infrastructure systems.

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APPLYING GREEN LEAN SIX SIGMA FOR RESILIENT HOSPITAL SYSTEMS: ADVANCING PUBLIC HEALTH SECURITY IN TIMES OF CRISIS

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Keywords: Green Lean Six Sigma, hospital resilience, public health security, crisis management, inclusive healthcare

The global landscape of public health has been fundamentally reshaped by a series of cascading crises, ranging from global pandemics to climate-driven disasters, which have pushed even the most advanced health systems to a breaking point. These events have done more than just strain resources; they have acted as a diagnostic tool, exposing deep-seated structural inefficiencies and persistent inequities that hinder a rapid, effective response (2). To move forward, we must look beyond traditional management and embrace a more robust framework. Green Lean Six Sigma (GLSS) stands out as a sophisticated, structured methodology that can bridge the gap between operational excellence and the urgent need for hospital resilience (1,5). By integrating these principles, we can enhance public health security while ensuring that the pursuit of efficiency does not come at the cost of sustainability or human-centered care.

At its core, GLSS is a powerful hybrid that marries the waste-reduction focus of Lean, the statistical precision of Six Sigma, and the ethical imperative of environmental sustainability (5). In a standard hospital setting, this approach is already recognized for streamlining workflows, cutting resource consumption, and boosting the overall quality of care (1). However, the real untapped potential lies in how GLSS can be applied to crisis management. Resilience in a healthcare context is often misunderstood as purely technical or financial strength, but true resilience requires an inclusive approach that accounts for the diverse needs and vulnerabilities of both patients and the frontline workforce (2).

When we look at the evidence from disaster management and quality improvement, it becomes clear that GLSS acts as a strategic enabler for adaptive capacity (2). During a crisis, a hospital must be able to pivot instantly, reallocating scarce resources and reorganizing complex workflows under extreme uncertainty. This is where the toolset of GLSS—such as value stream mapping and root cause analysis—becomes invaluable for data-driven decision-making and clearing systemic bottlenecks (1). Yet, for these tools to be truly effective in a crisis, they must be applied through a lens that prioritizes the human experience. It is not enough to move patients through a system faster; it is equally important to ensure that care pathways remain accessible to marginalized groups, including older adults and individuals with disabilities.

One of the most critical aspects of modern resilience is inclusive healthcare. While the digital transformation of medicine has brought significant efficiency gains, it has also inadvertently created a

digital divide. During crises, when digital tools often become the primary point of contact, individuals with limited access to technology or low digital literacy risk exclusion from essential services (3). Incorporating inclusive design principles into GLSS frameworks ensures that process improvements do not become barriers to equity. Redesigning patient pathways to include non-digital alternatives and accessible communication strategies enables healthcare systems to respond effectively to all population groups.

None of this is possible without strong and ethical leadership. Crisis governance requires balancing rapid decision-making with transparency, inclusivity, and accountability (4). GLSS offers a shared methodology and common language that fosters collaboration across clinical and administrative functions. This alignment supports coherent action under pressure and helps maintain public trust. When continuous improvement principles guide decision-making, hospitals become more agile and responsive in crisis situations.

Finally, environmental sustainability remains a core component of long-term resilience. Optimizing supply chains, reducing waste, and improving energy efficiency enable hospitals not only to lower their environmental impact but also to strengthen their preparedness against resource disruptions during crises (5). This integrated approach supports a holistic vision of public health security, where operational efficiency, environmental responsibility, and social equity are interconnected. Ultimately, embedding human-centered principles within GLSS enables the development of hospital systems that are not only efficient and sustainable but also inclusive and resilient. Future research should focus on empirical validation of these frameworks in real-world crisis contexts.

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AUTONOMOUS SYSTEM FOR SUPPLY ENERGY IN A HOSPITAL UNDER ANY SITUATION OF CRISIS OR DISASTER, CASE STUDY: IERAPETRA AND ERMOUPOLI

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Keywords: hospitals, energy, AI, crisis and disasters conditions, hybrid system.

Without a doubt energy is a crucial factor for urban development [1], in addition hospitals are the most critical infrastructure in any society, and their buildings are constructed with special features. Their electrical systems are also unique, owing to the requirement for power during any crisis or disaster. Continuous operation and specialized conditions make hospitals among the most energy-intensive facilities. In this article, a hybrid electrical system was optimized in order to cover the demands of a clinic in a Greek hospital. Simulations were performed using HomerPro (Hybrid Optimization Model for Multiple Energy Resources) software, which is an excellent tool for engineers determining the most financially sound and technically feasible way to combine different electricity sources for a specific case [2]. The system is based on the use of photovoltaic panels, small wind turbines, and generators, with the capability to store energy in batteries or fuel cells.

The proposed system was designed to be autonomous, with the intention of covering the needs of a typical hospital clinic building. The required energy demand on a daily basis can be easily derived from scientific references. However, the necessary daily load profile was created using an Artificial Intelligence algorithm due to a lack of real-time data. It is important to note that energy needs vary by month—not only for heating and cooling but also for required electricity for others uses; hence, each month has a corresponding load profile. By utilizing both renewable energy sources and storage systems, the presented hybrid system provides safety, energy savings, and significant environmental benefits to the local community in terms of that significant quantity from Greenhouse gas (GHG) emissions is not emitted into atmosphere.

As a case study, the system was optimized for a clinic building in two Greek cities, Ierapetra and Ermoupolis. Ierapetra is a small municipality with a population of approximately 25,700 residents, located on the south coast of Crete (Latitude 35.01°N, Longitude 25.74°E, Elevation 10 m). Ermoupolis is a small town and the capital of the Cyclades with a population of roughly 21,100 inhabitants (Municipality of Syros-Ermoupolis), located on the east coast of Syros (Latitude 37.44°N, Longitude

24.94°E, Elevation 20 m).

It is essential to say that although Crete is the largest island in Greece and the fifth largest in the Mediterranean; only recently was its interconnection with the mainland national grid completed. The longterm (1955–1997) meteorological data (wind speed, solar irradiation, heating degree-days, and cooling degree-days) required for Ierapetra and Ermoupolis simulations were derived from the TOTEE 20701-3 [3] and from official data from NASA [4].

In the presented case study, the daily solar radiation is 4.87 and 4.65 kWh/m²/day for Ierapetra and Ermoupolis correspondingly. The annual average wind speed is 4.73 m/s for Ierapetra while in Syros-Ermoupolis (Longitude 24.948, Latitude 37.421) recorded at 6.93 m/s. The required Heating Degree Days (HDD) (base 18°C) are 833 (Ierapetra) and 892 (Ermoupolis) and Cooling Degree Days (CDD) (base 26°C) are 310 (Ierapetra) and 284 (Ermoupolis). Data for the clinic building, derived from previous work by Serghides, Dimitriou, and Kyprianou [5], includes four floors with a total area of 1,179.4 m², of which 810.4 m² are conditioned. Energy demand in Ierapetra fluctuates from approximately 13,300 kWh in February, up to 22,600 kWh in July, which indicates a significant increase of approximately 70% during the summer months. In the case of Ermoupolis the power consumption varies between a low of 11,300 (February) and a peak of 20,600 (July) representing a difference of more than 82%. Based on the results from the HomerPro the optimum solution for Ierapetra includes 210 kW of photovoltaics, 9 wind turbines with rated power 5 kW, with 173 batteries, each of them with capacity 5.12 kWh and a 100 kW converter. Cost of energy is 0.269 €/kWh (Ierapetra). In the case of Ermoupolis the most economic system architecture is a hybrid system with 85.5 kW of photovoltaics, 14 small wind turbines with rated power 5 kW, one small 3 kW wind turbine with vertical axis, a 50 kW converter and batteries with total capacity approximately of 543 kWh (106 batteries), with cost of energy 0.197€/kWh. The simulations results showed that the cost of energy is comparable to the cost of electricity from the national grid.

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TECHNO-ECONOMIC FRAMING OF A PEM-BASED HYDROGEN-TO-POWER SYSTEM FOR A GREEK NON-INTERCONNECTED ISLAND

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Keywords: non-interconnected islands, green hydrogen, PEM fuel cell, curtailed renewable energy, techno-economic assessment

Greek non-interconnected islands remain highly constrained power systems, still relying on thermal generation units. At the same time, increasing wind and solar penetration often leads to renewable curtailment, mainly because of stability limits, minimum loading of conventional units. In this context, curtailed renewable electricity can be treated as a recoverable energy carrier rather than a system loss. This work presents a preliminary techno-economic assessment of a PEM-based hydrogen-to-power pathway for a representative medium-sized Aegean island.

The proposed chain includes desalinated water production, PEM electrolysis, hydrogen compression, gaseous storage, and electricity generation through a PEM fuel cell. For an island with an annual demand of about 140 GWh and several GWh of curtailed renewable energy, the available surplus could support approximately 100–180 t of green hydrogen per year. Assuming a PEM fuel cell net efficiency of 50% on a lower heating value basis and an H₂ LHV of 33.3 kWh/kg, each kilogram of hydrogen can deliver roughly 16.7 kWh of electricity.

Thus, about 60 kg H₂ are required for 1 MWh, while 600 kg and 6 t correspond to approximately 10 MWh and 100 MWh, respectively. A 500 kW PEM fuel cell would consume about 30 kg H₂ per hour, or nearly 720 kg for continuous 24-hour operation. The analysis indicates that the main capital cost drivers are the electrolyser, fuel cell, and compressed hydrogen storage, while reverse osmosis remains a secondary cost component. Overall investment is expected to lie in the range of a few million euros, with annual operating costs of a few hundred thousand euros. The proposed configuration is therefore not a replacement for the thermal fleet, but a technically credible option for targeted dispatchable support, renewable curtailment recovery, and improved island-system flexibility.

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DEVELOPMENT OF BIO-DERIVED NANOCOMPOSITE MATERIALS WITH ENHANCED MECHANICAL AND ABSORPTIVE PROPERTIES

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Keywords: poly(lactic acid), graphene oxide, nanolignin, grape pomace, food packaging

It is well known that plastic products are widely used in everyday life, because of the low cost and high adaptability. However, they cause environmental burdens and intensify the need for sustainable materials that support circular economy strategies. Therefore, there is an increasing need to use bio-based and biodegradable polymers such as poly(lactic acid) (PLA) for many applications, especially in the food packaging industry, which produces huge amounts of plastic waste. Although PLA has many advantages there are certain limitations such as low antioxidant activity, brittleness, low thermal stability and limited mechanical properties^[1]. To overcome these disadvantages, in this work PLA is reinforced with nanocomposites, nanolignin (nLG) and graphene oxide (GO), to enhance its structural and absorptive properties. Lignin is a biopolymer derived from lignocellulosic biomass and by reducing its size to nanoscale its reactivity and compatibility with PLA are improved, which is attributed to its specific surface area and improved dispersibility. GO is a nanomaterial used in the film to improve its thermomechanical, electrical and gas barrier properties^[2]. It is produced from grape pomace, an abundant agro-industrial waste, so circular economy is promoted. This approach contributes to waste valorization and resource efficiency, which are key components of resilience-oriented systems.

Kraft lignin was used to produce nLG through chemical processing, including alkaline treatment and acid precipitation, resulting in nanoscale particles with improved compatibility with the polymer matrix. GO was produced from grape pomace via pyrolysis, at different temperatures (400, 500, 600°C)^[3], yielding biochar as an intermediate product. After determining the optimal pyrolysis conditions, the selected biochar was used to synthesize GO via the Hummers method. The composite films (PLA, PLA/nLG, PLA/nLG/GO) were fabricated via melt extrusion using a 3D Filament Maker ONE single-screw extruder. The filaments were then used to fabricate films by fused deposition modeling (FDM). Their physicochemical properties were analyzed using Fourier-transform infrared spectroscopy (FTIR), and X-ray diffraction (XRD), while their structural properties were analyzed using scanning electron microscopy (SEM). To determine the optimal nLG and GO loading, water and ethanol absorption tests were conducted. The measurements were carried out according to ASTM D570, by immersing film samples in distilled water and ethanol, for specific durations (24, 48, 72, 96h), and the mass variation and absorption percentage were calculated. The results were used to assess the influence of nLG and GO concentration on the absorptive behavior of the films. Additionally, the mechanical properties were evaluated through tensile testing, according to ASTM D882-18. Specimens were fabricated with dimensions of 70mm × 10mm and tested using universal testing system, under controlled conditions.

Tensile strength, elongation at break and Young's modulus were determined to assess the effect of incorporation of nLG and GO on the mechanical properties of the film.

SEM analysis revealed that increased pyrolysis temperature enhanced the porosity of the biochar and increased carbon density. FTIR and XRD analysis revealed that higher temperatures promoted the formation of graphitic structures with 500°C identified as the optimal condition for producing materials suitable for further functionalization). Also, FTIR results confirmed the successful incorporation of nLG and GO in the PLA matrix as their functional groups formed strong hydrogen bonds with it. The absorption experiments indicated that nLG concentration plays a key role in the interaction of films with polar solvents. At lower concentrations, there was a moderate increase in the absorptive behavior, attributed to the presence of hydrophilic functional groups of lignin. However, at higher loadings the absorption decreased, due to particle agglomeration. Optimal performance was observed at 3% loading, where there was achieved a balance between dispersion and interaction with the polymer matrix^[4]. Mechanical testing showed that the addition of nLG significantly improved the tensile strength and stiffness of PLA films up to an optimal concentration of 3%, beyond which agglomeration effects reduced performance. Elongation at break exhibited a similar trend, highlighting the balance between flexibility and reinforcement. These findings demonstrate that controlling filler concentration and particle size is essential for optimizing material performance.

The combined incorporation of nLG and GO provided synergistic improvements in mechanical strength, barrier properties and functional performance, contributing to the development of multifunctional materials. These materials can be easily used in sustainable food packaging applications, where enhanced durability and extended shelf life can support food security and reduce waste. From a broader perspective, this research contributes to resilience-oriented material innovation by integrating waste valorization, use of sustainable resources and improved material performance. The use of agro-industrial residues such as grape pomace, aligns with circular economy principles and supports the transition toward more sustainable and environmentally resilient production systems. This study highlights the role of advanced food packaging films with improved mechanical and absorptive properties, suitable for food packaging, offering increased protection and safety to the consumer.

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SYNERGISTIC EFFECTS OF NANOBUBBLES AND CARBON NANOMATERIALS ON CEMENT HYDRATION AND MICROSTRUCTURAL EVOLUTION

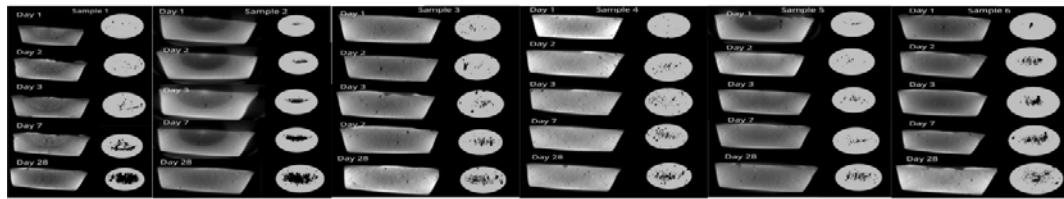
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Keywords: Nano-engineered cement, Infrastructure resilience, Nanobubbles, Carbon nanomaterials, Porosity and microstructure

Due to the growing exposure of climate-induced hazards, environmental degradation and age-related structural sensitivity, a series of significant challenges for risk evaluation and resilience planning has been presented [1]. Failures in architecture systems appear to have serious consequences on public safety and economic stability [2]. In that frame, the development of advanced structural materials, that are more durable and relatively degradation resistant, is of great importance for strengthening the resilience of the infrastructure systems and also providing information on risk mitigation strategies [3]. This study investigates the effect of air nanobubbles (NBs) combined with carbon nanomaterials (carbon nanotubes / CNTs and graphene nanoplatelets / GNPs) on the hydration process and microstructural evolution of Portland cement. The research focuses on the way the nanoparticles can improve the performance of the infrastructural longevity and resistance to environmental stress factors. Six cementitious samples were produced using a water-to-cement ratio of 0.5, using drilling water with or without NBs and with or without the addition of carbon based nanomaterials, allowing, through the experimental procedure, the assessment of independent and synergistic effects of NBs and nanomaterials. The samples were analysed during the days 1, 2, 3, 7 and 28 of hydration using multiple advanced characterisation techniques, them being X-ray diffraction (XRD) for the phase identification and Micro-computed Tomography (Micro-CT) for the analysis of porosity.

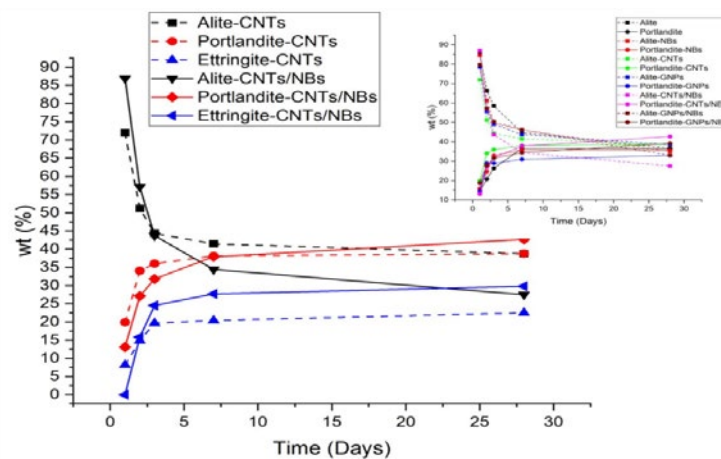
Micro-CT analysis revealed an important reduction in porosity when nanoparticles are added, especially where nanobubbles and nanomaterials work synergistically. NBs enhance the dispersion of nanoparticles leading to a much denser and more homogeneous microstructure (Figure 1). In this study, the microstructural improvement, specifically the reduced porosity, the enhanced particle dispersion and increased nucleation density, are directly associated with improved durability, lower permeability and increased resistance to environmental degradation, properties that are critical determinants of infrastructure performance under stress conditions [4].

Figure 1. Porosity progress during the 28 day hydration process through Micro-CT.



The XRD results show that the inclusion of carbon nanomaterials or nanobubbles does not alter the basic crystalline phases of the cement. However, via the Rietveld refinement analysis that took place using the raw data from the XRD, a significant acceleration of hydration reactions was observed, resulting in quicker stabilisation of the components. When nanoparticles are added in the cementitious matrix, the components are stabilised sooner, while when NBs and nanomaterials are inserted together, the products of the hydration reactions are mostly favoured. These results are strongly correlated with rapid construction or post-disaster reconstruction, where the longevity of the materials is critical [5]

(Figure 2. Basic cement components quantity progress during 28 day hydration through XRD. Comparison between the least and most enhanced substrates).



In conclusion, the synergistic use of air NBs and carbon nanomaterials represents a promising approach for the design of next-generation cement systems with enhanced performance characteristics. The findings of this study provide a scientific basis for further exploration of nano-engineered materials in infrastructure applications and underscore the importance of multiscientific approaches that combine materials science with resilience planning, policy development and also strategic infrastructure management.

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ENHANCING WATER RESILIENCE AGAINST CLIMATE RISKS: LOW-ENERGY FORWARD OSMOSIS USING NANOBUBBLES

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Keywords: Forward osmosis, Nanobubbles, Desalination, Membrane Technology

Climate change and increasing water scarcity dictate the development of resilient technologies for disaster preparedness and response. In emergency situations, such as power outages due to extreme weather events etc., the rapid provision of clean water with minimal energy requirements is critical. Forward osmosis (FO), is a spontaneous process based on the difference in chemical potentials between two solutions in contact with a semipermeable membrane. In a FO desalination process], water is transferred from feed solution (FS) to draw solution (DS) and the process is characterized by low energy consumption and zero liquid discharge [1]. Nanobubbles (NBs) are gas-filled cavities, usually containing air, in aqueous solutions with a diameter less than 1 μm . When NBs are introduced into water, its properties change [2]. In this work the effect of air NBs on the FO process is studied, aiming to develop a resilient, low energy water purification system for climate adaptation.

An Aquaporin HFFO2 biomimetic membrane [3] that allows high flux of water from feed to draw solution. This system does not require additional energy consumption for the production of NBs, making it ideal for relief operations and off-grid areas. The produced NBs have an average size of 200 nm and concentration of about 100×10^6 NB/mL [4]. Two experimental approaches were implemented: 1) preliminary test using deionized water (DIW) as FS and DIW with NaCl as DS, 2) realistic brackish water experiments, setting FS salinity to 2 g/L and DS salinity to 4, 5 and 6 g/L. These low salinity differences were strategically selected to isolate NB-induced hydrodynamic enhancement. In both experimental approaches conductivity, temperature and the time for collecting 100mL into the DS were recorded.

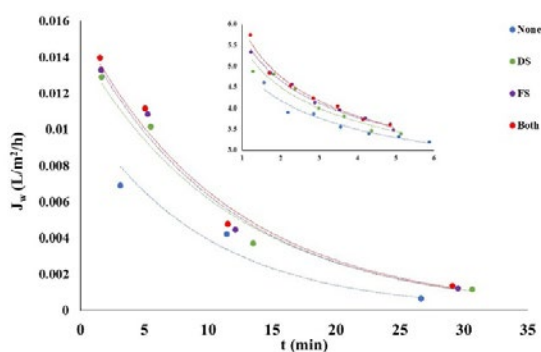


Figure 1: Water flux to cumulative time diagram for preliminary experiments (inset) and brackish water tests (main) with FS and DS salinity set to 2 g/L and 4 g/L respectively.

Figure 1 inset shows the preliminary results. Baseline (without NB) seems to be the slowest process. Introducing NBs to DS is faster by 12.9% compared to the baseline, while addition to the FS accelerated the process by 16.2%. The simultaneous use of NBs in both solutions resulted in an acceleration by 17.4%. An exponential negative rate of change in flow is observed (Figure 1 main) a phenomenon attributed to gradual fouling and internal concentration polarization (ICP) of the membrane. Figure 2 shows that the insertion of NBs significantly improved the process stability, by lowering the flux decline. The osmotic transport coefficient increased by 0.51%, 5.15% and 14.61% when NBs were added to the DS, FS and both respectively. This performance enhancement is potentially attributed to a synergistic effect of firstly a localized electrochemical interactions that amplify the osmotic driving force in active layer side (FS side) and secondly, hydrodynamic micromixing that mitigates concentration polarization at the membrane interfaces.

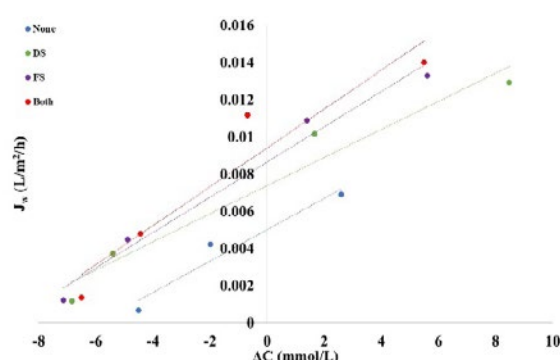


Figure 2: Water flux as a function of concentration difference (ΔC) between draw solution (DS = 4 g/L) and feed solution (FS = 2 g/L), under different experimental conditions

Finally, in Figure 3 Scanning Electron Microscopy (SEM) provides a direct visual confirmation of this mechanistic suggestion. SEM images showed that NBs inhibit NaCl crystallization when the membrane is exposed to brackish water by absorbing Na^+ ions. Therefore, the likelihood of Na-Cl coupling and precipitation was reduced, minimizing active nucleation points, maintaining the osmotic difference at high levels.

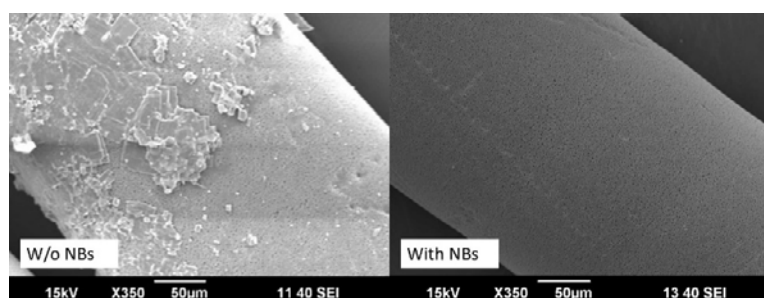


Figure 3: SEM images comparing a fiber membrane treated with NBs (right) and one treated with DIW only (left)

In this study we have demonstrate the use of NBs in the FO process. Since no energy consumption is required for the production of air NBs this approach constitutes a highly promising and resilient solution for the rapid provision of clean water, enhancing the preparedness and adaptation of infrastructure against increasing climate risks.

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HYDROPYRO: AN AI-DRIVEN PLATFORM FOR INTEGRATED WILD FIRE AND FLOOD RISK PREDICTION AND ENVIRONMENTAL DECISION SUPPORT

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Keywords: wild fire prediction, flood risk, machine learning, environmental monitoring, decision support systems

HydroPyro is an integrated, AI-driven environmental risk forecasting platform designed to address the increasing frequency and severity of hydro-meteorological and wildfire-related disasters under climate change conditions. The system combines advanced machine learning architectures with real-time environmental data streams to provide predictive insights into wildfire ignition probability, fire spread dynamics, and flood risk following extreme weather events. The platform is motivated by the urgent need for scalable, cost-effective, and accurate tools that support early warning systems and proactive decision-making at municipal and regional levels.

The core of HydroPyro is based on a hybrid deep learning framework that integrates Convolutional Neural Networks (CNNs) for spatial feature extraction from satellite imagery and Long Short-Term Memory (LSTM) networks for temporal analysis of meteorological data. This hybrid architecture enables the system to capture both spatial heterogeneity (e.g., vegetation density, land surface temperature, burn scars) and temporal dependencies (e.g., precipitation patterns, humidity fluctuations, and temperature trends), which are critical for accurate environmental risk prediction [1]. Satellite data are retrieved from platforms such as NASA GIBS, while meteorological inputs are obtained from open-access APIs (e.g., Open-Meteo), ensuring global scalability and real-time applicability.

HydroPyro introduces an over dual-risk modeling approach, where wild fire and flood risks are not treated as independent phenomena but as interconnected processes within the same environmental system. For example, post-wildfire landscapes exhibit increased soil hydrophobicity and reduced vegetation cover, significantly elevating flood susceptibility [2]. By incorporating such cross-risk interactions, the platform provides a more realistic and holistic assessment of environmental hazards compared to conventional single-risk models.

The system architecture includes three main modules: (i) data acquisition and preprocessing, (ii) predictive modeling, and (iii) visualization and decision support. The preprocessing pipeline applies normalization, feature scaling, and anomaly detection to ensure data quality. The predictive module outputs probabilistic risk indices, while the visualization layer provides intuitive geospatial dashboards that allow stakeholders to monitor risk levels in real time. This enables municipalities, civil protection agencies, and private stakeholders to optimize resource allocation, evacuation planning, and infrastructure resilience strategies.

Preliminary validation of the HydroPyro model demonstrates strong predictive performance in pilot regions, with high accuracy in identifying high-risk zones for wildfire ignition and post-event flooding. The model shows particular strength in detecting non linear interactions between environmental variables, a known limitation in traditional statistical approaches [3]. Furthermore, the use of open data sources significantly reduces operational costs, making HydroPyro accessible for deployment in resource-limited regions.

In addition to its predictive capabilities, HydroPyro is designed as a scalable platform that can be extended to include additional environmental risks, such as droughts or air pollution. The system also supports integration with Internet of Things (IoT) sensors for localized data collection, enhancing spatial resolution and model precision. Future development will focus on improving model interpretability, incorporating physics-informed machine learning approaches, and conducting large-scale validation across diverse climatic regions.

Overall, HydroPyro represents a novel contribution to the field of environmental risk management by combining advanced AI methodologies with a systems-level understanding of interconnected hazards. Its deployment has the potential to significantly enhance disaster preparedness, reduce economic losses, and support sustainable environmental governance in the face of escalating climate risks.

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POROUS CHITOSAN/CARBOXYMETHYL CELLULOSE AEROGELS MODIFIED WITH ACTIVATED CARBON AND MAGNESIUM OXIDE AS ADVANCED SORBENTS FOR CR(VI) REMOVAL

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Keywords: Adsorption, Chromium, Chitosan, Carboxymethylcellulose, Aerogels.

The contamination of aquatic environments by toxic heavy metals remains a critical global challenge, primarily driven by industrial effluents. Among these pollutants, hexavalent chromium (Cr(VI)) is of particular concern due to its high mobility, toxicity, and carcinogenic nature. Consequently, the development of efficient and environmentally friendly remediation strategies is essential. Adsorption has emerged as a preferred treatment method owing to its operational simplicity, economic feasibility, and high removal efficiency.

In the present study, eco-friendly aerogel materials were fabricated using chitosan (CS) and carboxymethyl cellulose (CMC), incorporating bio-based reinforcing agents such as activated carbon (AC) to enhance adsorption performance. Crosslinking with glutaraldehyde (GLA) was verified through FTIR spectroscopy, indicating the formation of imine (C=N) bonds via interactions with amino groups, leading to structurally stable networks. XRD patterns revealed predominantly amorphous characteristics for all synthesized aerogels. Morphological analysis using SEM demonstrated the formation of interconnected porous structures, with porosity strongly influenced by additive content and crosslinking density.

The CS/CMC/AC0.5-GLA sample exhibited the highest porosity (96.35%), while increased crosslinking resulted in reduced pore dimensions, as observed in CS/CMC/AC2-GLA. The aerogels displayed remarkable water uptake capacity, reaching 3440.8% within 10 minutes for the optimal composition, attributed to hierarchical porosity and the presence of functional groups on the AC surface. Sorption experiments indicated that Cr(VI) removal was strongly pH-dependent, with maximum efficiency achieved at pH 3.0. The decreasing removal efficiency at higher pH values suggests a chemisorption-dominated mechanism. Equilibrium data were best described by the Langmuir isotherm model, implying monolayer adsorption. The highest sorption capacity (155.53 mg/g) was obtained for CS/CMC/AC/MgO-GLA under optimal conditions (contact time: 24 h, adsorbent dosage: 0.5 g/L).



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EMERGING CONTAMINANTS ACROSS SOIL AND AGRI-FOOD MATRICES: A ONE HEALTH ANALYTICAL FRAMEWORK WITH VALIDATED METHODOLOGY AND UNCERTAINTY ASSESSMENT

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Keywords: emerging contaminants, multi-residue analysis, One Health, environmental monitoring, food safety governance

The pervasive contamination of agricultural soils and food systems by emerging contaminants (ECs) represents a growing threat to environmental integrity, food safety, and subsequently public health. In the context of an increasingly interconnected world, the uncontrolled accumulation of these substances in terrestrial ecosystems constitutes a silent yet escalating crisis, one that demands coordinated, evidence-based governance responses. ECs are chemicals that typically fall outside existing regulatory frameworks, which are detected at unexpected concentrations and can cause adverse effects on ecosystems and human health that are not yet completely understood. Pesticides, personal care products, nanoplastics, industrial chemicals, and pharmaceuticals are a few examples of these pollutants [1]. Pharmaceuticals are widely detected in soils through the application of biosolids, manure, and irrigation with reclaimed water, alongside pesticides which are used extensively in modern agriculture [2]. The One Health paradigm recognizes the complex correlations between human health and ecosystem integrity and provides the conceptual foundation for addressing this challenge. Robust, rigorously validated, and multi-residue analytical methodologies are thereby an indispensable prerequisite for evidence-driven policy, environmental monitoring programs, and ultimately for building resilient food and agricultural systems.

This study aimed to develop, optimize, and fully validate a multi-residue analytical method for the simultaneous detection and quantification of 36 target analytes, including pharmaceuticals and pesticides in soil. A secondary objective was to apply the validated method to real-world soil samples and agricultural food matrices, in order to assess the extent and distribution of contamination and evaluate the method's applicability across the agri-food continuum. Collectively, this work seeks to provide a fit-for-purpose analytical tool to support environmental monitoring, food safety surveillance, and risk assessment, capabilities that are foundational to integrated governance frameworks addressing chemical contamination as a systemic crisis.

Sample preparation was based on the QuEChERS ("Quick, Easy, Cheap, Effective, Rugged, and Safe") approach, which was evaluated across three procedural variants to identify the most suitable method for the simultaneous extraction of the target analytes from soil: (i) QuEChERS AOAC 2007.01, (ii) QuEChERS

EN 15662:2018, and (iii) an ultrasonic-assisted QuEChERS variant. The QuEChERS EN 15662:2018 procedure demonstrated superior overall performance and was selected as the basis for full method validation. Chromatographic separation and detection were performed by liquid chromatography coupled to high-resolution mass spectrometry (LC-HRMS). Separation was achieved using a Kinetex C18 100A column (2.6 μ m, 150 mm $\times$ 2.1 mm) under a gradient elution program with mobile phases consisting of (A) water acidified with 0.1% formic acid and (B) acetonitrile. The flow rate, sample injection volume, and column temperature were set at 350 μ L/min, 5 μ L and 40°C, respectively. Mass spectrometric detection was conducted in positive electrospray ionization (ESI) mode (60,000 FWHM, m/z 120–600), using an Orbitrap mass analyzer. The selected compounds were identified via $[M+H]^+$ ions and characteristic fragments using XCalibur v2.2 software.

Full validation of the QuEChERS EN 15662:2018 method was conducted in accordance with SANTE/11312/2021 guidelines, which encompassed the following performance parameters: recovery, precision (repeatability and reproducibility), linearity, limits of detection (LODs), limits of quantification (LOQs), matrix effects, as well as measurement uncertainty (MU). The validated QuEChERS EN 15662:2018 method demonstrated satisfactory performance across the evaluated parameters. Mean recoveries for the 36 target analytes were generally in the range of 60–130% with few exceptions, while RSDs were below <18.2%, meeting acceptance criteria. Linearity was satisfactory with coefficients of determination (R^2) exceeding 0.99. LODs and LOQs were determined at 0.01–2.54 ng/g and 0.04–7.62 ng/g, respectively, demonstrating adequate sensitivity for trace detections. Matrix effects were negligible (< $\pm$ 20%) with matrix-matched calibration applied to compensate for matrix interferences. Expanded measurement uncertainty ($k=2$, 95% confidence) was estimated with recovery correction in the range of 1.64–23.66% across analytes, meeting SANTE criteria (<50%). The validated method was subsequently applied to real soil samples, selected to represent diversity in land use, in order to provide an assessment of pharmaceutical and pesticide co-occurrence in these conditions. The protocol was further extended to agricultural food matrices to evaluate transferability and broaden the monitoring scope across the agri-food chain. Results from both the soil and agri-food investigations will be reported in full upon completion of analysis.

Conclusively, the contamination of soil and agri-food systems by pharmaceuticals and pesticides represents more than a localized environmental issue; it is a worldwide, systemic risk with direct implications for food sovereignty, public health equity, and ecological resilience. In the framework of integrated governance for crisis prevention and global resilience, the availability of validated, harmonized analytical tools is essential for risk assessment and management. Without reliable monitoring data, governance systems lack the evidence required to identify emerging contamination crises before they escalate, to enforce regulatory thresholds, or to design effective intervention strategies. The multi-residue methodology developed in this study, grounded in the One Health paradigm and validated according to international standards, directly addresses this gap, providing integrated, cross-sector knowledge that modern resilience governance demands.

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PLANT-BASED MILK ALTERNATIVES UNDER SCRUTINY: PESTICIDE RESIDUE PROFILING AND REGULATORY GAPS IN AN EVOLVING FOOD LANDSCAPE

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Keywords: extraction, food safety, multi-residue analysis, Plant-based milk alternative, uncertainty measurement

In recent years, the global market for plant-based milk alternatives (PBMA) has experienced rapid growth. Factors such as health awareness, environmental concerns and constant innovation drive consumer interest, contributing to the rapid growth of the global market. Various studies using statistical models show that consumers in Europe, including Greece, and the United States of America (USA) can be grouped based on their preferences: some prefer plant-based alternatives, others dairy products, and some consume both [1,2].

The European Court and regulatory frameworks have established rules to ensure proper labeling and circulation of plant-based products. This study focuses on detecting pesticide residues in plant-based beverages in the Greek market to assess potential consumer exposure [3]. Chemical contamination of plant-based beverages may occur at multiple points along the production chain [4]. Thus, the present study aims to establish a simple and reliable method for detecting pesticide residues in plant-based beverages, with the aim of assessing potential consumer exposure.

The QuEChERS method, widely applied to both plant- and animal-based foods, represents an effective approach for pesticide analysis in plant-based alternatives. The most common approaches were initially tested, and the optimum was validated for the determination of 29 pesticides in almond beverages, combined with liquid chromatography coupled to high-resolution mass spectrometry (LC-HRMS). Under the optimized conditions, the targeted pesticides exhibited good linearity in the range of 1–100 $\mu\text{g L}^{-1}$, yielding recoveries of 74–120% at spiking levels of 10, 50, and 100 $\mu\text{g L}^{-1}$, confirming the accuracy of the method across a broad concentration range. Furthermore, the limit of quantification (LOQ) for most of the analytes was below 1 $\mu\text{g L}^{-1}$, highlighting the high sensitivity of the method and its suitability for trace-level analysis.

The precision of the method, expressed as relative standard deviation (RSD), was consistently below 15%, demonstrating good repeatability and reproducibility. In addition, measurement uncertainty was estimated for all analytes and remained within acceptable limits, further confirming the reliability and robustness of the developed method for routine pesticide analysis in plant-based alternatives.

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TOXICOLOGICAL EVALUATION OF TITANIUM DIOXIDE NANOPARTICLES (TiO₂ NPs) IN BIOLOGICAL AND ENVIRONMENTAL SYSTEMS

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Keywords: Toxicity, TiO₂ NPs, Human, Environment

TiO₂ nanoparticles (NPs) are among the most widely used nanomaterials in consumer, industrial, and environmental applications. This is because they have unique physical and chemical properties, such as a large surface area, chemical stability, and high photocatalytic activity. Titanium dioxide nanoparticles (TiO₂ NPs) are extremely adaptable substances that are utilized in many different fields, such as food, medicine, cosmetics and environmental cleanup (water purification). Their extensive presence in the environment, particularly marine ecosystems, is a result of their massive global output. Although TiO₂ NPs have many technological and environmental advantages, their growing presence in marine waters, especially in coastal regions with considerable tourism and recreational activities, raises ecological concerns, including possible effects on bivalves [1].

The toxicity of TiO₂ NPs is greatly influenced by important physicochemical properties such particle size, surface coating, crystal phase (rutile vs. anatase), aggregation behavior, and exposure to UV or visible light, which can boost ROS production through photocatalytic activities. Their environmental fate is also influenced by transit, aggregation, interaction with natural organic matter, and the potential for bioaccumulation throughout ecosystems. Despite their widespread use in industrial products, water treatment, cosmetics, and coatings, questions remain over their longterm safety and environmental impact. Consistent toxicity assessment methods, longterm exposure studies, and safe-by-design approaches are essential for better understanding and mitigating potential risks. Although TiO₂ NPs are generally thought to be low toxicity at low concentrations, their biological and ecological impacts are highly context-dependent, necessitating thorough risk assessment to guarantee their safe and sustainable usage in future nanotechnology applications.

A significant area of research called “nanotoxicity” looks at the possible negative impacts of nanoparticles on ecosystems and living things. The discharge of nanomaterials like TiO₂ nanoparticles into biological and environmental systems has increased due to their growing application in industry, medicine, cosmetics, and environmental technologies. It is clear that worries about the safety of such NPs for both humans and ecosystems have been raised by their rising production, use, and exposure. Nanoparticles can readily interact with cells, tissues, and biological molecules because of their minuscule size. This can result in oxidative stress, inflammation, DNA damage, and other harmful effects. Nanoparticles can build up in soil, water, and sediments in environmental systems, impacting aquatic life, plants, and

microorganisms as well as perhaps making their way into the food chain. Therefore, evaluating the safety of nanoparticles, reducing possible dangers, and creating safer nanomaterials for sustainable uses all depend on an understanding of their toxicological behavior, transport, and bioaccumulation [2].

This study provides a comprehensive evaluation of the toxicological effects of TiO₂ nanoparticles in biological and environmental systems, emphasizing their mechanisms of action, contributing factors, and associated risks. In this work, TiO₂ nanoparticles (NPs) have been shown to be cytotoxic, cause oxidative stress, inflammation, DNA damage, and apoptosis in biological systems by making too many reactive oxygen species (ROS). This has an effect on macrophages and cell lines like HepG2 and A549. Adverse effects, such as growth suppression, developmental toxicity, and ecological imbalance, have been noted in algae, *Daphnia magna*, zebrafish embryos, soil microbes and plants in environmental systems.

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TOXICOLOGICAL EVALUATION OF SILVER NANOPARTICLES (AGNPS) IN BIOLOGICAL AND ENVIRONMENTAL SYSTEMS

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Keywords: Toxicity, AgNPs, Human, Environment

The evolution of nanotechnology is leading to the offering of new frontiers for humanity and is introducing new products to the environment. It is well known that it has brought revolution in the medical field, the industry and in everyday life. Due to the ongoing and increased usage of nanomaterials in a variety of fields, it is essential for their toxicity to be evaluated. Nanotoxicity is toxicity specifically associated with nanoparticles and it is known to include the undesired response of a variety of physiological mechanisms and environmental ecosystems. These responses are often triggered by the physical and chemical properties of materials in the nanoscale.

Silver nanoparticles, also known as AgNPs, are commonly found in a variety of applications, such as industrial processes, medical applications and consumer product, due to their unique antimicrobial properties and physicochemical versatility. Silver nanoparticles are among the most frequently used nanomaterials in everyday life, a fact that leads to high human and environmental exposure. They easily dissolve into toxic Ag⁺ ions and generate Reactive Oxygen Species (ROS), allowing researchers to study how size, shape, and surface charge control cellular damage and bioaccumulation. When they are released in to the environment, air, water and soil, there are concerns regarding their impact on the human health and ecosystems and overall their safety. When they are released via wastewater or industrial discharge, AgNPs go through significant transformations, such as agglomeration – they turn into a mass- and sedimentation. These transformations are dictated heavily by local pH levels and ionic strength [1].

It is important to note that the presence of natural organic matter is often able to stabilize these particles, ultimately assisting in their bioaccumulation from primary producers to higher- order consumers, through trophic transfer. Regarding mammals, exposure – either oral or dermal- results in significant accumulation in the liver, kidneys and spleen. This triggers oxidative stress and inflammatory pathways. In addition, data regarding environmental ecosystems, reveals that AgNPs reduce the biological ability of aquatic species, like zebrafish, to produce offspring, young or new growth. Furthermore, they alter nitrogen fixation and nitrification processes, which leads to the disruption of critical soil functions [2].

This review analyzes the current knowledge regarding AgNPs toxicology. It concentrates on biodistribution and organ-specific toxicity in humans, but also in animal models and the environment. It includes the examination of oxidative stress, inflammatory responses, genotoxic effects and

reproductive dysfunction. In this review, the behavior of AgNPs is investigated in environmental contexts, and the effects on the microbial community structure, the disruption of biogeochemical cycles and the trophic transfer in aquatic and terrestrial food webs is underscored. There has been extensive research regarding AgNP toxicology, but major challenges remain. Such challenges are the inconsistent exposure metrics, a lack of data on chronic low-dose and multigenerational effects and weak links regarding in vitro examinations and the outcomes in the real world. This review discusses an integrated framework that links mechanistic adverse outcome pathway mapping with nanoparticle engineering. Finally, the need for harmonized testing guidelines and regulatory measures able to adapt to human and ecological risks, while retaining the sustainable deployment of AgNPs, is highlighted.

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SYNTHESIS OF THIOLATED GRAPHENE OXIDE/CHITOSAN AEROGEL FOR ENHANCED OIL-SPILL REMEDIATION: SYNTHESIS, CHARACTERIZATION AND ABSORPTION MECHANISMS

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Keywords: UV-Cross-linking, chitosan, graphene oxide, aerogel, petroleum pollutants, diesel.

Given the increasing threat of aquatic ecosystem pollution by petroleum products, the development of efficient and environmentally friendly remediation methods is imperative. Traditional treatment technologies such as (i) bio-remediation, (ii) *in-situ* controlled burning and (iii) electrochemical dispersants are utilized to purify water [1]. However, they are often considered to be of high operational cost and of limited effectiveness in treating thin oil slicks. Among alternatives, absorption exhibits superior removal efficiency in addition to its sorbent regenerating ability which accounts for its eco-friendly nature. Natural absorbents are also widely exploited for their high sustainability, biodegradability and mechanical ability [2].

The primary objective of this study is the development of a 3D bio-copolymer aerogel through the cross-linking of nanomaterial thiolated graphene oxide (GO-SH) in a modified chitosan (CS) matrix. Due to its hydrophilic character, CS was yet to be considered a suitable candidate for oil sorption techniques. Moreover, the traditional cross-linking methodologies exhibited the need of highly toxic substances as cross-linking agents such as epichlorohydrin (EPH) or glutaraldehyde (GLA), causing significant environmental limitations. By replacing toxic cross-linkers like GLA and EPH with a UV-cross-linking or “green” pathway, the synthesis process aligns with the principles of the circular economy. More importantly, by introducing allyl groups (OAL) through reductive amination, the modified chitosan (CS-OAL) gains the necessary chemical handles for further functionalization. The site-specific C₆-modification of CS also addressed the inherent limitations of the polymer, specifically its hydrophilicity and structural vulnerability. The integration of GO-SH is achieved through a UV-triggered thiol-ene reaction, where the thiol functionalities of the GO form stable covalent cross-links with the modified chitosan chains. This ‘click-chemistry’ approach ensures a high-density network that enhances the aerogel’s structural integrity, hydrophobicity and mechanical durability without the use of toxic reagents.

The resulting aerogel exhibited high mechanical strength and significantly reduced swelling ratios. The resulting materials are evaluated for their effectiveness in absorbing hydrocarbon pollutants (diesel), aiming at a sustainable water remediation model with the potential for multiple reuse cycles. The experimental phase resulted in three distinct aerogel formulations, each representing a step-up in structural complexity and performance. A) CS/GO5%, a baseline co-polymer produced via physical mixing. While exhibiting some adsorptive properties, this product retained significant hydrophilic character

and suffered from structural degradation. B) CS-OAL/GO-SH 5%, the primary research focus, where the modified CS and GO-SH were covalently bound through UV-irradiation. This product demonstrated significant mechanical strength and a reduced swelling ratio compared to the simple blend, validating the effectiveness of the thiol-ene “click” chemistry. C) CS-OAL/GO-SH 5%/HB, the high-performance variant, where the cross-linked aerogel was subjected to a surface modification via Chemical Vapor Deposition (CVD) [3] using trimethylchlorosilane (TMCS) groups. This final coating created a “super-hydrophobic” barrier, effectively repelling water while maintaining high affinity for hydrocarbons. The resulting materials were evaluated through SEM, FTIR, XRD and contact angle measurements. The CS-OAL/GO-SH 5%/HB aerogel exhibited negligible water swelling. This low water-uptake is attributed to the synergistic effect of the hydrophobic OAL chains and the TMCS-coated surface, which successfully lowered the surface energy of the material.

Consequently, this super-hydrophobic version achieved the highest oil sorption metrics. The material demonstrated an exceptional “super-like” absorbance capacity, reaching sorption values significantly higher than those reported for unmodified biopolymer aerogels. The CS-OAL/GO-SH 5%/HB variant exhibited “super-like” absorbance capacity, successfully absorbing oil ten times its initial weight in controlled laboratory tests. By addressing the inherent limitations of CS through site-functionalization and green UV-cross-linking, this research provides a transition from a simple biopolymer blend to a super-hydrophobic, silanized 3D aerogel demonstrates a scalable path toward high-performance, eco-friendly materials that do not sacrifice mechanical durability for environmental safety.

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FORMULATION AND CHARACTERIZATION OF COSMETIC PRODUCTS ENRICHED WITH OLIVE LEAF EXTRACTS: PHOTOPROTECTIVE, ANTIOXIDANT, AND STABILITY ASSESSMENT

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Keywords: olive leaf extracts, cosmetics, antioxidant activity, photoprotection, formulation stability

The increasing demand for sustainable and natural bioactive-rich cosmetic formulations has driven significant interest toward the valorization of agri-food industrial by-products. Among these, olive leaves represent an abundant and underutilized source of phenolic and flavonoid compounds with well-documented biological properties. The present study investigates the formulation and physicochemical characterization of cosmetic products enriched with olive leaf green extracts, with particular emphasis on their antioxidant capacity, photoprotective performance, and formulation stability.

Olive leaf extracts were incorporated into cosmetic formulations, which were analysed using UV–Vis spectrophotometry. The analysis confirmed the presence of phenolic and flavonoid constituents, as indicated by characteristic absorption bands in the lower UV and UVB regions. These findings are consistent with the known spectral behavior of compounds such as hydroxytyrosol and oleuropein derivatives, which are widely associated with antioxidant and photoprotective properties.

Further structural characterization of the formulations was performed using Attenuated Total Reflectance Fourier Transform Infrared (ATR–FTIR) spectroscopy. The results demonstrated that the incorporation of olive leaf extracts did not alter the fundamental chemical structure of the cosmetic base. However, minor spectral variations were observed, suggesting successful incorporation of bioactive compounds and potential interactions between the extract constituents and the formulation matrix. Importantly, these spectral features remained stable over time, indicating satisfactory physicochemical stability of the developed formulations.

The photoprotective efficacy of the formulations was assessed through the determination of the sun protection factor (SPF). The results revealed that formulations enriched with olive leaf extracts exhibited enhanced SPF values compared to the control sample, which did not contain any of these natural bioactive additives. Notably, the olive leaf extract-containing formulation demonstrated consistent and relatively stable photoprotective performance over time, with only a slight reduction in SPF values ($13.0 \pm 0.7 \rightarrow 12.2 \pm 1.3 \rightarrow 11.9 \pm 0.4$). This gradual decrease may be attributed to minor degradation or

reduced availability of active compounds during storage, although the overall performance remained within an acceptable range. These findings highlight the potential of olive leaf-derived bioactives as natural photoprotective agents in cosmetic applications.

The antioxidant activity of the formulations was evaluated using multiple *in vitro* assays, including DPPH, ABTS, and FRAP methods, in order to obtain a comprehensive assessment of their redox behavior. The results indicated a clear dependence of antioxidant performance on the analytical method employed. Specifically, limited radical scavenging activity was observed in DPPH and ABTS assays, whereas the FRAP assay demonstrated a significant reducing capacity. Creams containing olive leaf extract (L 0.2%) exhibited higher FRAP values ($27.2 \pm 1.86 \rightarrow 18.4 \pm 4.89 \rightarrow 19.7 \pm 2.34$) than the control formulations (B) ($12.3 \pm 2.48 \rightarrow 9.9 \pm 2.63 \rightarrow 10.8 \pm 3.53$) throughout storage, although a slight decrease was observed over time. This discrepancy suggests that the antioxidant behavior of olive leaf extracts within complex cosmetic matrices may be influenced by factors such as solubility, molecular accessibility, and interactions with other formulation components. Therefore, the selection of appropriate analytical methods is critical for accurately evaluating antioxidant activity in such systems.

Overall, the findings of this study demonstrate that olive leaf extracts can be effectively incorporated into cosmetic formulations, enhancing photoprotective properties while maintaining structural and physicochemical stability. Although the antioxidant activity appears to be method-dependent and influenced by formulation parameters, the presence of active bioactive compounds is clearly supported by spectroscopic and functional analyses.

From a broader perspective, the utilization of olive leaf extracts aligns with current trends in sustainable product development and circular economy strategies, promoting the transformation of agricultural residues into value-added functional ingredients. Nevertheless, further research is required to optimize extraction methods, improve bioactive stability and bioavailability, and validate the efficacy of such formulations through *in vivo* studies.

In conclusion, olive leaf extracts represent promising natural ingredients for the development of innovative and sustainable cosmetic products, offering multifunctional benefits that include photoprotection and potential antioxidant activity, while contributing to the reduction of environmental impact associated with agro-industrial waste.

The proper management of agri-food by-products based on sustainable development and the circular economy is a mitigation strategy against climate change and its subsequent associated natural damages.



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SYNTHESIS AND STUDY OF METAL DOPED CARBON DOTS AS INNOVATIVE ANTIMICROBIAL AGENT FOR PUBLIC HEALTH PROTECTION

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Keywords: Carbon dots (CDs), Metal-doped nanomaterials, Antimicrobial activity, Anti-inflammatory properties, Photocatalysis, Public Health Protection

Following industrialization and the increase of microbial infections, the challenge of pathogen resistance and the limitations of conventional therapies have become major concerns. Infections caused by bacteria and fungi negatively affect human health and quality of life, often leading to relapses and reduced drug efficacy. In this context, the scientific community has focused on the development of new nanomaterials with antimicrobial properties, which could provide alternative or complementary solutions to traditional treatments [1][2]. The present work focused on the synthesis and characterization of metal-doped carbon dots (N-CDs, Cu-CDs, Zn-CDs), as well as on the investigation of their properties in diverse applications.

Over years of research, various methods have been developed for the removal of organic pollutants from the environment. However, several of these methods are associated with high costs, high energy consumption, and the risk of generating secondary pollutants. Carbon dots (CDs) emerge as an innovative solution, utilizing solar energy to produce reactive oxygen species (ROS), which effectively degrade pollutants into harmless products such as CO₂ and H₂O, providing an efficient and environmentally friendly process [3]. CDs are multifunctional nanomaterials with strong antimicrobial activity, attributed to ROS production and interactions with microbial membranes [1][4]. In parallel, they exhibit anti-inflammatory and antithrombotic properties, enhancing their potential for biomedical applications such as implant coatings, wound-healing hydrogels, and targeted drug delivery [6]. Moreover, their use in food packaging contributes to preserving quality and extending shelf life, making CDs an innovative and eco-friendly solution with wide application prospects.

In this context, the scientific community has increasingly focused on the development of novel nanomaterials with enhanced antimicrobial properties, capable of either replacing or complementing traditional therapeutic approaches. Among these, carbon-based nanomaterials—particularly carbon dots (CDs)—have attracted considerable attention due to their unique physicochemical characteristics, low toxicity, high biocompatibility, and multifunctional nature [2][5]. The present thesis focuses on the synthesis, characterization, and evaluation of metal-doped carbon dots, specifically nitrogen-doped (N-CDs), copper-doped (Cu-CDs), and zinc-doped (Zn-CDs), with the aim of exploring their potential in environmental and biomedical applications.

In this study, CDs were synthesized from different precursors and characterized by UV- Vis and FT-IR spectroscopy, as well as nanoparticle tracking analysis (NTA). Their photocatalytic activity was then evaluated for the degradation of organic pollutants such as oxytetracycline and the dye Eriochrom Black T, with particularly promising results [3][4]. Additionally, their antimicrobial effectiveness was tested through in vitro agar assays, where metal-doped CDs showed enhanced activity against bacteria and fungi. The biological evaluation also included studies of antithrombotic and anti-inflammatory activity, with Cu-CDs demonstrating the strongest inhibitory effect on platelet activation, highlighting significant biomedical potential [6]. Furthermore, Zn-CDs exhibited notable antimicrobial and photocatalytic activity, indicating their suitability for both environmental and healthcare applications.

Overall, the results demonstrate that carbon dots and their hybrid materials represent a highly promising platform for applications that combine pollutant degradation, antimicrobial protection, and biomedical utilization. Their multifunctionality further supports their prospects for applications in food packaging, wound dressings, antimicrobial coatings, and targeted therapies in the future.

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REFRAMING THE TRAINER: PROFESSIONAL PROFILES FOR EDUCATOR FORMATION IN CONTEXTS OF DISRUPTION, DRR, AND RESILIENCE

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Keywords: teacher educator identity; professional agency; crisis-sensitive pedagogy; community engagement; DRR education; context-responsive educator formation

Teacher education is often discussed through curriculum content, learning outcomes, and programme structure. These elements matter, but they do not fully explain the quality of educator formation. Equally important is the professional figure of the person who teaches within such programmes: how teacher educators understand their role, how they position themselves between research and teaching, how they exercise agency, and how they respond to institutional and social change. Recent research on university-based teacher educators shows that their professional identity is not fixed or singular. It is shaped by multiple roles, including those of researcher, teacher, expert, and learner, and by tensions between academic expectations, institutional demands, and educational practice [1]. Quantitative work also suggests that teacher educators who understand their task in more facilitative than transmissive terms tend to report stronger self-efficacy, more constructivist orientations, and more effective teaching strategies [2].

These questions become more urgent in contexts of disruption, disaster risk reduction (DRR), and resilience. Under such conditions, the trainer cannot be understood simply as a subject expert who delivers content to future educators. Disruption requires professional roles that can hold together knowledge, design, care, institutional mediation, community engagement, and practical judgement. Research on educational disruption has already shown that teacher educators may have to renegotiate professional identity, emotional labour, and agency when familiar educational conditions become unstable [3]. Work on teacher professional development in emergency contexts points in the same direction, highlighting crisis-sensitive instruction, learning continuity, flexible support, and psychosocially informed professional development as central concerns rather than additions to ordinary training [4]. At the same time, recent DRR education reviews suggest that implementation remains fragmented, with weak pedagogical integration and insufficient engagement with local and indigenous knowledge [5].

This paper argues that educator formation at the intersection of disruption, DRR, and resilience requires a clearer conceptualisation of the trainer. It develops this argument through the PATH of Environmental and Disaster Education strand of the MSc “Resilience, Risk, Crisis, Emergency Management, and Homeland Security,” designed within a Greek-Canadian postgraduate development initiative, treated here not as a descriptive curriculum case, but as a conceptual lens through which the trainer becomes visible as a central design question. The term professional profiles is used deliberately. No single trainer

identity can adequately capture the demands of this field. What is needed is a set of interrelated profiles that together describe the kind of professional capable of preparing educators for disruption-sensitive, DRR-aware, and resilience-oriented practice.

Seven professional profiles are proposed, not as separate job descriptions but as overlapping dimensions of trainer work. One concerns epistemic integration: the trainer must connect pedagogy, DRR, resilience, sustainability, and institutional realities rather than teach them as separate domains. A second concerns curriculum design, since complex agendas have to be translated into outcomes, tasks, assessment strategies, and sequenced learning experiences. The third is crisis-sensitive and facilitative: the trainer works with emotionally charged material, recognises vulnerability and stress, and sustains participation in psychologically safer ways. The fourth is policy-and-systems mediating: the trainer links international frameworks, educational policy, institutional constraints, and classroom realities. The fifth is practice-anchored and mentoring: the trainer guides bounded intervention design, pilot implementation, reflective revision, and ethically accountable educational action. The sixth is community-engaged: the trainer helps future educators connect with local actors, community realities, culturally grounded knowledge, and the social environments in which disruption is experienced. The seventh is continuity-and-support oriented: the trainer prepares educators to sustain learning during disruption through flexible provision, support-oriented communication, and crisis-sensitive instructional response. Together, these profiles describe a trainer who does more than transmit expertise. They describe a professional able to design learning, support ethical participation, mediate between policy and practice, and prepare educators for action in unstable educational environments.

The contribution of the paper is to shift attention from curriculum content alone to the professional profiles required to make such curricula credible. In disruption-sensitive educator formation, the trainer is not a neutral channel for transmitting knowledge. The trainer is part of the curriculum architecture itself. The paper therefore proposes a conceptual framework for thinking about who must teach in programmes concerned with disruption, DRR, and resilience, and what kinds of professional capacities such teaching requires. Its value is not evaluative but design-oriented: it offers a basis for curriculum planning, staff profiling, programme review, and professional development in postgraduate educator formation.

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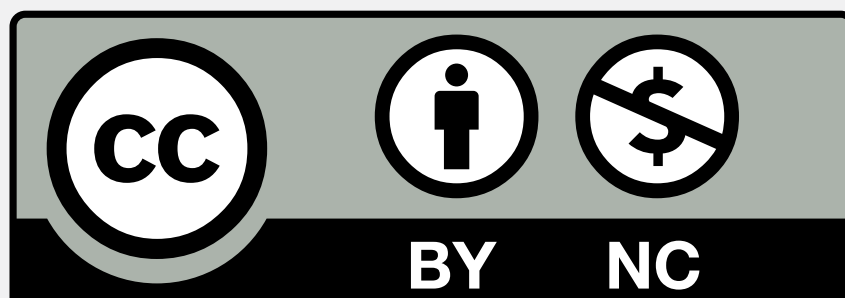
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