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National and Kapodistrian University of Athens

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GEOL 50 YEARS
DEPARTMENT of GEOLOGY & GEOENVIRONMENT

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ΠΕΡΙΦΕΡΕΙΑ ΚΡΗΤΗΣ
REGION OF CRETE

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new technologies & civil protection

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about

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supported	▪ Region of Crete
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Chouvardas Konstantinos, MSc.	Region of Eastern Macedonia & Thrace, Civil Protection Department, Head

topics

Special Sessions

- **COVID-19**: studies, actions, best practices, consequences, challenges
- **Multi-hazard Crisis Management**
- **Early Warning Systems**: technology, applications, crisis management, social dimensions
- **Prediction and Forecasting**: Methods, Successes, Lessons learned, Social dimensions (Meteorology, climate change, earthquakes, tsunamis etc.)

Regular Topics

- **Natural Disasters**: causes, prevention, management, best practices, lessons learned
- **Technological & Man-made Disasters**: causes, prevention, management, best practices, lessons learned
- **Natech (Mixed Natural & Technological) Disasters**: causes, prevention, management, best practices, lessons learned
- **Marine, Road, and Air Accidents**: Prevention and management, lessons learned
- **Innovative technology and methods** on disaster study, prevention and management (Decision Support Systems, 3D-Printing, Artificial Intelligence, Applications, Remote Sensing etc)
- **Climate Change/Crisis** and its impact on Natural Phenomena and Human Culture
- **Human Activity** and its impact on Natural Phenomena (Hydrocarbon Research, Mining etc)
- **Biodiversity**: the impact of Climate Change/Crisis and destructive Phenomena on Biodiversity
- **Security**: Critical Infrastructure protection from malicious actions, terrorist acts management, Cyberprotection
- **Crises Management Issues**
- **Institutional & Legislative Framework** for Civil Protection
- **Training**: to citizens, volunteers, teachers, students, staff
- **Search & Rescue, Humanitarian Aid**
- **Civil Protection & Media**: Information dissemination and interdependent relationship between the bodies and the media
- **Civil Protection - Insularity - Tourism**
- **Civil Protection & Disability / Third Age**
- **Civil Protection & Cultural Heritage**
- **Volunteering: Role, work, Institutional Framework, Challenges**
- **Economic dimension of disasters, crises, prevention**
- Civil Protection & **GDPR** (EU General Data Protection Regulation)
- **Transnational level: International, European and Mediterranean Programmes and Civil Protection synergies**

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POST GRADUATE PROGRAM

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agenda 14.10

OPENING CEREMONY

09:00 - 09:30 **Welcome Greetings**

Gerassimos Papadopoulos, *Scientific Collaborator EU and UNESCO, SafeGreece President*
Nikos Chardalias, *Deputy Minister for Civil Protection and Crisis Management*
Chara Kafantari, *ΣΥ.ΡΙΖ.Α. - Progressive Alliance Parliament Group, Deputy Head of Civil Protection*
Pantelis Bougdanos, *Association of Greek Regions, Regional Deputy Governor of Chios*
Stavros Arnaoutakis, *Crete Regional Governor*
Tassos Kouroupakis, *Civil Protection Deputy Regional Governor, Region of Crete*
Giorgos Patoulis, *Attica Regional Governor*

special session: MultiHazards

Chair: Gerassimos Papadopoulos

09:30 – 10:15 **Efthymios Lekkas [invited speaker]**
Earthquake Planning and Protection Organisation of Greece, Chairman | University of Athens, Professor
Multiple disasters and crises: the new challenges on management in a climate and pandemic crisis era

10:15 – 10:30 **Nikos Androulakis**
Member of European Parliament | Amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism Instructor
Amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism - rescEU

Chair: Michalis Diakakis

10:30 – 10:45 **Kostas Chondronikolas**
Secretariat General for the Aegean and Island Policy
Multiple Crises Management in an island environment

10:45 – 11:00 **Evi Georgiadou**
Hellenic Institute for Occupational Health and Safety (ELINYAE)
New Challenges for Multi – Hazard Emergency Management in the COVID-19 Era in Greece
Evi Georgiadou, Dimitra Pinotsi, Theoni Koukoulaki, Konstantina Kapsali

11:00 – 11:15 **Chih-Long Pan**
National Yunlin University of Science and technology, Taiwan
An Innovative Emergency Medical Regulation Model in Natural and Manmade Disasters
Chih-Long Pan, Michail Chalaris, Jet-Chau Wen

11:15 – 11:30 **Sotiria Stefanidou**
Aristotle University of Thessaloniki
Fragility Analysis of Bridges in a Multiple Hazard Environment
Stefanidou Sotiria, Vassilis Papanikolaou

session: Climate Crisis

Chair: Efthymios Karymbalis

11:30 – 11:45 **Thanos Giannakakis**
WWF Hellas
Nature-Based Solutions: an Innovative (Though Not New) Approach to Deal with Immense Societal Challenges
Thanos Giannakakis, Ilias Tziritis, Dimitris Ibrahim, Panagiota Maragou

11:45 – 12:00 **Yannis Krestenitis**
Aristotle University of Thessaloniki
Coastal Inundation due to Storm Surges on a Mediterranean Deltaic Area under the Effects of Climate Change
Christos Makris, Vasilis Baltikas, Yannis Androulidakis, Yannis Krestenitis

12:00 – 12:15 **Georgios Tasionas**
Democritus University of Thrace
Optimization Model of the Mountainous Forest Areas Opening up in Order to Prevent and Suppress Potential Forest Fires
Georgios Tasionas, Ioannis Koukoulos, Ioannis Sismanidis, Vasileios C. Drosos

session: Natural Hazards

Chair: Ioannis Koukouvelas

12:15 – 12:30 **Konstantinos Kokolakis**
Decentralized Administration of Macedonia – Thrace and the Region of Central Macedonia, Civil Protection former Director
We and the lightning

12:30 – 12:45 **Kostas Kalabokidis**
University of the Aegean, Professor
Landscape Fire Risk Governance
Kostas Kalabokids, Palaiologos Palaiologou

12:45 – 13:00 **Despoina Bafi**
Harokopio University of Athens
Multitemporal Monitoring of Ecosystem Response Using Burn Severity and NDVI Index: the Case of Kineta Wildfire 2018
Despoina Bafi, Andreas Karavias, Ioannis Papadopoulos, Issaak Parcharidis

13:00 – 13:15 **Aglaia Matsakou**
Aristotle University of Thessaloniki
Assessment of Seismically Induced Landslide Susceptibility at the Island of Lefkada Based on Data Provided by the 2003 and 2015 Earthquakes
Aglaia Matsakou, Vassilis Marinos, George Papathanassiou, Sotirios Valkaniotis, Athanasios Ganas

13:15 – 13:30 **Nikolaos Tavoularis**
Region of Attica
Towards the Development of an Updated GIS-based Landslide Hazard Map in Attica Region, Greece; Dias Project
Nikolaos Tavoularis, Panagiotis Argyrakis, George Papathanassiou, Athanassios Ganas

13:30 – 13:45 **Vassilis Lekidis**
Institute of Earthquake Engineering & Engineering Seismology
The instrumentation of University of Macedonia building (Thessaloniki, GR) for seismic response analysis and health monitoring
Vasslis Lekidis, Stelios Pardalopoulos, Christos Papaioannou

special session: COVID-19

Chair: Maria Manousaki

13:45 – 14:00 **Nikolaos Katsaros**
NCRS DEMOKRITOS Ex. Director of Research | Dept. of Biomedicine NEW YORK COLLEGE Director
The 7 Myths about the COVID-19 and the Origin of Coronavirus along with its Consequenses to the Enviroment

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Survey on Attitudes, Perceptions and Believes Regarding COVID-19 and its Management in Greece: Early Findings
Aspasia Karamanou, Miranda Dandoulaki

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Harokopio University of Athens
Changes in Nitrogen Dioxide Levels over Greece after the Outbreak of COVID-19; a Satellite View
Andreas Karavias, Isaak Parcharidis, Maria-Elissavet Koukouli, Ioanna Skoulidou , Dimitris Balis, Astrid Manders, Arjo Segers, De Bilt, Henk Eskes, Jos van Geffen.

14:30 – 14:45 **Phoebe-Demeter Speis**
National & Kapodistrian University of Athens
The COVID-19 Pandemic Initial Outbreak in Greece in Spring 2020. Public Perceptions and Behaviour
Phoebe-Demeter Speis, Ioannis Andreadakis, Emmanouil Andreadakis

14:45 – 15:00 **Fotini Gioltzidou**
Aristotle University of Thessaloniki
#MENOUMESPITI, #MENOUMEASFALEIS, #COVID19GREECE: The role of hashtag's language in the dissemination of information in Greece
Georgia Gioltzidou, Dimitrios Amanatidis, Ifigeneia Mylona, Fotini Gioltzidou

15:00 – 17:00	**Poster Session (p. 13-14)**

Chair: Assimina KOurou

17:00 – 17:30	**Kyriaki Makri [invited speaker]** *National Observatory of Athens, Postdoctoral Research Fellow | Committee of GEOsciences Didactics of the Geological Society of Greece, President.* Conceptual development of the term Natural Disasters in textbooks from 1830 until today
17:30 – 19:00	**Round Table:** **Information and Education Role in Risk Reduction** Panel: Assimina Kourou (EPPO, co-ordinator) Miranda Dandoulaki (Region of Attica) Aspasia Karamanou (Region of Attica) Vassileios Vathrakogiannis (Hellenic Fire Corps)

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special session

Prediction, Forecasting, Early Warning Systems

15.10

Chair: Gerassimos Papadopoulos

09:00 – 09:45 **Alessandro Annunziato [invited speaker]**
Joint Research Centre European Crisis Management Laboratory, Head
"Last Mile" Tsunami Project: Kos and Bodrum Tsuami Early Warning System

09:45 – 10:00 **Iraklis Katsaloulis**
National and Kapodistrian University of Athens
The Perils of Earthquake Prediction: a Historical and Epistemological Approach

10:00 – 10:15 **Stavroula Fotopoulou**
Aristotle University of Thessaloniki
Towards an Earthquake Early Warning and Real-Time Seismic Risk
Kyriazis Pitilakis, Stavroula Fotopoulou, Anastasia Kiratzi, Stelios Siskos, Kostas Siozios, Christos Spandonidis

Chair: Issaak Parcharidis

10:15 – 10:00 **Petros Katsafados**
Harokopio University of Athens, Associate Professor
Nowcasting an Extreme Flash Flood Event: the Case of Mandra, Greece
Petros Katsafados, Christos Spyrou, George Varlas, Aikaterini Pappa, Angeliki Mentzafou, Anastasios Papadopoulos, Marios N. Anagnostou, John Kalogiros

10:30 – 10:45 **Christos V. Komninos**
Hellenic Fire Corps
Cell Broadcast Messages as Public Warning System in Greece After Message, What?
Christos V. Komninos, Paraskevi D. Soulopoulou, Vasileios C. Komninos

10:45 – 11:00 **Athanasios Kalogeras**
Research Centre ATHENA, Industrial Systems Institute
Establishment of a Transnational Civil Protection Early Warning System in Adrion Territories: Project "Transcpearlywarning"
Athanasios Kalogeras, Miranda Dandoulaki

11:00 – 11:15 **Theodoros Gatsios**
National & Kapodistrian University of Athens
Exploring deformation patterns of the Methana volcano in Greece using Copernicus Sentinel-1 MTInSAR, GNSS/GPS and seismic data
T. Gatsios, F. Cigna, D. Tapete, V. Sakkas, K. Pavlou, I. Parcharidis

11:15 – 11:30 **Aggelos Chasiotis**
METRICA
Natural Disasters: Applications for online monitoring in order to on time forecasting and early warning
Aggelos Chasiotis, Hippocrates Pappas

11:30 – 11:45 **Stelios Bollanos**
PLANETEK
COPERICUS Emergency Management Service
1. Rapid Mapping
2. Risk & Recovery (FLEX & STANDARD)

session: Natural Hazards

Chair: Dimitrios Pyrros

11:45 – 12:30 **Kyriazis Pitilakis [invited speaker]**
Aristotle University of Thessaloniki, Professor | European Association of Earthquake Engineering (EAEE), President
The European Seismic Risk Model 2020 (ESRM20)

12:30 – 12:45 **Vasiliki Kouskouna**
National & Kapodistrian University of Athens, Associate Professor
The 19 July 2019 Mw5.1 Attica Earthquake: a Multidisciplinary Approach
V. Kouskouna, A. Ganas, M. Kleanthi, I. Kassaras, N. Sakellariou, G. Sakkas, S. Valkaniotis, E. Manousou G. Bozionelos, V. Tsironi, I. Karamitros, N. Tavoularis, Ch. Papaioannou7 and R. Bossu

12:45 – 13:00 **Georgios Panagopoulos**
International Hellenic University, Greece
Seismic Risk Assessment of the City of Serres Using the Openquake Platform
Georgios Panagopoulos, Anatoli Sismanidou, Sotiria Stefanidou, Emmanouil Kirtas

session: Search & Rescue

Chair: Michail Chalaris

13:00 – 13:15 **Harris Georgiou**
Hellenic Rescue Team of Attica (HRTA)
Resilient communications and UAV fleet for future Search & Rescue operations
Harris Georgiou, Alexis Vlachopoulos, Aspasia Tzeletopoulou, Miltiadis Koutsokeras, Alexandros Kordonis, Eleftherios Ouzounoglou6, Angelos Amditis, Friedrich Steinhäusler, Auer Lukas9, Andreas Feichtner, Christoph Oberauer, Anaxagoras Fotopoulos, Pantelis Lappas, Georgios Diles

13:15 – 13:30 **Vassilis Trizonis**
SPELEO caving club | Greek Cave Rescue team
The cooperation between Civil Protection and Cave Rescue teams: The example of Sarchos

13:30 – 13:45 **Aspasia Tzeletopoulou**
Hellenic Rescue Team of Attica (HRTA)
Smart boots, fusion engine and aerial assets for enhanced situational awareness and safety in Search & Rescue operations
Harris Georgiou, Alexis Vlachopoulos, Aspasia Tzeletopoulou, Georgios Diles, Eva Jaho, Anaxagoras Fotopoulos, Angelos Chatzimichail7, Anastasios Karakostas, Panayiota Demosthenous, Antonis Hadjiantonis, Henry Meissner, Thomas Kraft, Adrian Schischmanow, Gustav Tolt, Claudio Paliotta, Norman Kerle, Maria Krommyda, Lazaros Karagiannidis, Constantinos Vassilakis, Angelos Amditis

13:45 – 14:00 **George D. Romosios**
Hellenic Fire Corps
The Flashover: Description and Firefighter Tactics
George D. Romosios, Vaios Zygouris, George Ntzaferis

14:00 – 14:15 **Alexios Vlachopoulos**
Hellenic Rescue Team of Attica (HRTA)
Enabling gesture-based controls for first responders and K9 units
Alexis Vlachopoulos, Harris Georgiou, Aspasia Tzeletopoulou, Panagiotis Kasnesis, Christos Chatzigeorgiou5, Dimitris Kogias, Charalampos Z. Patrikakis, Georgios Albanis8, Konstantinos Konstantoudakis, Anastasios Dimou, Petros Daras

session: Accidents & Hazards

Chair: Paraskevi Nomikou

14:15 – 14:30 **Michail Chalaris**
International Hellenic University | Hellenic Fire Corps
Novel Systems for Detection and Monitoring of Dangerous Substances in Water Environmental Sensitive Areas
Nikos Tsalas, Giorgos Katsouras, Michalis Chalaris, Stelios Samios, Efthymios Lytras, Kostas Papadopoulos, Nikos Kouris, Simos Malamis, Costas Noutsopoulos5, Danos Mamais5, Andreas Andreadakis

14:30 – 14:45 **Markela Giannousopoulou**
NCSR DEMOKRITOS
Maritime accidents and environmental hazards. Creating a dynamic model for predicting maritime accidents and environmental pollution
Markela Giannousopoulou, Myrto Konstantinidou

14:45 – 15:00 **Konstantina Bantouvaki**
Harokopio University of Athens
Earth Observation for Coastal Erosion Monitoring in Europe: the Space for Shore Project

15:00 – 17:00 **Poster Session (p. 13-14)**

17:00 – 19:00 **Round Table:**
Legislative Framework and its Role for Local Authorities
Panel:
Gerassimos Papadopoulos (Coordinator)
Konstantinos Kokolakis, Decentralized Adm. of Macedonia – Thrace Civil Protection former Director
Kostas Chouvardas, Region of Eastern Macedonia & Thrace, Civil Protection Department, Head
Elena Rapti, Legal Adviser to the Deputy Minister for Civil Protection and Crisis Management

16.10

09:00 –10:10 **Parallel Event by EPPO**
Seminar for Teachers: "Seismic Protection of School Units" (Annex I)

session: Education

Chair: Assimina Kourou

10:10 – 10:15 **Gerassimos Papadopoulos [invited speaker]**
Scientific Collaborator EU and UNESCO
Earthquakes in Greece: Past, Present, Future: a comment

Chair: Gerassimos Papadopoulos

10:15 – 10:30 **Afroditi Salta**
2nd Lyceum of Megara, West Attica Secondary Education Directorate
Natural Disasters and Technological Accidents: Educated to Protect and to be Protected in Senior High School

10:30 – 10:45 **Marianna Kalendi**
Management Organization Unit of Development Programs (MOU S.A.)
Risk Communication and Disaster Management in Greece: the Prospect of an Adult Education Program

10:45 – 11:00 **Assimina Kourou**
Earthquake Planning and Protection Organisation of Greece, Training Department, Head
Child Care Earthquake Preparedness: EPPO Initiative
Asimina Kourou, Ioanna Nikolopoulou, Aimilios M. Saber, Spilios Kyriakopoulos, Argiro H. Florou, Natalia Anyfanti

session: Innovation & Technology

Chair: Konstantinos Chouvardas

11:00 – 11:15 **Michail Chalaris**
International Hellenic University | Hellenic Fire Corps
I-REACT: Improving Resilience to Emergencies Through Advanced Cyber Technologies
Michail Chalaris, Conrad Bielski, John Alexander, Vangelis Pipitsoulis, Ioannis Kassaras

11:15– 11:30 **Ioannis Kassaras**
National & Kapodistrian University of Athens, Associate Professor
I-REACT RSRA: Development of a Rapid Seismic Risk Assessment Tool that Integrates Instrumental, Crowdsourcing, Social Media Data and Empirical Vulnerability
I. Kassaras, V. Pipitsoulis, P. Papadimitriou, N. Voulgaris, V. Kouskouna, G. Kaviris, V. Kapetanidis, A. Karakonstantis, E. Lekkas, S. Lalechos, P. Bernard, R. Bossu, L. Fallou, F. Finazzi, C. Bielski, M. Chalaris, R. Kosheleva, A. Mitropoulos, P. Kinanlis, D. Kazantzidou-Firtinidou, L. Stupina , J. Alexander

11:30– 11:45 **Olga Markogiannaki**
REDI Engineering Solutions PC
Application for the Real-Time Estimation of Building's Seismic Damage in City-Scale on the Basis of Artificial Neural Networks
Konstantinos Morfidis, Olga Markogiannaki, Sotiria Stefanidou

11:45 – 12:00 **Ioannis Kontos**
MARATHON DATA
The ArcGIS Platform as a useful tool for Civil Protection

12:00 – 12:15 **Despoina Bafi**
Harokopio University of Athens
A Geospatial Intelligence Application Based on SAR Interferometry to Support Immediate Post-Seismic Infrastructure Inspections: the Cases of Earthquakes in the Balkan Peninsula
Despoina Bafi, Andreas Karavias, Theodoros Gatsios , Asimakis Fylaktos, Olga Markogiannaki, Efthymios Lekkas , Issaak Parcharidis

12:15 – 12:30 **Athanasios Emmanouil Mourampezis**
Harokopio University of Athens
Geospatial Features and Mapping of Flood Events in Transboundary Basins in the Southern Balkans Using Earth Observation Satellite Data

12:30 – 12:45 **Spiridon G. Krokidis**
Ionian University
A Low-Cost Seismograph: First Results
Spiridon G. Krokidis, Ioannis Vlachos, Nikolaos M. Polymenakos, Markos Avlonitis, Anastasios Kostoglou and Vasileios Karakostas

12:45 – 13:00 **Michail Chalaris**
International Hellenic University | Hellenic Fire Corps
Novel Solutions for Command & Control Network for Disaster Management
Michail Chalaris, Vangelis Pipitsoulis, Itamar Banayan

session: Crisis Management

Chair: Miranda Dandoulaki

13:00 – 13:45 **Amir Yahav [invited speaker]**
Israel National Steering Committee for Earthquake Preparedness, Director
Israel preparedness for tsunami, emphasizing on the March 2019

13:45 – 14:00 **Lazaros Filippidis**
University of Greenwich , U.K.
Multimodal Wildfire Evacuation at the Microscopic Level
L. Filippidis, P. J. Lawrence, V. Pellacini, A. Veeraswamy, D. Blackshields, E. R. Galea

14:00 – 14:15 **Anna Karatzetzou**
Aristotle University of Thessaloniki
A Prioritization Scheme for Seismic Intervention in School Buildings. The case of Thessaloniki, Greece
Anna Karatzetzou, Evi Riga, Stefania Apostolaki, Stella Karafagka, Kyriazis Pitilakis, Efthymios Lekkas

14:15 – 14:30 **Miranda Dandoulaki**
Harokopio University of Athens
Emergency Evacuation in Case of an Imminent or an Ongoing Disaster in Greece: a Comment

14:30 – 14:45 **Michail Chalaris**
International Hellenic University | Hellenic Fire Corps
Long-Distance Voice Messaging Systems (Clear Voice) During the Time of Natural and Manmade Disaster According to Health and Safety Regulations
Michail Chalaris , Vangelis Pipitsoulis, Ray Ingblum

14:45 **Closure** [Gerassimos Papadopoulos & Ilias Argyris]

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NEW CHALLENGES FOR MULTI – HAZARD EMERGENCY MANAGEMENT IN THE COVID-19 ERA IN GREECE

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ABSTRACT

The current study focuses on new challenges regarding multi-hazard emergency management in the COVID-19 era in Greece. A literature review is presented and also a field research that was conducted in Greece, focusing on risk perception, awareness and emergency preparedness of the workers and the public with regards to COVID-19 epidemic and natural and technological disasters. A research tool was established based on literature. The results of the field research reveal a high level of concern for epidemic COVID-19, mainly among employees in workplaces where there is contact with the public. The level of preparedness, however, is relatively low. It was found that the higher the level of protective measures was at the workplace, the higher the subjective assessment of the respondents concerning the level of preparedness for SARS-COV-2 spread. The level of the information provided to the public concerning issues of prevention and guidance for self-protection in case of natural and technological disasters remains relatively low. A positive relation is found regarding the level of preparedness for natural and technological disasters with previous training for emergencies at the workplace. The present study reveals challenges and priorities in the COVID-19 era for all the stakeholders (workers and employers, public, researchers, public authorities etc.). The priority is to enhance collaboration among all the stakeholders for raising public awareness and to provide relevant information and training for prevention and preparedness against multi-hazard major risks. Priorities for research and development were also identified. Integrated risk assessment tools and effective emergency plans for mutli-hazard risks are among those priorities. Occupational safety and health procedures in this context are critical.

Keywords: multi – hazard, emergency management, NATECH, COVID-19, OSH

1. INTRODUCTION

Today's hazards such as biological, environmental, geological, hydro meteorological and technological processes and phenomena (as mentioned in the Sendai Framework for Disaster Risk Reduction 2015-2030) pose a major threat to humans and the environment [1,2,3]. Disaster risk management must take into consideration the interrelation of risks ("multi-hazard" perspective). A significant aspect is that a technological accident can be triggered by a natural hazard or disaster which is commonly referred to as NATECH accident [4]. According to the United Nations Office for Disaster Risk Reduction (UNDRR), *"there is an urgent need to investigate further the direct and indirect linkages and effects of natural, biological, technological and other human-induced hazards to identify better and understand cascading and complex hazards and risks in a systematic way. The shift towards a broader view and a more context-dependent definition of hazards requires a systematic approach to risk that considers hazard, vulnerability, exposure and capacity together and better understands their complex interactions".* [5]
The SARS-COV-2 threat, poses new difficulties and challenges for risk assessment and management in the context of multi-hazard risk management approach [6,7,8,9]. From previous studies it has been demonstrated that some important aspects in the context of establishing effective prevention and

emergency response policies for multi-hazard risk assessment and management, are the contribution of occupational safety and health (OSH) procedures, as well as, public awareness and training [10,11,12,13]. The present study focuses on these aspects in the COVID-19 epidemic era in Greece. We try to answer to the following research questions: Which are the priorities for establishing effective multi-hazard emergency management procedures in Greece in the COVID-19 epidemic era? What is the level of workers and public awareness and preparedness for multi-hazard risks? In what way is emergency preparedness affected by risk perception of workers and the public? How can occupational safety and health procedures contribute to an effective multi-hazard risk management?

2. METHOD

This study involves literature review and a field study in Greece. A special research tool (electronic questionnaire) was established in order to conduct the field study [10,14]. After its validation, the questionnaire was distributed to the public via a web platform. The sample of the study consists of male and female adults of all ages and education levels. For the use of the research tool, all terms concerning the personal data protection complied to the country's legislation. The parameters that were examined relate to risk perception, awareness and emergency preparedness of workers and the public, with regards to COVID-19 epidemic, natural and technological disasters (earthquake, flood, tsunami, strong winds, hazardous materials accidents etc.), as well as fire emergencies at the workplace. In this paper, the preliminary results of the study are presented. The sample under study is considered to be a sample of the general population during this time. Based on this condition statistical tests were conducted in the "sample". The confidence level used was a=0.05 in order to prove the statistical significant differences.

3. RESULTS AND DISCUSSION

Many recent studies discuss the challenges arising for multi-hazard risk assessment and management today due to COVID-19. For example, according to the UN Office of Disaster Risk Reduction, *"in situations where disaster managers are dealing with crises on multiple fronts, responding to one disaster may exacerbate the impact of another. For instance, COVID-induced mobility restrictions may hinder safe evacuations while physical distancing regulations may preclude evacuating large numbers of people to temporary shelters. (…) Community awareness and risk communication may also be impacted."*[8] Ishiwatari et al. mention that: *"Response activities without social distancing may spread COVID-19 among staff members of disaster management. If COVID-19 measures are overdone, flood response may be inadequate to decrease damage."* [6] According to Cardil & de-Miguel: *"First responders must ensure the continuity of essential services to protect people although the virus is critically decimating them. (….) Authorities are reacting to the pandemic through well-known restrictions depending on national governments that are already changing organizational workflows in most agencies, limiting intra and inter-institutional interactions, and making difficult strategic and tactical responses to coming emergencies".*[7] According to Quigley et al. *"inclusion of natural hazard inputs into COVID-19 epidemiological models could enhance the evidence base for informing contemporary policy across diverse multi-hazard scenarios, defining and addressing gaps in disaster preparedness strategies and resourcing, and implementing a future-planning systems approach into contemporary COVID-19 mitigation strategies"*. [9]

The UN Office of Disaster Risk Reduction recommends some actions for combating the Dual Challenges of Climate-related Disasters and COVID-19, such as, *"enhance multi-hazard disaster preparedness efforts, strengthen overall health system preparedness, proactively reduce the vulnerability from other*

hazards, plan specifically to protect older people, and other vulnerable groups, prioritise integrated disaster risk management, protect first responders and frontline workers, support local action to prevent, prepare for and respond to disasters, use remote assessments and community feedback to determine humanitarian needs''. [8]

The literature review and the field research indicate the challenges and priorities for multi-hazard emergency management in Greece in the COVID -19 epidemic era. The importance of enhancing multi-hazard emergency preparedness efforts in the context of an integrated risk management is evident. In this context the role of occupational safety and health procedures at the workplace is significant.

The outcomes of the field research reveal a high level of concern for epidemic COVID -19, mainly among employees at workplaces with contact with the public. In fact, as expected, comparatively to a previous relevant study [10], the public concern of an epidemic outbreak appears to be significantly higher. The level of preparedness, however, is relatively low. The level of workers protection with regards to COVID-19 was examined, according to protective measures that are proposed by EU-OSHA [14] and national legislation. It is shown that the higher the level of protective measures at the workplace, the higher the subjective assessment of the respondents concerning the level of preparedness for SARS-COV-2 spread.

Additionally previous relevant studies in Greece are confirmed, regarding the risk perception and the level of awareness and emergency preparedness of the workers and the public for natural and technological disasters [10,15]. For example, the level of the information provided to the public concerning issues of prevention and guidance for self-protection in case of natural and technological disasters remains relatively low. The level of the training on related issues is even lower. A positive association is detected between the level of preparedness for natural and technological disasters and previous training for emergencies at the workplace.

Previous studies in Greece demonstrate the need for enhancing collaboration among all the stakeholders for developing effective multi-hazard emergency plans. According to the relevant literature and the present field study, the new COVID-19 epidemic poses new challenges in emergency preparedness in Greece, which must be taken into consideration.

An integrated risk assessment and decision making approach regarding prevention measures for SARS-COV-2 spread, OSH procedures, prevention measures for hazardous materials major accidents and natural disasters, can contribute to an effective multi-hazard emergency management.

Especially, the role of OSH procedures is very important for: (a) strengthening prevention policies in every workplace, (b) promoting education, training and safety culture policies for workers and the public, (c) taking into consideration the changes of the work environment which may affect the lever of multi-hazard risk, (d) supporting decision makers in all levels for effective emergency response procedures in urban areas, (e) supporting emergency services by analyzing occupational risks and proposing relevant preventive measures (e.g. appropriate personal protective equipment, musculoskeletal hazards assessment and ergonomics promotion, occupational health surveillance).

4. CONCLUSIONS

The field research and the literature review recognize the factors that contribute to the risk perception, awareness and preparedness of workers and the public, regarding risks such as epidemics, natural and chemical disasters The challenges and priorities for all the stakeholders (workers and employers, public, researchers, public authorities etc.) in the COVID-19 era are exposed, calling for an enhancement of collaboration for raising public awareness and provision of relevant information and training on the prevention and preparedness for major multi-hazard risks. Priorities for research and development of integrated risk assessment tools and effective emergency plans for mutli-hazard risks are also put forward. The role of OSH in this context is critical.

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AN INNOVATIVE EMERGENCY MEDICAL REGULATION MODEL IN NATURAL AND MANMADE DISASTERS

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ABSTRACT
The purpose of this research is to introduce an innovative idea of an Emergency Medical Regulation Center (EMRC) to the emergency medical service (EMS) system for mass casualty incidents (MCIs) during natural and manmade disasters. This project focuses on two significant disaster events in Taiwan: one is the worst natural catastrophic event in 2009, the 88 Wind-caused Disasters, resulting by the Typhoon Morakot, and another is a calamitous manmade disaster of the Formosa Fun color dust explosion in 2015. The EMRC scenario is simulated and evaluated in the two events. Initially, a proposed EMRC is constructed in a safe location near the disaster area to accommodate the moderate and the minor casualties and provide a first aid to them. Moreover, a strategy of an advanced emergency medical transportation, the sequential-conveyance method, is complemented by the EMRC to promote the efficiency of the ambulance services related to transportation time and distance. In this case, ambulances are classified into 2 categories: the first-line ambulances, which reciprocate between the EMRC and the disaster area to save time and shorten the working distances and the second-line ambulances, which transfer patients in critical condition from the EMRC to the requested hospitals for further treatment. Based on the results, the EMRC model is more efficient than the conventional method for EMS transportation in a MCI. This method improves the time efficiency by 52.15% and the distance efficiency by 56.02% in the case of the Xiaolin village in the 88 Wind-caused Disasters, and the apparent prehospital time has a 47.61% reduction by employing an EMRC model in the Formosa Fun color dust explosion. Conclusively, an EMRC model including the sequential-conveyance method for the EMS transportation is not only more efficient but also more adaptive in responding to a MCI during a catastrophic natural and manmade disaster.

Keywords: Emergency medical service, mass casualty incident, Emergency Medical Regulation Center, sequential-conveyance method, natural and manmade disaster

1. INTRODUCTION
The catastrophic effects of natural and manmade disasters have drawn the attention of researchers and response sectors worldwide [1-5]. Storms, floods, droughts, fires, heat waves, and manmade disasters have caused mass injuries and also deaths frequently over the last few decades. As a consequence, the large casualty caseloads force the emergency medical service (EMS) system to develop an adequate adaptation plan. Once the overloaded patients in a mass casualty incident (MCI) surge to the emergency departments (EDs) of the response hospitals, two questions will be asked: Does the response ED have enough capacity to receive the patients? How to reserve the higher level medical resources for the serious injured persons? In order to resolve above questions, an Emergency Medical Regulation Center (EMRC)

has been designed for accommodating the moderate and mild cases to provide a professional medical treatment, while the sever ones will be transfer to the EDs directly by the on-scene ambulances. It can not only prevent the competition of medical centers' resources between the urgent and non-urgent patients, but also release the surge pressure of EDs by employing the EMRC as a buffer space. The EMRC is a transient location or building between the disaster area and response hospitals, while the supported medical teams will provide first aid and stabilize the condition of the moderate and mild patients. An EMRC can be considered as a conceptual term, since its format will be modified based on the demands of each incident. For example, in Boston marathon bombing in USA, the EMRC can be set up by tents and carpets, while during the Chi-Chi earthquake disaster in Taiwan, schools and stadiums would be requisitioned in order to meet the patients' needs. In order to evaluate the function of an EMRC model, a natural disaster of Typhoon Morakot that occurred on 8 August 2009 [1] and a manmade disaster of Formosa Fun Color Dust Party explosion on 27 June 2015 [2] were employed as cases studies.

2. METHOD

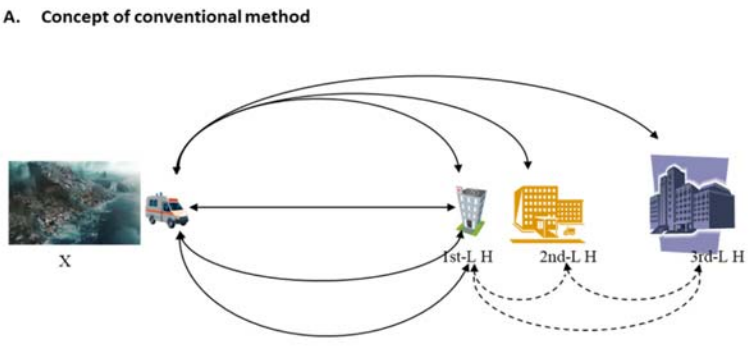
2.1. Background

On 8 August 2009, Typhoon Morakot wrought havoc in Taiwan, by taking the lives of 702 individuals and by causing damage of roughly US$ 6.76 billion. Almost all the southern regions of Taiwan were flooded by a record-breaking heavy rain that caused damages beyond any imagination. This tragedy is also known as the ''88 Wind-caused Disasters.'' The research concentrates on Xiaolin mountain village, which was heavily destroyed by a devastating mudslide during the Typhoon Morakot. It is believed that >400 residents buried alive, whereas 137 people were saved and sent to safety areas; 16 of them with injuries were transported to hospitals for further medical care.

Another case study is the Formosa Fun Color Dust Party explosion on 27 June 2015 in Taiwan, caused 499 persons in different degrees of burn wounds were transported to the hospitals via different means such as ambulances, taxis, private cars, and military vehicles. Due to the policy of the local health sectors, the casualties in situ were evacuated within 3.5 hours approximately. Although the strategy for emergency medical transportation is far from the regular guidance which is a triage-based transportation practice, the mortality is quite low (about 3%). Therefore, it is worth evaluating the EMS transportation plan thoroughly in such a case to learn the lessons for a burn MCI revolution, and try to develop an adaptive EMS transportation plan to reduce the deficiency and improve efficiency.

2.2. An EMRC Model

The EMRCs are designed for receiving the moderate and mild patients in a MCI, and the sequential-conveyance method is applied in the EMRC-based emergency medical transportation. The ambulances are categorized into two lines: the first-line ambulances are shuttling between the disaster area and an EMRC, while the second-line ambulances are standing by in an EMRC to transport unstable patients to the response hospitals under the doctors' instructions. A comparison of the conventional EMS transportation and the EMRC-based sequential conveyance method is depicted in the Figure 1.



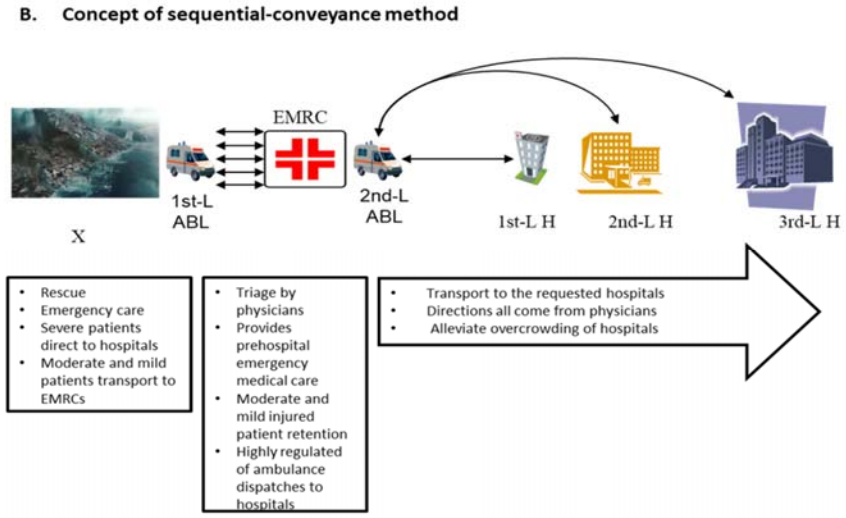


Figure 1. A comparison between the conventioal EMS transportation (Panel A) and the EMRC-based sequential-conveyance method (Panel B). 1st-L, first-line; 2nd-L, second-line; 3rd-L, third-line; ABL, ambulance; EMRC, Emergency Medical Regulation Center; EMS, emergency medical service; H, hospital; X, disaster area. (Adapted from reference [1])

2.3. Time and distance efficiency

To evaluate the efficiency of the EMS transportation between the conventional and the sequential-conveyance method, the difference of the required time and the difference of the distance of these 2 methods are estimated. The subtraction of the total EMS transportation time of the conventional method (T_{CM}) from that of the sequential-conveyance method (T_{SM}) divided by T_{CM} equals to time efficiency (TE). The subtraction of the total transportation distance of the conventional (D_{CM}) method from that of the sequential-conveyance method (D_{SM}) divided by D_{CM} equals to distance efficiency (DE).

2.4. Apparent prehospital time

Since the emergency condition of the Formosa Fun Color Dust Party explosion site, records of the ambulance arrivals and departures, transportation time, and on-scene time were missing, apparent prehospital time (*app*PHT) can be defined as the time period from the initiation of the explosion until the time patients registered and admitted to the EDs. The efficiency of the EMRC model can be evaluated by a reduction of the *app*PHT by comparing of the on-scene EMS transportation with the EMRC scenario in the event.

3. RESULTS AND DISCUSSION

The relations between the EMRC retention and the TE or the DE are shown in Figure 2. The patient ratio (PR) in different supposed values would meet different T_{CM} and T_{SM} by permutation and combination algorithm in the conventional and the sequential-conveyance method. If a maximum T_{CM} encounters a minimum T_{SM} by a fixed PR, a maximum TE boundary (TE*max*) (Figure 2: Panel A) can be obtained. On the other hand, when a minimum T_{CM} encounters a maximum T_{SM}, a minimum TE (TE*min*) is acquired. However, in a retrospective case study, the patient and the non-patient flow of each hospital and each refuge respectively, are kept in a determinate ratio (a fixed PR). In such situations, the maximum and minimum value of TE depend on the EMRC retention for the patients. Therefore, due to the EMRC retention (Figure 2: Panel A), an apparent TE*max* (*app.* TE*max*) and an apparent TE*min* (*app.* TE*min*) calculation are executed to evaluate the effect of the sequential-conveyance method. The same mathematical logic is applied for DE*max*, DE*min*, *app.* DE*max*, and *app.* DE*min* calculations (Figure 2: Panel

B). In the real case of Xiaolin village, if 16 patients (PR≒0.1185) were subjected to the EMRC retention, the *app.* TE*max* = 63.22%, and *app.* DE*max* = 66.88% would be obtained. Alternatively, since the patients are not retented in an EMRC, the *app.* TE*min* = 52.15%, and *app.* DE*min* = 56.02% are obtained. These values are also equal to TE and DE, respectively. In addition, the apparent prehospital time has a 47.61% reduction by employing an EMRC model in the Formosa Fun color dust explosion.

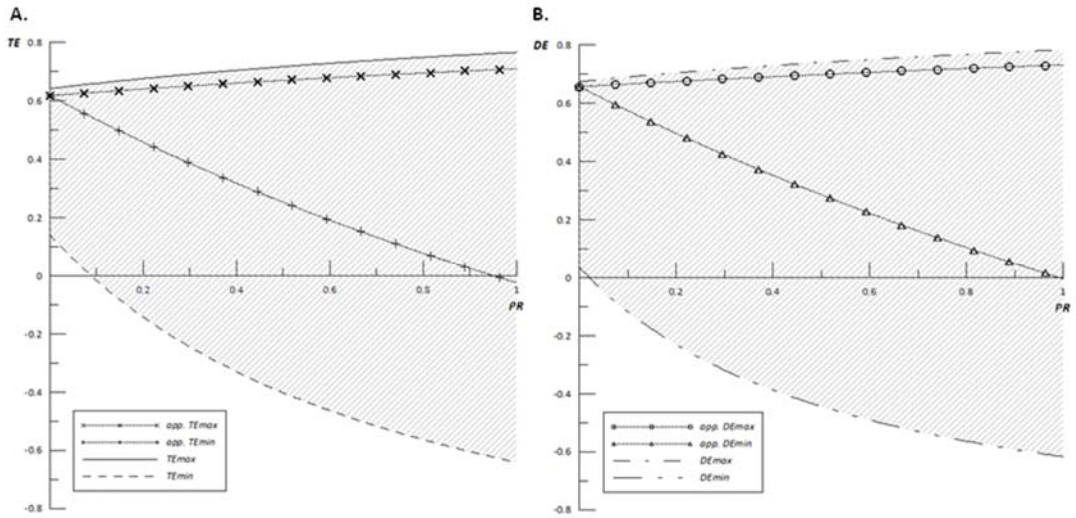


Figure 2. The TE and DE (panel A and B, respectively) analyses of the sequential-conveyance method compared with the conventional method using different transportation maneuvers. DE, distance efficiency; PR, patient ratio; TE, time efficiency. (Adapted from reference [1])

4. CONCLUSION

Based on the results of this research, the scenario design of the EMRC including the sequential-conveyance method improve both time/distance efficiency and apparent prehopital time for the EMS transportation. Furthermore, the EMS adapt more effectively in MCIs, therefore, these findings are also vital to every decision-making regarding the advanced EMS transportation. Yet, additional studies should promote innovations in this field and focus on the selection of the optimal EMRC location(s), EMRC-based information integration, EMRC's role(s) in different types of MCI, etc., in order to maximize the potential of EMRC for the patient regulation.

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FRAGILITY ANALYSIS OF BRIDGES IN A MULTIPLE HAZARD ENVIRONMENT

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ABSTRACT

Since road and rail networks are exposed to multiple hazards, the impact of the latter on the reliability assessment of structural components (such as bridges) should be accounted for in the frame of fragility analysis and resilience assessment. The aim of this paper is to propose and apply a structure-specific methodology for fragility analysis of bridges for the combined events of earthquake and scour, advancing the state-of-the art regarding the limit state threshold definition, dully tailored to account for all pier and pile foundation properties that affect component capacity and, hence, fragility. The most critical component, namely bridge piers, is considered and limit state thresholds are explicitly derived based on the pertinent pushover curves considering both the pile foundation alone and the pier-foundation system. Local damage in both piers and pile foundation is accounted for in the analytical estimation of limit state thresholds. Fragility curves for the combined effects of scour and earthquake are provided, accounting for varying pier and soil properties via related uncertainties and different scour depths (1.5m and 2.0m), while the results are discussed from the perspective of road network resilience in a multihazard environment.

Keywords: bridges, multiple hazard, fragility curves, scour, earthquake

1. INTRODUCTION

Road bridges are important projects as the state financial investment for their construction is high, while bridge failures are related to significant direct and indirect social and economic losses. Bridges are in direct interaction with the environment and are exposed to multiple hazards and climate risks, including extreme weather events, the frequency and severity of which has been significantly increased and will continue being aggravated due to climate change. Serious damage due to extreme weather events (e.g., flood) has been observed at the Greek urban and interurban road network recently Greece. Two characteristic examples are presented in Fig.1, the failure of a bridge at Kalamata, Trikala in 2016, due to flood loading resulting in deck unseating (left) and the failure of a newly constructed bridge at Rodopi, Iasmos, possibly due to foundation and abutment failure (rotation). Very recently, in September 2020, flooding in Karditsa resulted in failure of bridges and overpasses.

Figure 1: Bridge failure due to flood, causing deck unseating at Trikala, Kalampaka. Bridge failure due to foundation failure (rotation) at Iasmos, Rodopi.

Several methodologies are available in literature for the estimation of bridge fragility in a multiple hazard environment, however, many of them do not account for all critical components or failure modes for the estimation of seismic capacity, demand and, finally, seismic fragility, rendering the results dependent on the assumptions made and the level of accuracy. Fragility analysis results are important for retrofit prioritization, guidance and optimal retrofit strategy selection, therefore multiple hazards at the lifetime of the bridge should be accounted for. It should be outlined that fragility analysis for multiple hazards is essential for newly constructed bridges as well, highlighting the most vulnerable components and optimizing the maintenance and retrofit costs. To this end, a methodology for the derivation of bridge-specific fragility curves is proposed and applied herein, accounting for different failure modes (both at substructure and foundation). A pile foundation bridge is analysed and fragility curves are derived accounting for scour at bridge piers. Bridge capacity is calculated accounting for foundation damage as well and the effect of scour on seismic fragility is evaluated.

2. FRAGILITY OF BRIDGES IN A MULTIPLE HAZARD ENVIRONMENT

2.1. Available methodologies in literature

The available methodologies for the estimation of bridge fragility curves are classified into empirical (based on expert judgment or actual damage), analytical (based on analysis results) and hybrid (a combination of the above). In the last 30 years the development of analytical methodologies has occupied several research groups that cover both existing and reinforced bridges. Regarding the exposure of bridges in a multiple hazard environment, it is noted that several methodologies are proposed in the last decade for the vulnerability estimation of bridges not only against earthquake but for other natural disasters as well, having a high probability to happen during the lifetime of the structure (multi-hazard framework). Most of the proposed methods account for the vulnerability estimation in case of combined action of earthquake and flood, while some of them take into account the interaction with the environment (corrosion, etc). It is worth noting that only one methodology assesses the overall vulnerability for all of the above [1] while most of them take into account bridge piers as a critical component, ignoring the effect of other components on the systems' vulnerability.

Specifically, Wang et al., [2] showed that the scour depth plays an important role in seismic response as it renders the foundation of the structure weaker and more flexible increasing the eigenperiod. They showed that the probability of failure, in general, increases with the scour depth, while Ganesh Prasad & Banerjee, [3] found that this increase is non-linear and a significant depth of the undercut to 3m. Yilmaz et al., [4], report that the bridge component that is most influenced by scour is the piers and in particular the first and last failure level, along with the bearings in the longitudinal direction, while the abutments remain practically unaffected. Similarly, Gehl & D'Ayala, [5] found that that the influence of the scour depth is greater for large limit states (related to loss of bearing capacity or collapse), and Wang et al., [6] that in the case of scour the most critical and vulnerable component is bridge piers.

Very recently, Stefanidou and Kappos [7] proposed a component-based methodology for the estimation of bridge-specific fragility curves accounting for all critical components and various failure modes. The methodology is extended to account for foundation damage, defining limit state thresholds initially for the pile foundation and subsequently for the pier – pile foundation system, accounting for series connection between components (Fig.2(a)). It should be noted that limit states of the pile foundation are expressed in displacement terms, based on inelastic analysis results and the pushover curve, as depicted in Fig.2(b).

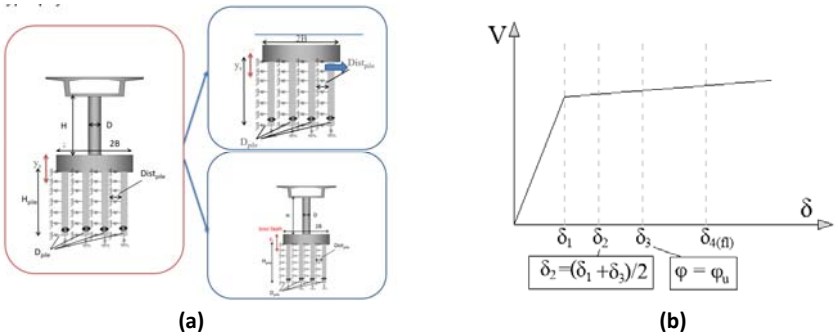

Figure 2. (**a**) Analysis of bridge pier system for the capacity estimation; analysis of the pile foundation and the total (pier and pile foundation) system (**b**) Limit state threshold definition based on the capacity curve of the bridge pier system

A pier-pile foundation system is analysed herein and fragility curves with and without scour consideration are provided. The two subsystems of the pier system are analysed, namely the pile foundation with dimensions 12.0x12.0(m), 4x4 piles having 25m length and 1.0m diameter and the cylindrical pier having D=2.0 diameter and longitudinal reinforcement ratio equal to 1%. Pile springs are calculated considering soil type D, while scour depth equal to 2.0m is considered. The capacity curves of the pile-foundation and the pier-pile foundation system are presented in Figure 2 (a & b) and are differentiated when scour is accounted for. The decrease in strength is expected, since the inelastic deformation in piles occurs earlier, while the structure, in case of scour, is more flexible. Furthermore, the decrease in stiffness is obvious, owning to the removal of soil springs and the increase of free pile height.

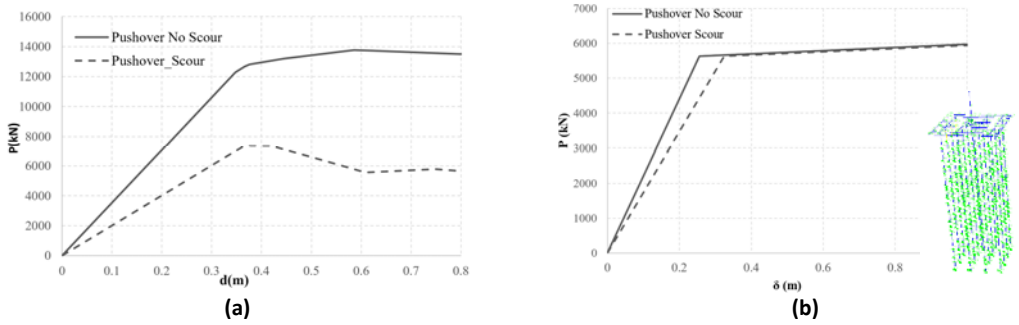

Figure 3: Capacity curve of pile foundation (a) and pile-foundation system (b) with and without scour

Fragility curves of the pier- pile foundation system are calculated and depicted in Figure 4, highlighting that seismic fragility is increased due to scour for all limit states. It should be outlined that the critical system component is the pier, yielding before the pile foundation.

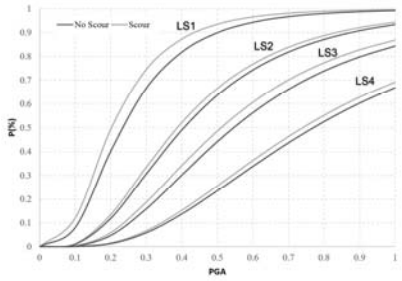

Figure 4: Fragility curves of bridge pier for all limit states, with and without scour consideration

3. CONCLUSIONS

The most improtant findings are summarised below:

- The effect of scour on the seismic capacity of bridge piers is essential, resulting in strength and stiffness reduction of the pile foundation and the system pier - pile foundation.
- Foundation scour results in an increase of seismic fragility for all limit states considered.
- During the evaluation of the effect of scour depth on the seismic fragility of bridges the critical component of the pier- pile foundation system should be considered. In case that the bridge pier yields before the yielding of the system of the pile foundation, the forces transferred to the foundation are approximately constant and foundation damage may occur at a next stage. The possibility for an adequately designed pile foundation to fail should be examined, highlighting the possibility to consist a more vulnerable, compared to bridge piers, component.
- The effect of scour on the seismic fragility of bridges is expected to be more crucial, in case that bridge foundation is the most vulnerable component of the system.

ACKNOWLEDGMENT

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NATURE-BASED SOLUTIONS: AN INNOVATIVE (THOUGH NOT NEW) APPROACH TO DEAL WITH IMMENSE SOCIETAL CHALLENGES

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ABSTRACT
The extensive alteration of the natural landscape, the degradation of the natural ecosystems, and the following biodiversity crisis, along with the increasing impact of weather events due to climate change are among the indicators that show the absurd and unsustainable way that societies have been grown. Traditional development has lead the societies unprotected to natural hazards and biodiversity in declining. As an alternative, Nature-based Solutions (NbS) use ecosystems and the services they provide to address societal challenges such as climate change, food security or natural disasters. Although NbS were first introduced in early 2000s, it's only been 2016 that the term has become more populated and more widely used among conservationists and practitioners. Progress has been made in the last 5 years towards the support of the approach at a wider scale. IUCN has been leading the effort to promote NbS while the EU has also practically moved the same direction by proposing a definition on the term and by supporting a multi-stakeholder dialogue platform for their promotion. It's has also been very positive that the recently presented European Green Deal refers to NbS as being essential in the effort to evolve and adapt to the new conditions. Even so, European and national policy makers are still far from accepting them as a key approach to address main challenges, let alone the lower level administration or the public. Within this framework, WWF Greece recognizes the significance of NbS, tries to expand/start the public dialogue on their value and is proposing four distinct though complementary pillars of work.

Keywords: *Nature-based Solutions, disaster risk reduction, climate change*, ecosystems, societal challenges

1. INTRODUCTION

Signs of climate change have been more than obvious for decades and the scientific community has been intensively alerting on its impacts for livelihoods and the environment [1]. However, it's only the last few years that extreme devastating events are occurring repeatedly and are directly threatening local societies and economies, taking also a toll on biodiversity [2]. Recent phenomena like the occurrence of megafires in Australia and Siberia, catastrophic floods in the Mediterranean coast of Spain, or the long known submerging of Venice, the Cape Town water crisis, and the well documented temperature rise pattern at a global scale are only the tip of the iceberg. Similarly, extreme events taking place in Greece (fires and floods in suburban areas, droughts, etc.), just prove that Greece is not immune to the impacts of climate crisis.
At the same time, humans intensively use the natural resources (land, water, forests, etc.), causing an extensive degradation of natural ecosystems and a biodiversity crisis that further worsens climate change while also reducing drastically the resilience of both natural and modified ecosystems to the impacts of the climate change phenomena. As a result, even natural phenomena once characterized as normal, now "it seems as if the forces of nature are arrayed against our homes, businesses and economies" [3].

In order to deal with the societal challenges emerging from the aforementioned situation, an innovative approach emerged during the late 00's, aiming to "support the achievement of society's development goals and safeguard human well-being in ways that reflect cultural and societal values and enhance the resilience of ecosystems, their capacity for renewal and the provision of services" [4]. Nature-based solutions (NbS), although not introduced as a panacea to all climate challenges, it is widely accepted that should have, along with other interlinked approaches (e.g. green & blue infrastructures, natural capital, ecosystem-based approaches, etc.) the main role in our efforts to adapt and mitigate against the climate crisis.

Very recently there is an increasing interest in Europe towards the development and promotion of Nature-based Solutions [5]. This is a direct result of the strong position of the EU to promote NbS at a European and International scale, thus supporting sustainability [6]. Similarly, the WWF network has started turning its focus on NbS approaches to cope with the societal challenges emerging from the reduced resilience of the ecosystems and the climate crisis.

Following, a short analysis on Nature-based Solutions (definition, societal challenges, and criteria) will be attempted and their connection with global goals and policies will be presented.

2. NATURE-BASED SOLUTIONS: DEFINITION AND CRITERIA

Multiple definitions have been provided to explain the term "Nature-based Solutions", however the most widely accepted has been provided by IUCN:

"Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."

Table 1. Clarification of terms used in the NbS definitional framework (modified from [4])

Term	Clarification
Ecosystems	This term refers to and addresses all types of ecosystems, including natural and modified ecosystems.
Societal	NbS explicitly address societal challenges. The solutions are not aimed at addressing only environmental challenges or minimising only environmental impacts, although these may be part of what the NbS is targeting. Societal challenges have been defined as following - NBS for water security (connected to SDG6) - NBS for food security (SDG 2) - NBS for human health (SDGs 3, 11, 13) - NBS for disaster risk reduction (SDGs 11, 13, 1, 2, 3, 6, 15) - NBS for climate change (SDG 13) - NBS for Economic and Social Development (SDG 3)
Actions	This term was chosen to underline the need for active solutions to major societal challenges. All NbS interventions are nature- or ecosystem-based solutions, and do not include interventions that are merely inspired by nature, such as biomimicry.

Very recently, a new report has been published by IUCN including certain directions in designing and implementing intervantions that are compatible with the NbS approach. More specifically, 8 criteria and 28 indicators are proposed in an effort to "support the final users in 1) assessing the extent to which a proposed solution qualifies as an NbS and identifying what actions can be taken to further strengthen the robustness of the intervention; 2) enabling purposeful design of a solution to adhere to the Criteria and Indicators, while building in adaptive management mechanisms to maintain the relevance and robustness of the solution through its lifespan" [7]. The 8 criteria are summarized in table 2.

Table 2. The 8 Criteria as were defined by IUCN [6]

a/a	Criterion
1	NbS effectively address societal challenges
2	Design of NbS is informed by scale
3	NbS result in a net gain to biodiversity and ecosystem integrity
4	NbS are economically viable
5	NbS are based on inclusive, transparent and empowering governance processes
6	NbS equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple benefits
7	NbS are managed adaptively, based on evidence
8	NbS are sustainable and mainstreamed within an appropriate jurisdictional context

3. NBS ARE CONNECTED TO GLOBAL GOALS AND POLICIES

As the necessity to incorporate more sustainable approaches into policies and agreements that will help the societies to reverse the biodiversity loss, mitigate climate change and adapt to the new era, there is a clear effort, at least in the last few years, towards this direction. Following, in table 3, a connection between the NbS and global goals, strategies, and agreements is attempted.

Table 3. Connection of NbS with European and global policies, strategies and agreements

Connected strategies, goals, agreements, etc.	Details
European Green Deal & EU Biodiversity Strategy 2030	Of the 25% of the EU budget dedicated to climate action, a significant proportion will be invested in biodiversity and nature-based solutions. Also, to ensure that nature restoration across land and sea picks up, increases the EU's resilience, and contributes to climate change mitigation and adaptation as a key nature-based solution the EU Biodiversity strategy 2030 will incorporate – among others – a proposal for legally binding EU nature restoration targets to restore degraded ecosystems.
Paris agreement	NbS are not directly mentioned, however indirect references to nature (ecosystems, natural resources, forests) indicates the need for better management and protection of natural ecosystems. In addition, the fact that 130 NDCs include NbS means there is a consensus for the role of nature towards meeting climate change goals. The close connection between NDCs and NbS can also be justified by the numerous reports that indicate ways to mainstreaming NbS into NDCs. [8], [9], [10]
UN	The period 2020-2030 has been declared as UN Decade on Ecosystem Restoration. The decade for restoration aims to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean. The SDGs also are strongly connected to the idea of dealing with societal challenges through the protection, restoration and promotion of sustainable use of the ecosystems.

4. WWF GREECE'S SUPPORTS SOLUTIONS THROUGH NATURE

The role of Nature-based Solutions is expected to increase as a result of the global and European goals and policies. Following a first internal consultation, WWF Greece has defined four distinct though complementary pillars of work:

- **Reduction of the risk for societies** by focusing on suburban areas, where the interaction between nature and people is more intense, in an effort to deal with the consequences of climate change and reduce the risks from especially fires and floods.
- **Reduction of the risk for natural ecosystems** through planning of appropriate ecological corridors and promoting species and habitat adaptation to climate change, thus increasing their resilience.

- **Advocacy for Greece's stronger commitment to international policies and conventions** by promoting the inclusion of Nature-based Solutions in the revised NDCs and harmonizing them with National Adaptation Plans.
- **Improvement of well-being in urban environments** by exploring the possibility of developing a solid and impactful program on urban river and stream restorations.

Although these work lines are still debatable, they set the base for further discussion. Ideally, they should be the starting point for creating strong synergies with research institutions, public stakeholders, active communities, financial institutions and the private sector in an effort to overturn the business as usual practices that have lead the societies unprotected to natural hazards and biodiversity in declining [11].

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COASTAL INUNDATION DUE TO STORM SURGES ON A MEDITERRANEAN DELTAIC AREA UNDER THE EFFECTS OF CLIMATE CHANGE

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ABSTRACT
This paper investigates the estimated climate change impacts on the future variations of coastal water inundation dynamics at a characteristic Mediterranean deltaic environment for the 21st century. Output by three Regional Climate Models (RCM) are used with Representative Concentration Pathways (RCP) 4.5 and 8.5, for a short-term (2021-2050) and a long-term (2071-2100) future period. The latter feed a coupled modelling system for the simulation of storm surges and consequent coastal inundation on the littoral floodplain of Nestos river delta (northern Aegean Sea, Greece). Thorough validation of storm-induced sea level elevation is presented and the differentiations of model outputs driven by various RCM/RCP combinations are investigated. Increased deltaic vulnerability due to coastal inundation is found under the RCP8.5 scenario especially for the 1st half of the 21st century.

Keywords: coastal inundation, storm surge, Nestos river delta, climate change, numerical modelling.

1. INTRODUCTION

The Mediterranean Sea basin is considered to be a hotspot in terms of Climate Change (CC) projections, associated with regional impacts on sea level variations of the coastal zone, *i.e.* affecting the intensity and frequency of occurrence of storm surges. Intense storm surge events threaten low-land coastal areas mainly by increasing the inundation risk of littoral floodplains that may provoke human casualties, land loss, onshore infrastructure and property damages, environmental degradation, etc. Therefore, in the present work, the storm surge patterns in the Mediterranean coastal zone are investigated for a 130-years period (1971-2100) incorporating the newest available climatic data. The impact of CC on an environmentally sesnitive Mediterranean deltaic area is also explored by examining the future variation trends of storm-induced coastal inundation, simulated with a coupled system of surge-flood models.

2. METHODOLOGY

Numerical simulations of coastal hydrodynamics cover three 35-years time-windows, *i.e.* the Reference Period (RP) from 1971 to 2005, the Short-term Future (2021-2055) and the Long-term Future (2066-2100) Periods (SFP and LFP).

2.1. Available Climatic Data

The atmospheric forcing of the storm surge model (wind and sea level pressure fields) is provided by three RCMs, namely the CMCC-CCLM, CNRM-ALADIN, GUF-CCLM-NEMO, of the MED-CORDEX database (https://www.medcordex.eu/). Historical climate data by all the RCMs have been validated against ECMWF's CERA-20C re-analysis dataseries (https://www.ecmwf.int/en/research/projects/cera), and estimations of future CC projections are based on RCP4.5 and RCP8.5 [1].

2.2. Numerical Modelling

2.2.1. Storm Surge Model - MeCSS

The surge-induced sea surface height (SSH) in coastal areas is numerically simulated with the Mediterranean Climatic Storm Surge (MeCSS) model [2, 3], which is a 2-DH barotropic model for hydrodynamic ocean circulation, based on the depth-averaged shallow water equations [4, 5]. MeCSS has been proven robust in reproducing the inverse barometer effect and wind setup in coastal areas, causing intense SSH rise due to extreme storm surges, either in forecast [6] or climatic mode [7, 8].

2.2.2. Coastal Inundation Module - CoastFLOOD

The flooded area (FA) due to storm surge in the coastal zone is numerically simulated with CoastFLOOD module [9], which is based on the raster-based, storage cell concept, similarly to the structure and numerical approach of the well-established LISFLOOD-FP model [10]. This way, SSH on the shoreline drives the seawater flow on the coastal floodplain via Manning-type equations in decoupled 2-D formulation. Inundation extents on the floodplain terrain are simulated on a super high-resolution (*dx*=5m) regular Cartesian grid of available data in raster GIS format (https://www.ktimatologio.gr/).

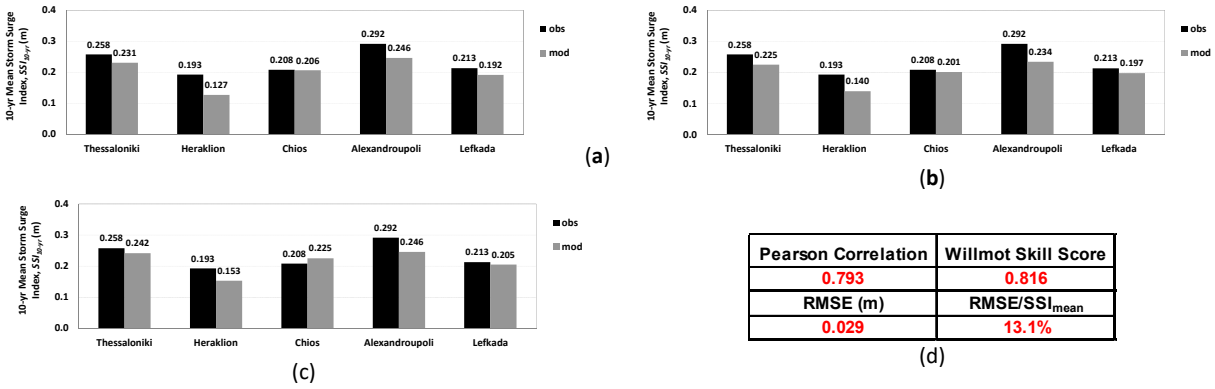

Figure 1. Comparison of 10-yr average *SSI* (m) in 5 Greek stations for: a) CMCC-forced, b) CNRM-forced, and c) GUF-forced MeCSS model (mod) and field (obs) data; d) Validation of the GUF-forced MeCSS model implementation by various scores: Pearson correlation, RMSE, RMSE/SSI_{mean} and Willmott Skill.

3. RESULTS AND DISCUSSION

3.1. Model Validation

In situ SSH observations from tide gauges by the HNHS (https://www.hnhs.gr/), during a part of the RP, are used to evaluate the performance skill of MeCSS model in several Greek coastal areas. Figure 1 illustrates comparisons between historical sea-level data and simulation outputs in the Greek coastal zone based on the Storm Surge Index (*SSI*) for all RCM-MeCSS implementations. The Root-Mean-Square-Error (RMSE), Pearson correlation, and Willmott Skill score for intra- and inter-annual *SSH* maxima reveal that the GUF-forced MeCSS setup occasionally produces the most reliable suimulations compared to the CMCC- and CNRM-forced MeCSS model runs. In general, MeCSS output is in acceptable to good agreement with field observations, thus considered credible for CoastFLOOD module forcing.

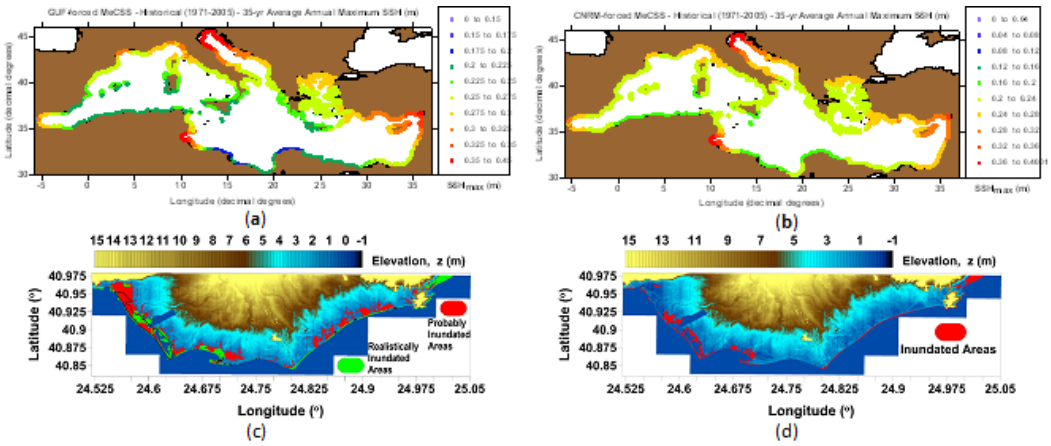

Figure 2. Illustrations of mapped MeCSS output of 35-yr average annual maxima SSH_{max} (m) during the RP for a) GUF-forced and b) CNRM-forced setups. CoastFLOOD results of storm surge inundation in low-land coastal areas of the Nestos river delta for c) a theoretical extreme value of *SSH*>0.5m and d) simulated MeCSS SSH_{max} in RP; c) red color refers to probably inundated low-land areas; green color refers to actually inundated areas by realistic CoastFLOOD simulations; black closed lines refer to possibly affected regions (lagoons, urban and touristic sites).

Table 2. MeCSS-driven CoastFLOOD (M-CF) model results of: a) Flooded Area, FA (ha); b) respective differences Diff (%) between climatic scenario runs; c) Diff (%) by different forcing input as CMCC-, CNRM-, GUF-forced storm surge implementations.

Study Case		**a**			**b**			**c**		
Scenario	Period	CMCC M-CF FA (ha)	CNRM M-CF FA (ha)	GUF M-CF FA (ha)	CMCC M-CF Diff (%)	CNRM M-CF Diff (%)	GUF M-CF Diff (%)	CMCC-CNRM M-CF Diff (%)	CNRM-GUF M-CF Diff (%)	GUF-CMCC M-CF Diff (%)
Historical	RP	380.897	354.832	452.257	0	0	0	7.09	-24.14	17.13
RCP4.5	SFP	381.420	358.847	447.705	0.14	1.13	-1.01	6.10	-22.03	15.99
	LFP	352.045	356.615	382.425	-7.57	0.50	-15.44	-1.29	-6.98	8.27
RCP8.5	SFP	365.465	377.780	359.442	-4.05	6.47	-20.52	-3.31	4.97	-1.66
	LFP	359.477	365.055	383.352	-5.62	2.88	-15.24	-1.54	-4.89	6.43

3.2. Coastal inundation by storm surges

Figure 2a and 2b present characteristic MeCSS simulation results of inter-annual *SSH* maxima for the 35-years RP, throughout the entire Mediterranean coastal zone. The largest storm surge levels are observed in the northern Adriatic Sea, the Gulf of Gabes and the northeastern part of the Levantine Sea (SSH_{max}=0.35-0.50m). In the Nestos river delta coastal zone storm surge maxima reach up to 0.33m. During the SFP SSH_{max} was estimated to slightly increase (<14%) compared to the RP (*not shown here*). GUF-forced MeCSS produces slightly higher estimations compared to CNRM- and CMCC-forced setups.
Figure 2c presents detailed maps of low-land areas susceptible to flooding (*FA*=1,803.76ha), overlayed by realistically inundated areas (*FA*=541.69ha) due to an extreme storm surge event in the coastal floodplain of the Nestos river delta. Figure 2d shows the flood extents simulated by GUF-forced CoastFLOOD during RP, revealing a *FA*=452.26ha, i.e. 25.1-83.5% of low-land or probably affected areas.

Table 2 presents CoastFLOOD results of *FA*, and their respective calculated percentage differences (*Diff*, %) between two RCPs for SFP/LFP and RP values; *Diff* due to various forcing input, is also examined in couples between CMCC-, CNRM-, GUF-forced coastal inundation implementations. The latter overestimates the flood extents compared to CMCC- and CNRM-forced setups for almost all study periods. A tendency for attenuation of coastal floods towards the end of the 21st century is estimated, i.e. reachnig down to -20% under any future RCP scenario. However, CNRM-forced CoastFLOOD results, show inundation patterns with a slight increase up to 6.5% under RCP8.5 for the 1st half of the 21st century.

4. CONCLUSIONS

Our results confirm the ability of MeCSS model to estimate the episodic sea surface elevation due to storm surges as a response to intense climatic conditions. We estimate a general decreasing trend in the averaged patterns of storminess under the considered climate scenarios. However, the magnitudes of *SSH* maxima may increase locally in certain regions of the Mediterranean during the 21st century. Nestos deltaic area is estimated to pertain probable hotspots affected by coastal inundation, such as lagoons, rural agricultures around the urban environment and some of the touristic sites on the coast.

ACKNOWLEDGEMENTS

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OPTIMIZATION MODEL OF THE MOUNTAINOUS FOREST AREAS OPENING UP IN ORDER TO PREVENT AND SUPPRESS POTENTIAL FOREST FIRES

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ABSTRACT
Climate changes produce increase of the temperature and therefore enhance the forest fire risk, especially in Mediterranean ecosystems. Forest fires are a real threat to natural environment in these countries. The paper deals with an optimization model of the opening up of the forest mountain areas taking into account the prevention and suppression of forest fires in the framework of the socio-economic conditions prevailing in the country, which are expected to exacerbate the situation. Research area is the mountain forest complex of W. Nestos of Drama Prefecture. The percentage of forest protection area is examined under the light whether the total hose length corresponds to the actual operational capacity to reach a fire source. The most important forest technical infrastructures to prevent fire are road networks (opening up) for fire protection and buffer zones. Patrols of small and agile van 4×4 appropriately equipped (hose length of 500 meters and putting pressure on uphill to 300 meters) for the first attack of the fire in the summer months coupled with early warning of fire lookout stations adequately cover the forest protection of the mountainous forest areas.

Keywords: wild fires, protection, opening up, GIS.

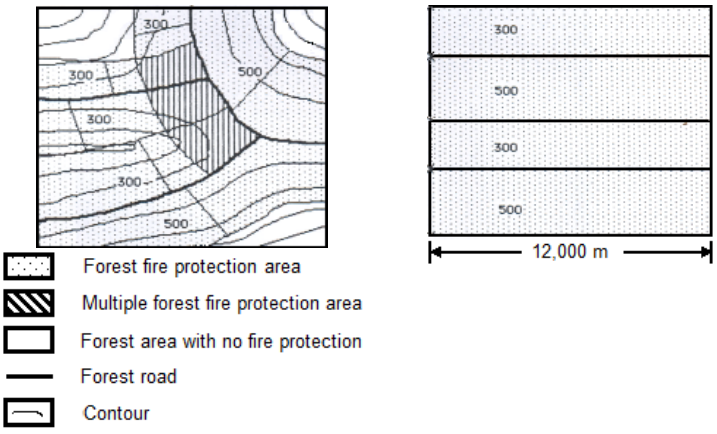
1. INTRODUCTION AND OBJECTIVE

The consequences of the torrential phenomena that occur on the urban environment are even greater because of the foliage loss due to the forest fires. A definite cause of fires is the lack of inventory of forests, woodlands and grasslands, as well as the disputed recording of property rights for the creation of Forest Cadastre, forest maps and land use maps.
Forest maps are a useful tool both at the stage of responding to natural disasters (for guiding fire-fighting vehicles, etc.), as well as at the stage of rehabilitation and restoration of the area to the status quo of sustainable development. Over the past few years and after events that are of dramatic significance for mankind which occurred due to the reckless and catastrophic for the environment linear economical “developmental” activity, it became common consciousness, the notion that development should occur in harmony with the natural and cultural environment. This applies equally to economic, social, technological and cultural developments [1, 2]. To achieve the sustainable development, suitable land use planning and Forest Cadastre (forest maps) are needed, meaning the essential foundations for development and means of land policy implementation. Infrastructure construction and, more specific, spatial planning of land use and innovative ideas for sustainable development are necessary. Plato predicted centuries ago that the deforestation of the mountain slopes means reducing their ability to help people and animals live comfortably, or in other words, the salvation of the cities is on the mountain and we should initially concentrate there.

Development of a region either mountainous or semi mountainous or lowlands is inextricably linked to the human activity and can either exacerbate the risks (humanitarian and environmental crises) or mitigate the effects. This human activity often degrades the natural and structured environment, which is, at the same time, the raw material for its development [3, 4].
The paper deals with an optimization model of the opening up of the forest mountain areas taking into account the prevention and suppression of forest fires in the framework of the socio-economic conditions prevailing in the country, which are expected to exacerbate the situation.

2. EXPERIMENTAL METHOD

İn order to achieve the research goal that is the prevention and suppression of forest fires depending on the forest opening up model that have been set in the frame of this paper were used AutoCAD Civil 3D 2009 and Raster Design on Autodesk Map 3D 2009 and the subroutine of Autodesk Map 3D for Geospatial 2009.
Digital orthophotos were the primary source of spatial data required for this study. Additionally, carried out the vectorization from TIFF format analog topographical maps in scale 1:50000 and the corresponding analog topographical diagrams in scale 1:5000 of Hellenic Geographic Military Service.
The most important forest technical infrastructures to prevent and suppress forest fire are:
a. forest roads network (opening up) for fire protection
b. spatial distribution (Buffer Zones)
Direct fire suppression requires access on forest roads in the outbreak of fire and appropriate equipment of fire fighting vehicles with special hoses [5]
Figure 1 are shown the protection zone when used specifically linked hoses in length of 300 meters uphill and 500 downhill.



(**a**) Real forest road sitting (**b**) Ideal forest road sitting

Figure 1. The real and the ideal forest road sitting.

The difference in the uphill and downhill measures is due to the greater need for a water pressure uphill. The distance of 300 meters uphill depends on the pump pressure of vehicles, but it is sufficient for an average slope of 30% in the normal fire [6], which may be up to 100 %. E.g. fire pump ROSENBAUER NH20 in vehicle ELBO has a pump flow at low pressure: 1750 l / min at 10bar and at high pressure: 400 l / min at 40 bar. In table 1 the characteristics and total length of hoses available on fire brigade vehicles are shown.

Table 1. Characteristics and total length of hoses available on fire brigade vehicles. [7]

Type of Fire Brigade Vehicle	Cross sections of hoses mm	Number of hoses per section	Length of hoses per section m	Total length of hoses m
(1)	(2)	(3)	(4)	(5) = (3)X(4)
UNIMOG 2,5	25 and 45	15 and 6	25 and 15	465
MAN 1,5	25 and 45	15 and 6	25 and 15	465
IVECO 2,5	25 and 45	15 and 6	25 and 15	465
MAN 5	25 and 45 and 62	15 and 6 and 6	25 and 15 and 15	555
MERCEDES 10	45 and 62	15 and 8	15	345
MERCEDES 11	45 and 62	15 and 8	15	345

3. RESULTS AND DISCUSSION

The existing road density of forest complex of W. Nestos (Forest Office of Drama and Forest Office of D. Nevrokopiou), is 15.09 m·/ ha and the road distance in 10000 / 15.09 = 663 m. According to the model of figure 1 is satisfactory because the road density exceeds the threshold of 12.5 m·/ ha and road distance is less than 800 m. Given that the productive mountainous forests the optimum road density for mechanization of skidding works, should reach the optimum economic that the complex of W. Nestos amounts to 21.90 m·/ ha corresponding to 457 meters road distance this will be even more satisfying.

Regarding the space allocation of roads to the existing network:

- Optimum road distance 457 m (hence timely firefighting in 150 m uphill and 250 m downhill) was calculated forest protection percentage 45.62% (Forest office of Drama D_{ex} = 16.64 m·/ ha) and 38.60% (Forest Office of D. Nevrokopiou with D_{ex} = 11.03 m·/ ha).
- Optimum road distance 663 m (200 uphill and 400 downhill) estimated forest protection percentage 57% (Forest Office of Drama) and 50.7% (Forest Office of D. Nevrokopiou).
- Optimum road density 800 m (300 uphill and 500 downhill) estimated forest protection percentage 63.7% (Forest Office of Drama) and 57.6% (Forest Office of D. Nevrokopiou).

So with tube length 500 m (by road distance 800 meters), and with the proper space allocation of roads parallel with the increase of road density until D_{ec} expected more adequate fire protection percentage > 70%. Improving space allocation of roads need the Eastern part of the Forest Office of Drama and the West part of the Forest Office of D. Nevrokopiou until the optimum road density of 21.90 m·/ ha.

4. CONCLUSIONS AND SUGGESTIONS

In mountainous productive forests for wood transport, escaping of fire fighting vehicles is ensured by adequate road density (typically 25 m / ha, much higher from the broadleaf evergreen forest that is less than 10 m / ha) and the lower speed of spread of the fire (max 14.8 km / ha and evergreen understory 25 km / ha). These speeds are less than the average speed of trucks in the forest, which is an average of 25 km / ha.

Patrols of small and agile van 4 × 4 appropriately equipped (hose length of 500 meters and putting pressure on uphill to 300 meters) for the first attack of the fire in the summer months coupled with early warning of fire observatories adequately cover the forest protection of W. Nestos complex. But in spatial distribution needed improvements to a road density of the optimum economic D_{ec}, both forest protection and for better management (skidding) of woody capital.

It is evident that in the actual design of the road network is double and triple coverage forest protection at intersections, so we choose the route of the hose with the shortest distance and altitude difference

uphill. In narrow streams cross wind conditions created by the fire itself can create differentiation of behavior by changing the propagation direction and speed of propagation uphill of the opposite slope resulting in entrapment of staff fighting. Therefore, the actual design should be provided and connecting roads between parallels to escape vehicles in case of entrapment.

The road is a basic fire break that prevents the expansion of the forest fires located higher and further ensures convenient and fast approach to forest (improved geometric data, construction of engineering works, macadam or laying the base).

Geographical Information Systems can be valuable in terms of efficiency and accuracy not only for mapping burned forest areas but also for performing various spatial analyses concerning opening up models and terrestrial fire protection. The combination D.T.M. with information, such as vegetation, air temperature and direction of winds can contribute to better prevention and suppression of fires or even in the better design of fire lookout stations for immediate warning of fire.

Terrestrial protection against fire is very important offering the ability to eliminate the negative impacts when it is applied minutes after fire occurs and before the aerial means are used. This study demonstrates the crucial importance of forest road network to fire protection. It is important that Greek fire service employs the adequate personnel taking into account that each fire brigade needs at least five firemen in order to implement the proposed firefighting system.

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WE AND THE LIGHTNING

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ABSTRACT
Every day 8 million lightning strikes the earth, resulting in adverse effects on humans, as well as the urban and natural environment (forest fires). Lightning strikes during the so-called dry storm as well, without a raindrop or even a cloud. Dry storms are the number one wildfires natural cause worldwide.
We should be able to recognize when the storm is approaching and know what we should do in any case, for our self-protection, since lightning is the second leading cause of death from weather events after floods. 24,000 people were injured by lightning and another 240,000 were injured. In Greece 35 people have lost their lives in the last 20 years. Finally we need to know when we should feel safe at the end of a storm.

Keywords: Lightning, effects, protection measures

1. INTRODUCTION

Lightning, which is commonly seen during a storm, is the second leading cause of death from flooding worldwide. Every year 24,000 people die from lightning strikes and another 240,000 are injured [5]. 80% of them have been hit during summer. The victims of lightning in Greece (2001-2020) are 35 (Figure 1) and 756 are the victims in USA (1990-2003)
According to Meteorologists, during the daily occurrence of storms, 8 million lightning bolts strike the earth every day, resulting in adverse effects on humans, as well as the urban and natural environment (forest fires). Most lightning strikes occur in the areas of Equator and do not occur at open sea and at the poles. The power of a lightning bolt can exceed 3 billion kW, energy that could power more than half a billion homes. The maximum temperature of lightning is 33,000^{o} C. The maximum distance the human ear hears a thunder is 25 Km. The time interval between flash and sound divided by 3 returns the lightning strike distance in kilometers, and multiplied by 344 in meters [12]. A lightning rod of positive polarity can fall within a radius of up to 30 km from the accompanying cloud.
Lightning strikes during the so-called dry storm as well, without a raindrop or even a cloud. Dry storms are the number one natural cause of wildfires worldwide.
The storm is approaching when (1) Lightning flashes appear at closer intervals (2) The sound of lightning keeps increasing in volume and the time intervals between thunder strikes keeps reducing (3) The sky becomes darker (4) The wind becomes stronger.
The risk in cities is negligible since there are lightning rods on the tall buildings, on the schools, on the bell towers of churches, on factories chimneys and on the PPC pillars.
June 28th has been established as Lightning Protection Day.

1.1. Effects on humans other than death
The most often affected by lightning parts of the body are the head, neck and shoulders. (Figure 1) Frequent observed memory loss, unexplained fatigue, tremors, nausea and insomnia, ringing in the ears, overheating feeling, loss of balance and suicide attempts.

Figure 1.

Έτος	Μήνας	Ημέρα	Διάρκεια (ημέρες)	Περιοχή	Απώλειες (αριθμός)	Περιγραφή
2001	5	13	1	Αχαΐα	1	Ισχυρές καταιγίδες στην Πελοπόννησο. Νεκρός ορειβάτης στον Ερύμανθο από κεραυνικό πλήγμα.
2001	7	11	1	Φθιώτιδα	1	Νεκρός από κεραυνό στην Τιθορέα Φθιώτιδας.
2001	8	25	1	Χαλκιδική	1	Νεκρός από κεραυνό στη Γαλάτιστα Χαλκιδικής.
2002	7	1	1	Κιλκίς	1	Κτηνοτρόφος νεκρός από κεραυνό στο Κιλκίς.
2002	9	12	1	Αττική	1	Νεκρή από κεραυνό στο κοιμητήριο Νίκαιας Αττικής.
2002	12	7	2	Μεσσηνία	1	Νεκρός ιστιοπλόος από κεραυνό στους Γαργαλιάνους Μεσσηνίας
2003	6	4	1	Ιωάννινα	1	17χρονος κτηνοτρόφος νεκρός από κεραυνό στο Μέτσοβο.
2003	6	19	1	Πρέβεζα	1	Γερμανός ταυρίστας νεκρός από κεραυνό στην Πρέβεζα.
2003	8	10	1	Χαλκιδική	2	Δύο νεκροί από κεραυνό στην Καλλικράτεια και στην Ασπροβάλτα Χαλκιδικής.
2003	9	3	1	Σέρρες	1	Νεκρός αγρότης από κεραυνό στις Σέρρες.
2004	7	25	1	Θεσσαλονίκη	1	Νεκρή αγρότισα από κεραυνό στη Ν. Ραιδεστά Θεσσαλονίκης.
2006	5	15	1	Θεσσαλονίκη	1	Ισχυρές καταιγίδες στην κεντρική Μακεδονία, με ένα νεκρό στον Λαγκαδά από κεραυνικό πλήγμα.
2009	5	18	1	Μεσσηνία	1	Θάνατος ενός ανθρώπου από κεραυνικό πλήγμα στη Μεσσήνη.
2009	6	12	1	Ροδόπη	1	Ένας νεκρός και τέσσερις τραυματίες από κεραυνό στο Νομό Ροδόπης.
2009	7	6	1	Ημαθία	1	Νεκρή στα Τρίπολα Ημαθίας μια 53χρονη γυναίκα, η οποία χτυπήθηκε από κεραυνό.
2010	6	30	1	Ροδόπη	1	Ένας νεκρός από κεραυνό στο νομό Ροδόπης.
2010	8	4	1	Κοζάνη	1	Ένας νεκρός από κεραυνό στη Κοζάνη.
2011	9	7	1	Ιωάννινα	1	Νεκρός 40χρονος στο μοντείο Δωδώνης από κεραυνό.
2013	3	14	1	Αιτωλ/νία	1	Ένας ψαράς έχασε τη ζωή του από κεραυνό στη θαλάσσια περιοχή της Θόνιτσας.
2013	9	27	1	Ροδόπη και Ξάνθη	2	Δύο νεκροί από κεραυνό, στον Ίασμο Ροδόπης και στην ορεινή Ξάνθη.
2014	8	1	1	Λάρισα	1	Νεκρός από κεραυνό στη Λάρισα.
2014	9	7	1	Χαλκιδική	1	Ένας νεκρός από κεραυνό και πλημμύρες στη Χαλκιδική.
2014	11	13	1	Εύβοια	1	Ερασιτέχνης ποδοσφαιριστής, 28 ετών, έπεσε νεκρός από κτύπημα κεραυνού στην Κήρινθο Εύβοιας.
2015	9	21	1	Σαλαμίνα	1	Νεκρή μετά από χτύπημα κεραυνού βρέθηκε 73χρονη γυναίκα στη Σαλαμίνα.
2015	9	21	1	Αρκαδία	1	52χρονος κτηνοτρόφος κεραυνοβολήθηκε κι έχασε την ζωή του στην αγροτική περιοχή Ξηροκάμπι, στον Άγιο Πέτρο Κυνουρίας.
2016	9	1	1	Καρδίτσα	1	Ποδοσφαιριστής κεραυνοβολήθηκε στην περιοχή Καρδιτσομαγούλα και έσβυσε 2 ημέρες μετά.
2017	5	10	1	Πιερία	1	Νεκρή αγρότισσα από κεραυνό στη Νεοκαισάρεια Πιερίας
2017	7	16	1	Αιτωλ/νία	1	Νεκρός βοσκός από κεραυνό στο Μέγα Κάμπο Αμφιλοχίας
2018	6	2	1	Κοζάνη	1	Νεκρός από κεραυνό 22-χρονος βοσκός στην Εορδαία Κοζάνης
2018	6	3	1	Θεσσαλονίκη	1	Μοτοσυκλετιστής νεκρός από κεραυνό στην Εγνατία Οδό.
2019	6	18	1	Γκούρα Κορινθίας	1	Νεκρός αγρότης από κεραυνό
2019	8	15	1	Μαγνησία	1	59χρονος βοσκός νεκρός από κεραυνό σε ορεινή περιοχή του Σέσκλου Μαγνησίας
2019	9	24	2	Ηλεία κ' Μεσσηνία	2	2 νεκροί από κεραυνό σε Λεχαινά Ηλείας και Αλιμάκι Τριφυλίας
2020	5	26	1	Σκόπελος	1	52χρονη γυναίκα νεκρή από κεραυνό στην Πευκιά Σκοπέλου
2020	6	10	1	Λάρισα	1	60χρονος νεκρός από κεραυνό στην Κρήνη Φαρσάλων Λάρισας

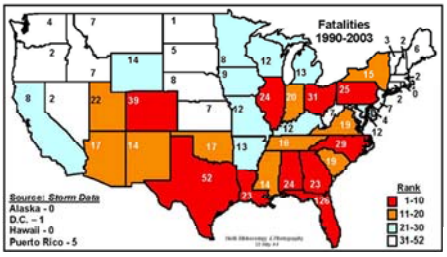

Figure 2. Victims of lightning in Greece (2001-2020) and USA (1990-2003)

2. SELF-PROTECTION MEASURES

When a person walks, the "step voltage", ie the difference in voltage at the opening of the person's legs, which comes from the lightning strike in the area can cause electric shock or even death. Don't make wide steps when trying to protect yourself. Move away with small jumps or small steps, to have a small "step tendency" (Figure 3)

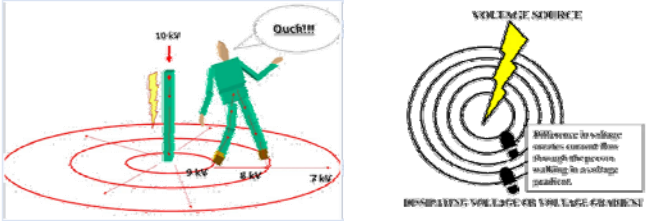

Figure 3.

How to protect yourself from lightning when you are…	
in the forest	**close to metal structures**
-Avoid sitting under large and isolated trees -Find shelter under the foliage of low trees -Choose coniferous trees (pines, firs, etc.) as they having millions of needles, and do not accumulate large loads. Broad-leaved trees (poplars, plane trees, beeches, chestnuts, etc.) are more dangerous	-Get away from metal structures or metal machinery -Get away from train lines, water supply networks and PPC. -Do not touch metal objects inside the car. The railway lines and the aforementioned networks can carry the lightning of a lightning at a distance of 20 - 40 km
in a cottage	**on the mountain**
-Move away from windows, doors, fireplace, water pipes. -Shut down computers, televisions and electrical appliances immediately. Disconnect the TV from the antenna. -Do not use the phone and the bathtub	-Never sit on top of a hill. -Generally you should avoid being at the highest point of an area. -If time is enough, look for shelter in the nearest pit of the slope
in a liquid element	
-If you are at sea and swimming or in a boat and you see lightning, get out in time. The danger is still far away. -If thunder is heard the danger is approaching and you should not stay on the shore. The water-land dividing line is lightning territory	-If lightning strikes and you are in a halted boat, raise the anchor. -Do not use the oars during the storm. -Generally stay away from the liquid element (sea, river, lake, pool, water hole)
in the car	
-Stop the car on the side of the road away from trees. -Remain in the car with the warning lights on (alarm) until the storm passes.	-Lower the radio antenna. -Close the windows. -Do not touch metal objects inside the car [16}
holding a mobile phone	
-The Fire Academy states that you can use mobile phones [9] The Australian Lightning Protection Standard recommends that metal objects, including cell phones and cordless phones, not be used or carried outdoors in the event of a lightning storm. -The National Weather Service of the United States does not recommend this. -British doctors insist that the view should be adopted that mobile phones should not be used during storms. There are three recorded victims of lightning that were struck by lightning while talking on their cell phones (2005 China, 2004 South Korea, 1999 Malaysia)	When someone is struck by lightning, the high resistance of human skin causes the lightning to be transmitted without entering the body. This phenomenon (flashover), causes a low death rate. When in contact with the skin, materials that are good conductors of electricity such as liquids and metals, prevent this phenomenon, thus allowing lightning to enter the body resulting in severe damage to internal organs and higher death rates. When we are outdoors and there is lightning and thunderstorms, it is not good to have objects with metal parts (mobile phones, iPods or others) that come in contact with the skin, because we are more at risk of being struck by lightning. In necessary use, use remotely from the ear, with the speaker open.
unprotected in the countryside	
-In case where there is no place to take precaution and "the atmosphere is electrified" -a sign that lightning will fall - something you notice by the fact that you feel your hair rising or itching -Throw away every metal object at a distance of about 100 meters	-Do a "deep seat" with your head between your legs, protect your ears with your hands and close your eyes -Avoid leaning on the ground with your whole foot - only press on your shoes toes. The risk is significantly reduced.

CAUTION: Do not lie on the ground
-If you are with other people, move away from each other. The horizontal radial distance of the lightning current from the point where it came in contact with the ground has been measured at least twenty meters (20 m).
-Never hold an umbrella with a metal spike on its end. [17]

When should we feel safe?
- When the thunder is heard and nothing has happened to us.
- We should avoid going outdoors before at least 30 minutes have passed from the last lightning
- A storm to the West is probably coming towards us, a storm to the East is probably over.
The human body does not store electricity. It is perfectly safe to touch someone who has been hit from lightning to offer him first aid. This is the worst myth about lightning. A person may die because people are afraid to give him cardiopulmonary resuscitation.

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LANDSCAPE FIRE RISK GOVERNANCE

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ABSTRACT

Recent studies worldwide have shown that it is better to increase focus on the socioecological causes of wildfire risk pathology rather than to remedy the symptoms. We anticipate solving wildfire problems by a risk governance system that gives emphasis on taking more preventive measures through strategic planning and anticipatory management rather than investing mainly in suppression efforts. Adopting such a new governance system framework requires policies that influence coupled human-natural (socioecological) and landscape fire management interrelationships at multiple spatiotemporal and organizational scales. Catastrophic wildfires call for fire prevention that includes managing landscape fuel conditions (quantity and spatial arrangement) to aid fire suppression cost-effectively and reduce the number of potential harmful fire events to disaster-prone communities, and towards a vision of integrated fire management. Successful applied research in N. America and S. Europe demonstrates that investing more in prevention, preparedness and recovery planning will provide the means to cope with the upcoming challenges that emerge from the wildland-urban interface, expansion of unmanaged forest regrowth and climate change. The proposed methodology and findings can guide the development of strategies to reduce risks posed by large wildfires and to protect values-at-risk, in relation to biophysical criteria (frequency, intensity, size, season) and socioeconomic impacts (vulnerability, scenario planning, trade-offs analysis). In addition, it is expected that novel fire risk governance policies will make an impact on improving the effectiveness of current fuel management planning activities and investments, thus reducing firefighting and restoration costs.

Keywords: wildfire, risk, vulnerability, mitigation, governance

1. INTRODUCTION

Catastrophic wildfires call for reconsideration of wildfire risk mitigation strategies and development of integrated fire management (IFM) policies, especially in current socioecological conditions that enhance fire risk governance inefficiencies [1, 2]. Integrated planning must ensure environmental, societal and economic resilience to landscape fires by mainly addressing risk governance. Unplanned expansion of the wildland-urban interface (WUI) and unmanaged forest regrowth multiply extreme fire events and demonstrate that existing risk mitigation policies and reliance on non-systematic efforts to fire suppression and fuel reduction will not change the current wildfire losses. These wildfires are due to climate change, exclusion of wildfire in fire-adapted ecosystems, rural abandonment, mismanaged reforestation attempts, urban expansion and tourism development [3]. However, it is considered better to proactively increase focus on the socioecological causes of wildfire risk pathology [4] rather than to simply remedy the symptoms (Figure 1).

Adapting to escalating wildfire disasters is a complex risk governance problem worldwide [5]. A key factor that undermines wildfire risk governance is the spatiotemporal scale mismatch between biophysical risks

and the socioeconomic organization tasked with fire management efforts. Most wildfire losses are from large-scale fires that spread over distances, and thus reflect the aggregate effect of hazardous fuel distribution on the landscape (in addition to diverse human environment, extreme weather patterns and dangerous topographic terrain). Planners rarely assess the risk from large-scale fires and the contribution of the various surrounding land tenures and wildfire fuels. A temporal scale mismatch exists when fuel management strategies that appear effective in the short term may have unintended consequences including no impact (e.g. re-vegetated fuelbreaks) in the longer term, or when contemporary people do not respond to wildfire risk factors because they lack risk perception.

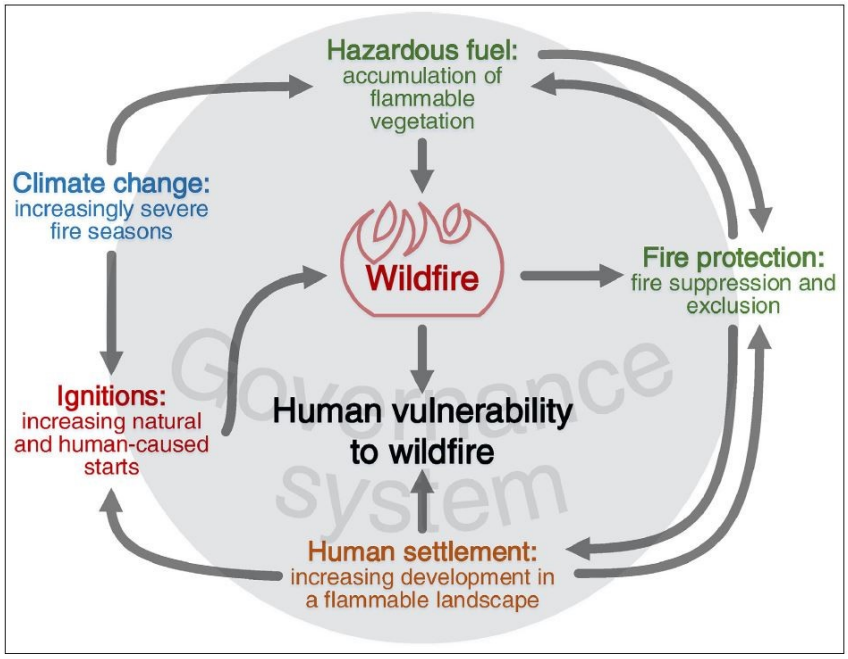

Figure 1. Wildfire risk in fire-prone land tenure systems is a result of interacting positive feedback loops that link wildfire and human vulnerability through key drivers of land use and natural resource management [4].

Fire risk governance policies need to recognize the importance of multiple spatial, temporal and organizational scale as it relates to large landscape fires and risk perception by people affected [6, 7]. Proper assessment and active management of the multifaceted nature of wildfire risk is required in prevention, preparedness and recovery planning; for example, how wildfires are propagated among land tenures and transmitted into communities or values-at-risk from the surrounding landscape, and how cooperation among different institutions (government, economic activity entities, social groups) is necessary to achieve fire-resilient landscapes and fire-adapted communities [8] in conjunction with optimum wildfire emergency responses. Thus, improving wildfire risk governance will require thorough analyses of the socioecological drivers of wildfires such as land ownership and use, divergent public attitudes, institutional diversity, wildland fuel components, fire ecology and management, through strategic planning and anticipatory management rather than investing only in suppression efforts [9].

2. METHODOLOGIES AND FINDINGS

We propose a Coupled Human and Natural Systems (CHANS) framework that relies on the joint assessment of biophysical risk and adaptive capacity elements that affect the potential for effective risk mitigation in large spatiotemporal and institutional scales; and public strategies that are directed towards

responding to environmental and socioeconomic needs. Findings are expected to offer implementation of novel concepts and tools in wildfire risk governance that explicitly disentangle the scale and source of risk on mixed landscapes as they relate to wildfire disasters.

2.1. Natural System (biophysical aspects of wildfire risk)

The scale of risk in typical fire-prone landscapes and their salient differences in terms of wildfire transmission, land use, landscape fragmentation, "firesheds", values-at-risk, mitigation strategies and fuel management practices; including performance in terms of costs, containment success, implementation time, duration of effectiveness and prediction of wildfire behavior and effects.

2.2. Human System (social and institutional aspects of wildfires)

Social capacity varies among disaster-prone communities and surrounding WUI [8] in order to adapt to wildfire protection (i.e. adaptive capacity); sociocultural and organizational factors contribute to these differences and mechanisms, including their influence on capacity building for long-term wildfire risk management and social forecasting of alternatives.

2.3. Coupled Human and Natural Systems (CHANS of integrated fire management)

Using findings from 2.1. and 2.2. above, scale and structure of biophysical risk is related to community adaptive capacity to understand patterns of wildfires under different socioecological systems. A CHANS typology is utilized as a tool to support wildfire risk governance and IFM, with appropriate modifications and investments that will improve the response to future wildfires and more efficient risk mitigation. IFM has five essential facets (the 5-Rs), similarly to the globally-adopted characterization of the Sendai Framework for Disaster Risk Reduction 2015-2030, used in describing disaster prevention and active management: i.e. Research, Risk reduction, Readiness, Response and Recovery [10].

3. DISCUSSION

Understanding of how wildfire is transmitted into disaster-prone landscapes and values-at-risk is vital to building mitigation plans that are appropriate to the context of each threatened community. Small fires affect a small area of landscape. Large fires start in one area and are transmitted through vast areas of land. In this way, risk is transferred through a network of fuels and landscapes, making risk management more difficult since the benefits of mitigating hazardous fuels are contingent on many factors [1, 9].

Transmitted risk can be analyzed in terms of wildfire regimes (i.e. frequency, intensity, size, season), socioeconomic impacts (vulnerability, scenario planning, trade-offs analysis), operational feasibility to manage wildland fuels (e.g. thinning, clearing, grazing, prescribed burning, mechanical fuel treatments for adequate defensible space in firefighting), technical constraints and administrative regulations that prompt for certain actions [8]. Fire transmission can be visually represented as a network diagram [2], which illustrates the likelihood that landscape fires originate on a land tenure and cross social and ecological boundaries in their transmission to another land use and/or community (Figure 2).

Advances in wildfire and social sciences allow the recognition of the extent where large fires are likely to ignite and spread into areas of high-risk, high-use and high-value forests [11]. These "firesheds" define the biophysical risk in terms of ownerships, wildfire regimes and management capacities. Incorporating also socioeconomic information into this fireshed analysis could aid in the design of an integrated CHANS

framework that can address long-term fire risk mitigation [3-7]. All of the above characteristics may be important in the process of adapting to wildfires with proper and strategic fire risk governance policies.

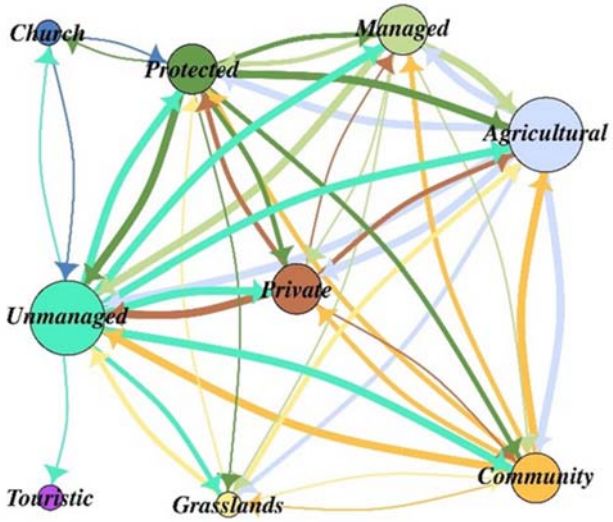

Figure 2. Wildfire transmission network for major land tenures. Arrow width is colored by its source and represents the amount of fire exchange, while node size represents the sum of incoming fire [2].

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MULTITEMPORAL MONITORING OF ECOSYSTEM RESPONSE USING BURN SEVERITY AND NDVI INDEX: THE CASE OF KINETA WILDFIRE 2018.

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ABSTRACT

Remote sensing is a useful tool for effective monitoring of anthropogenic and natural changes, qualitatively, reliably, at low cost and time. Wildfires are a usual phenomenon in Greece during summer, causing severe damages and result to the loss of human lives and property. The increasing trend of the occurrence of these events require the mapping an monitoring of the regrowth of the burnt areas. The aim of this work is to map and assess the damage of the burnt area in the area of Kineta, as well as the detection of the level of regrowth and ecosystem response after the fire of July 23, 2018 and then to monitor the changes in land use in the wider area, which suffered a great ecological disaster. The free Copernicus Sentinel-2 satellite data and the free Corine Land Cover 2018 data are used for the export of results. The processing was executed in the open SNAP software and for the export of the final results the commercial ArcGIS software environment was used. The first processing steps include the calculation of the indexes NDWI, NBR, dNBR, RBR, in order to produce the Burn Severity and then the calculation of NDVI index to additionally compare changes in vegetation, for area of interest before fire, after fire, as well as the state of vegetation two years later.

Keywords: Kineta, Wildfire, Burn Severity, NDVI, Regrowth.

1. INTRODUCTION

Almost every summer, massive forest wildfires break out in several areas, leaving behind severe destruction in forested and agricultural land, infrastructure and private property, and losses of human lives **[1,3]**. These disasters also have long-term environmental effects such as rising temperatures, flooding events and the degree of landslide hazard. The increasing trend in the occurrence of fire events has underlined the need for the development of a reliable procedure in order to map burned areas accurately and rapidly **[2,3].**The aim of this project is to investigate the changes that took place in the area of Kineta, as well as the wider area, detecting the changes in land use after the fire that occurred on July 23, 2018. In order to assess the situation, Sentinel-2 and Corine Land Cover 2018 data are used. This data will be processed in the open source SNAP software, and the map synthesis will take place in the ArcGIS commercial software environment. The goals are summurized in the following:

- The mapping the extent and level of destruction by the wildfire by calculating the Burn Severity and combine the results with NDVI results for the 2018, 2019 and 2020 which will also provide information about the regrowth and regeneration of the burnt area.
- Observation of the environment before the occurrence of the fire, after the occurrence of the fire and the next two years after its occurrence.
- Type of burnt areas based on the Corine Land Cover 2018 data.

Therefore, the reason NDVI and Burn Severity were used, is to cross-reference information, supplement and enrich the results so that they are more complete and estimate the regrowth of burnt area.

2. MATERIALS AND METHODS

2.1 Data

The data that were used are Sentinel-2 data and Corine Land Cover 2018 (CLC 2018) and RUS material was consulted **[4].** Concerning, Sentinel-2 is an European wide-swath, high-resolution, multi-spectral imaging mission. The full mission consists of the twin satellites flying in the same orbit but phased at 180°, is designed to give a high revisit time of 5 days **[5].** Sentinel-2 data are available from the open source of Copernicus Open Access Hub. Furthermore, the Corine Land Cover 2018 (CLC 2018) data are provided by Copernicus Land Monitoring Service database which is coordinated by the European Environment Agency (EEA) and produces land cover / land use (LC/LU) information **[6].**

2.2 Methodology

For the processing, Sentinel-2 images were used and the sensing dates are the following, 30/06/2018 (before fire), 19/08/2018 (Post-Fire) , 29/08/2019 and lastly the date 13/08/2020. The indices that were used and calculated are NDWI, NBR, dNBR, RBR, and NDVI and later will provide with information, map and evaluate the damage that was caused by the fire. The calculation Burn Severity, was attained after the estimation of NDWI, NBR, dNBR and RBR. The definition of the term Burn Severity, is restricted to the loss of organic matter in or on the soil surface **[7].** The next step is the calculation of the Normalized Difference Vegetation Index (NDVI) that is an indicator of the greenness of the biomes **[6]**.The NDVI index in contrast to the other indices is been calculated for the 3 years (2018,2019,2020). The previous results are combined with Corine which will provide information on the land uses that existed in the burned areas. In addition to the emergence of burn severity, the state of vegetation before and after the fire is compared, as well as its state in 2020. For the purpose of monitoring the burnt area we have calculated and classified the Burn Severity **[8].** As the burn severity can be used as a tool to estimate the regrowth of vegetation and ecosystem response, domains of every class of severity were made in order to calculate the mean values of NDVI of every year per class, for the purpose of monitoring the restoretion of vegetation.

3. RESULTS

After the processing is carried out, the results shows that burnt area is around 52,813 km^2 (Figure 1) and the class of severity with most area being burnt is the class of Low Severity and the High Severity class is has the lowest value (Figure 1). Concerning, Corine Land Cover 2018 the type of land cover that has been damaged by the fire is Coniferous Forest (Figure 1). The NDVI results are being presented on Figure 2. The NDVI values in 2018, before the fire, are mostly close 0 and reach up to 1, which is interpreted as sparse to dense vegetation. While, after the fire most of the area is close to -1 which corresponds to water but also in this case, barren areas. In 2019 there is a slight change in the North and West area of interest. Moving to 2020 there is an obvious change in the West and north-east area (Figure 2). The Figure 3 makes this change more evident presenting the domains of every class of severity that were used to calculate the mean values of NDVI of every year per class. This bar-plot shows something very interesting since High Severity class has shown a more rapid regrowth compared to the other classes (Figure 3).

3.1.1. Tables, Images and Figures

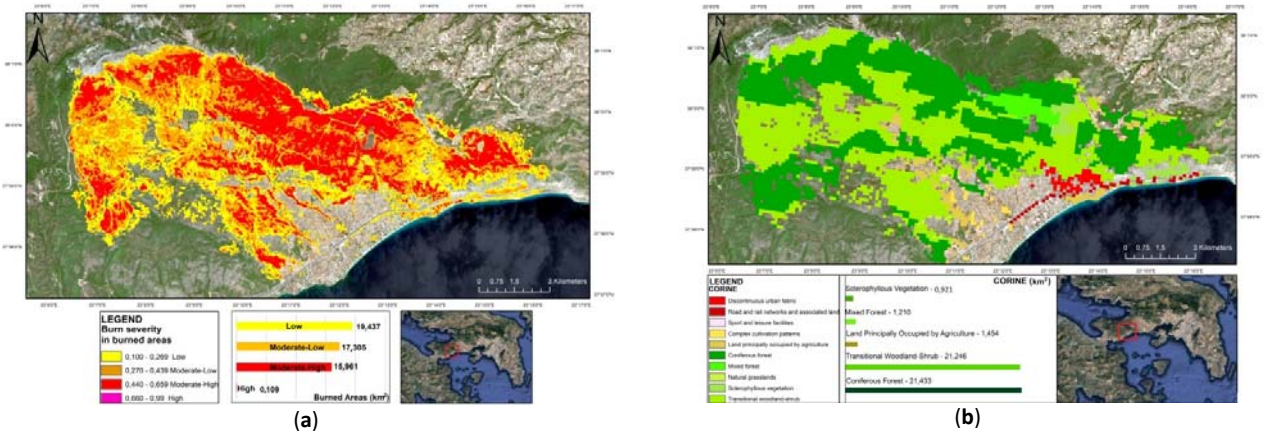

Figure 1. (**a**) Burn Severity for Kineta, the pair of images used is, one before the fire (30/06/2018) and one after the event (19/08/2018). Barplot presenting the burnt area in km^2 per class of Severity is also included; (**b**) Corine Land Cover 2018 (CLC 2018) Data for the area of interest. Barplot presenting the km^2 that burnt per type of land cover is also included.

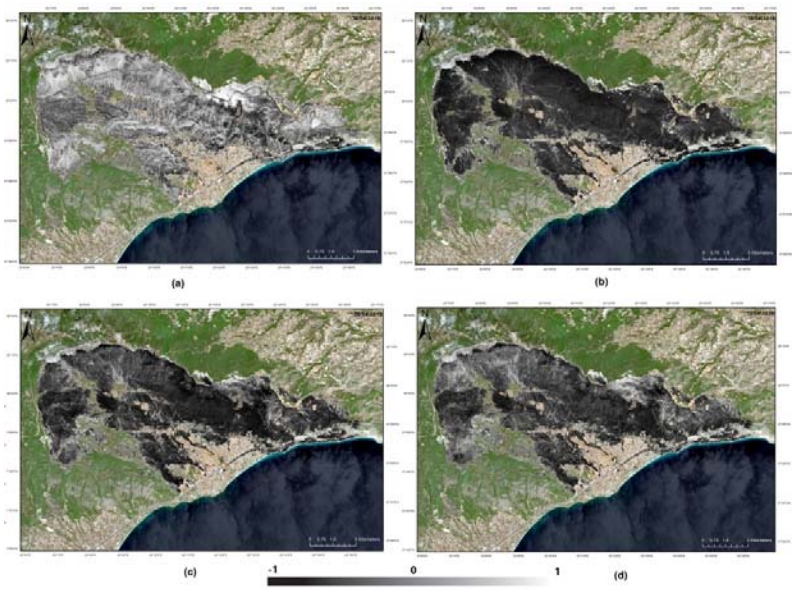

Figure 2. NDVI Index calculated for Kineta for different years. (**a**) NDVI before Fire (30/06/2018); (**b**) NDVI post-fire (19/08/2018); **(c)** NDVI 2019 (29/08/2019); **(d)** NDVI 2020 (13/08/2020).

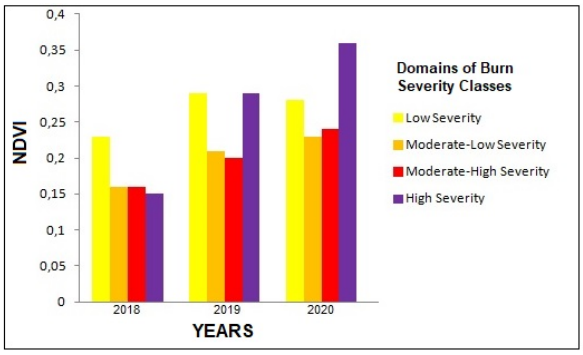

Figure 3. Domains of every class of severity for calculation the mean values of NDVI of every year per class.

4. DISCUSSION- CONCLUSION

Since it is known that fires are a very serious problem in Greece, remote sensing can be a very useful tool that helps to monitor several issues, such as, in this case, the study of burnt areas, vegetation and the change of land uses, as well as the regrowth. When all these elements are integrated in a Geographic Information System, a very useful tool is created which can contribute to the management of the fire, but also to the management of the burned areas and their immediate restoration. To conclude, the Burn Severity of the area showed the serious damage caused mainly in the forests, where the highest values appear, but also the course of the fire which reached the beach, as a result of which the urban fabric was also affected. The regeneration of the area is mostly evident in the Central West and the Central East area, where the burn severity was in Low and Moderate Low class and from the CLC 2018 it is shown that these areas were covered by Coniferous and Mixed Forest. The conclusions drawn from the picture of land uses, complement the above results by presenting the areas of coniferous forests and low vegetation and shrub forests to occupy the largest area. The results of the vegetation indices pull together the total frame of the disaster in the area, demarcating the traces of the fire.

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ASSESSMENT OF SEISMICALLY INDUCED LANDSLIDE SUSCEPTIBILITY AT THE ISLAND OF LEFKADA BASED ON DATA PROVIDED BY THE 2003 AND 2015 EARTHQUAKES

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ABSTRACT

The aim of this contribution is to assess the susceptibility of the earthquake-induced landslides in the island of Lefkada and to develop the relevant susceptibility map that can be used in order to predict slope failure locations in a future earthquake. In order to achieve this, information regarding the spatial distribution of slope failures generated by the 2015 and 2003 earthquakes were analyzed in ArcGIS. Furthermore, the spatial distribution of landslides was statistically analyzed in relation to the causal factors of geology and topography (classified at classes), in order to investigate their influence in landsliding phenomena. Parameters such as densclass (percentage of landslides within each class) and densmap (density of landslides throughout the map), were evaluated, to calculate the weighted factors. Subsequently, these factors were overlaid as thematic layers and the resulted map was classified at 10 susceptibility classes (using the natural breaks method). As an outcome, a landslide susceptibility map was compiled. Moreover, this susceptibility model was further analyzed by calculating frequency values, in order to estimate the success rate. The outcome of the analysis shows that 61,58% of the landslides corresponds to the 10th susceptibility class, (in susceptibility classes 8,9,10 the rate is 88,93%). Considering the prediction rate, we took into account the landslide inventory of 14/8/2003 M6.3 earthquake, following the same procedure**.** The susceptibility map indicates that 51,99% of the 302 landslides corresponds to the 10th susceptibility class, (in classes 8,9,10 the rate is 88,74%). Finally, for both cumulative curves (success and prediction rate), 25% of the map verifies and predicts more than 90% of landslides, proving the reliability of our model. Summarizing, this study presents the updated earthquake-induced landslide susceptibility map of Lefkada island.

Keywords: Lefkada, earthquake, GIS, Statistical analysis, Landslide susceptibility map

1. INTRODUCTION

Landslides consist one of the most important and widespread natural hazards worldwide. The compilation of landslide inventory and susceptibility maps play an important role in the design of technical projects, in the development of urban design, and in the proper selection of land use. The aim

of this project is to study the earthquake-induced landslides triggered by the 17/11/2015 M6.5 earthquake in the island of Lefkada and to develop a susceptibility model in order to predict slope failure locations in a future earthquake. Brabb (1984), [2], define the landslide susceptibility as the likelihood of a landslide occurring within an area on the basis of local terrain conditions. The evaluation of susceptibility can be achieved using regional landslide predictive models that estimate "where" landslides are likely to occur over a given region on the basis of a set of environmental characteristics [5]. It is widely known that GIS is a very usable and applicable tool in geosciences as it is very suitable for indirect landslide susceptibility mapping, in which all possible landslide-contributing terrain factors are combined with a landslide inventory map, using data integration techniques [1,3,9]. In particular, these factors are employed into GIS environment and converted from vector-to-raster maps. Subsequently, an overlay is made of each factor map with the landslide inventory map and the frequency statistics are calculated for the combinations of the two maps [8]. In statistical landslide hazard analysis, the combinations of factors that have led to landslides in the past are determined statistically, and quantitative predictions are made for areas currently free of landslides but where similar conditions exist. Two different statistical approaches are used in landslide hazard analysis: bivariate and multivariate. In bivariate statistical analysis, and more specifically in Landslide Susceptibility Index (LSI) method, each factor map is combined with the landslide distribution map, and weighting values based on landslide densities are calculated for each parameter class [8].

2. DATA AND METHODS

Nowadays, earth scientists mainly use the geographic information system (GIS)-based techniques and remote sensing data in order to map the landslide susceptibility and hazard and evaluate the risk within an area. More specifically, these GIS-based techniques are considered as very suitable for indirect landslide susceptibility mapping, in which all possible landslide-contributing terrain factors are entered into GIS environment and combined with a landslide inventory map, using data integration techniques [1,3,9,6].

Based on the inventory of 2015 the layers of geology, landslides and faults, were imported in ArcGIS and as a result the geological map was constructed. Moreover, the DEM of Lefkada was also imported, with 5m resolution (KTIMATOLOGIO S.A.) and the slope, aspect and elevation maps were produced. In addition, the vector data were converted into raster data (10x10m pixel size) and the weighted factors were exported (based on the LSI statistical method) for the casual factors of geology, slope, aspect, and elevation. In addition, all these factors were overlaid as thematic layers and as a result the landslide susceptibility map was produced (Fig 1). This spatial model was further validated based on the inventory of 2003 developed by Papathanassiou et al. (2017), [7]. It must be highlighted that the inventories that were used for the development of the landslide susceptibility map (training and validation dataset) are based on data provided by strong, shallow earthquakes occurred on the northern part (14/8/2003) and on the southern part (17/11/2015 event) of the island.

3. RESULTS AND DISCUSSIONS

The outcome of our analysis shows that the most susceptible formations are the carbonate rocks (mainly limestone) of Paxos zone (weighted factor 1.64) and the slope angle of 40° - 50° (weighted factor 1.62). It was also derived that the casual factors of slope aspect and elevation do not play such a crucial role, as the geology and the slope angle.

Moreover, the 61,58% of the 596 landslides corresponds to the 10th susceptibility class, (in classes 8,9,10 the rate is 88,93%). Concerning the prediction rate, we took into account the landslide inventory of 2003

earthquake (302 landslides), following the same procedure, [6]. The susceptibility map indicates that 51,99% of the 302 landslides corresponds to the 10th susceptibility class, (in classes 8,9,10 the rate is 88,74%). These two cumulative curves, success rate & prediction rate curves, present the percentage distribution of the susceptibility map and the percentage of landslides. Regarding the success rate, the 10% of the susceptibility map includes the 78% of landslides, while the 75% of the landslides could be predicted in the 10% of the susceptibility map (based on the prediction rate carve). Finally, for both curves, 25% of the susceptibility map verifies and predicts more than 90% of landslides, proving the reliability of our model. This landslide susceptibility map and the map depicting the road network in relation to the susceptibility classes are considered as the updated susceptibility maps for the island of Lefkada and can be used by public agencies and civil protection authorities in order to forecast slope failures triggered by future earthquakes, and to protect the road network, respectively.

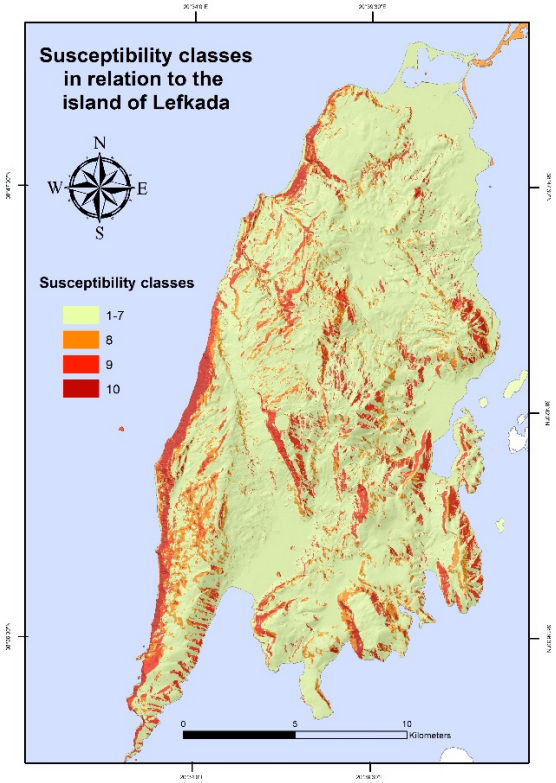

Figure 1. Map showing the susceptibility classes in Lefkada island. From 1 to 10 are the landslide susceptibility classes; the 1st class represents very low susceptibility, whereas the 10th class represents very high susceptibility. The susceptibility classes from "1" to "7" have been grouped within one class, so the correlation among the three highest susceptibility classes "8","9" and "10" could be clearly presented to the reader.

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TOWARDS THE DEVELOPMENT OF AN UPDATED GIS-BASED LANDSLIDE HAZARD MAP IN ATTICA REGION, GREECE; DIAS PROJECT

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ABSTRACT
The scope of this project, named Landslide Risk Management of Attica Region (DIAS), is to construct a uniform and updated database of slope failures that have taken place in the Attica Region (Greece), and compile a landslide inventory map for the development of raster cartographic products (such as those of hazard and risk maps) capable of supporting risk evaluation activities. These maps can be used by the Civil Protection Authority (C.P.A.) in conjunction with the Euro-codes 7 and 8 (geotechnical and seismic design of buildings) and the 2007/60/EC Flood Directive. They can help for the protection of urban and suburban areas as well as many critical infrastructure facilities in the administrative area of Attica, including the peninsula and its islands. Furthermore, since Greek C.P.A. has, recently, issued a new generic mitigation plan called "Dardanos" against floods damages and their resulting landslides, DIAS project can facilitate the role of Civil Protection Authorities, by providing inputs for prevention and preparedness (first phase of Civil Protection). In addition, DIAS can be a valuable tool for the successful cooperation among different stakeholders such as those of public authorities, researchers, planners, and decision makers regarding civil protection issues. In this paper, an updated landslide inventory map is presented, being the first step for the production of the upcoming landslide hazard and risk maps. DIAS products will contribute in communicating to the society the landslide risk, and increase the resilience. This research is co-financed by Greece and the European Union (European Social Fund – E.S.F.) through the Operational Programme "Human Resources Development, Education and Lifelong Learning 2014-2020", M.I.S. (5050327).

Keywords: Landslides, inventory map, Attica region, risk, civil protection

1. INTRODUCTION AND OBJECTIVE
Landslides represent a major threat to human life and infrastructure in many countries all over the world and they have a significant impact on their national economy. With the rising pressures of climate change, overpopulation, and urbanization, we can expect mitigation costs to increase evermore. Landslide identification is one of the first steps for evaluating the relevant hazard and for proposing measures aiming to minimize the risk. In particular, the accurate delineation of landslides can be used for assessing landslide susceptibility and for risk mapping. These maps can then be used by planners and policymakers in restricting construction in hazardous areas, and ultimately reduce the impact of landslides and increase the resilience of the society.
In Greece, landslides are one of the three most hazardous natural phenomena (the rests are floods and earthquakes), causing significant damages to infrastructures and buildings. Particularly in the Attica region, there are many documented landslide areas; Attica is a county of 3.810 km^2, concentrating almost half of the Greek population as well as high-value properties, heavy industry, transport networks and other infrastructure.
Following the updated collection of data describing landslide phenomena, it can be preliminary stated that in the Attica Region (Fig. 1), the susceptible to slope failure areas are classified as follows:

(a) areas where there is a history of landslide, such as:
i) the coastal areas of North-Western Attica (e.g., Alepochori – Psatha) and West Attica (e.g., Kakia Skala) respectively, ii) areas of North-Eastern Attica (e.g., Kalamos, Oropos, Dilesi, Kapandriti, Agios Stefanos), iii) areas of South-Eastern Attica (e.g., Kouvaras, Keratea, Varkiza, Lavrio), iv) areas of Eastern Attica (e.g., Penteli, Ntrafi, Porto Rafti), v) rockfalls occurred in Attica islands e.g., Kithira, Salamina, Aigina, Poros, Spetses, Ydra, due to the existence of steep slopes and active faults, vi) deep-seated failures on natural slopes (e.g., Malakasa site in 36th km of National Motorway Athens - Thessaloniki)
(b) areas where there is no history of sliding but human intervention dictates sliding (e.g., slopes degraded by recent forest fires such as that of the catastrophic one in Mati area during July 2018 and Mandra land area degraded by flash floods during November 2017, due to urban sprawl (unplanned urban growth),
(c) areas when there is no history of slope failures but geological and geomorphological conditions are such that sliding is possible due to floods or active erosion from streams: stream banks in soil subject to floods and/or active erosion (e.g., bank slopes subjected to undercutting by rivers exist in Kifisos river, Pikrodafni, Sapfous, Eschatia, Chalandri, Podonifti stream and other minor ones)
(d) landslide areas that have not been reported. These zones will be delineated and included in the developed database.
All the above-mentioned slope failures have already caused (and many other likely to failure slopes can cause) damages to various infrastructure facilities such as highways, roads, railways, major critical lifelines (e.g., water, gas pipelines and electricity power lines).
Those problems can be confronted with the use of products of this research project named DIAS, which is a project that is focused on landslide inventory, susceptibility, hazard and risk mapping; a key prevention activity that will be specifically addressed to urban, suburban and critical infrastructures. The main outcomes of this project, can be used by the Greek Civil Protection Authority following the four basic priorities for action that have been declared by the Sendai Framework for Disaster Risk Reduction 2015-2030 [1]. These actions briefly are: 1) Understanding disaster risk, 2) strengthening disaster risk governance to manage disaster risk, 3) investing in disaster risk reduction for resilience, 4) enhancing disaster preparedness for effective response.

2. METHODOLOGY

The generated inventory map, and the landslide geodatabase of DIAS, cover a chronological period from 1961 up to present (2020). The methods that were used for the generation of the inventory can be classified into the following main groups:
(a) Collection of technical reports from public authorities (e.g., Directorates of Technical Works in Attica), research institutes (e.g., HSGGME) and newspaper articles,
(b) Field surveys and review of previously mapped landslides by the authors,
(c) Satellite Image analysis and interpretation: (i) using multi-temporal images from Google Earth Pro, (ii) hill-shading images (as well as slope and aspect map) derived from a Digital Elevation Model with pixel size of 5 m. The landslides areas were delineated based on the guidelines recommended by the protocol (Special Paper 42) of Oregon (U.S.A.) Department of Geology and Mineral Industries [2].
The identified slope failures were employed in an ArcGIS database as spatial data and tabular (descriptive) data. The collection, analysis and presentation of the gathered landslide data is based on JTC-1 Technical Committee guidance [3] about the terminology of landslides and the EU INSPIRE directive about the process and interpretation of the geodatabase [4].
After this step, a landslide susceptibility mapping will be produced based on a semi-quantitative heuristic methodology named Rock Engineering System [5, 6], using independent static parameters such as those of geology, (active) faults, rivers, slope aspect, and distance from roads. The last steps of this research will be the construction of hazard and risk maps using triggering dynamic factors like earthquake and rainfall data, as well as different elements of risk (for vulnerability estimation), respectively in specific areas. The outcome of the DIAS project, will be accessible to the public, through a web-based platform using an open-source G.I.S. software so as to aid awareness of

landslides and the associated hazards (floods, earthquakes) among different stakeholders (e.g., landslide experts, government agencies, planners, citizens).

3. RESULTS AND DISCUSSION

Figure 1 shows a preliminary landslide inventory map compiled for the purposes of this project. Delivering a map and its associated geodatabase is extremely useful for end-users, especially for Civil Protection actors. A total number of 211 slope failures (existing and potential ones) have been identified where thirty-nine (39) are slides, seventy-two (72) are rockfalls and one hundred (100) are falls due to river erosion and (flash) floods. The geographical spread of them is depicted as follows.

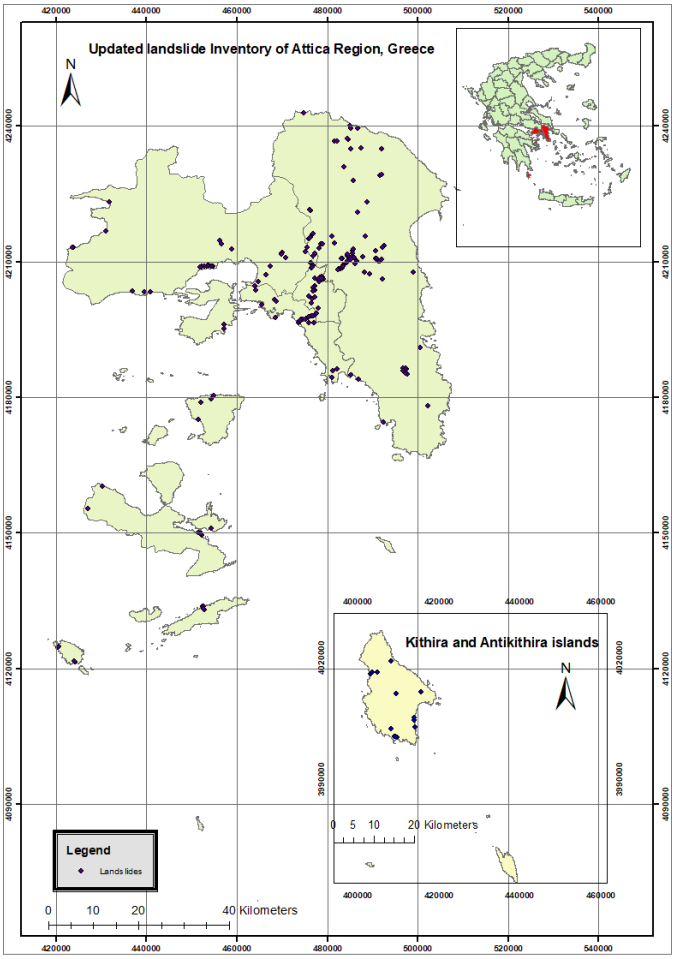

Figure 1. Updated landslide inventory map of Attica region (scale 1:700.000) for the period 1961-2020. Solid circles depict occurrence of landslide phenomena (slides, falls, rockfalls)

Of particular interest is the landslide inventory due to strong ground motion from strong shallow earthquakes, such as the 1999 [7, 8] and the 2019 Athens earthquakes [9], where rock falls were mapped along the Egaleo ring road, several provincial roads and mountain paths. The region of Attica contains also active faults [10] and the simulation of strong ground motion may indicate localities with enhanced likelihood of slope failures.

To this direction, taking into account the deliverables of the European Union U-Geohaz project [11], it can be clearly said that, DIAS:

1. facilitates the communication between the scientists and the project final operational users (e.g., C.P.A.'s), and increases the knowledge regarding the slope failure-prone areas, providing products useful for the pre-event of the landslide risk management cycle

2. prepares an updated landslide database and generates maps which depict the susceptibility, hazard and risk zoning in different places and scales. Civil protection agencies (C.P.A.) need such maps in order to make emergency plans at different administrative levels
3. correlates the outputs of this project to other regional initiatives i.e., maps with a) the already produced potential highly flood hazard zoning maps of Attica Region authorized by the Greek Ministry of Environment and Energy, and b) with the produced flooded area maps, delivered by the Copernicus Emergency Management Service – Mapping [12]

4. CONCLUSION

Evaluating the landslide hazard is essential to properly face the risk management of vulnerable areas, such as transports network elements (roads, railroads, bridges, tunnels), hospitals, administrative buildings, security/emergency structures, residential buildings, etc. In this sense, one of the most important tasks from disaster risk management is to carry out prevention methodologies, products, and services to take action for the protection of people in case of catastrophes and emergencies [13]. Government authorities and those who formulate policy need to develop a better understanding of the socio-economic significance of landslides. That knowledge will allow officials at all levels of government (including those of C.P.A.'s) to make rational decisions on the allocation of funds needed for landslide research; for avoidance, prevention, control and warning; and for post-failure repair and reconstruction [14]. The authors of this paper believe that the above mentioned can be addressed through the use of DIAS outcomes.

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THE INSTRUMENTATION OF MACEDONIA UNIVERSITY BUILDING (THESSALONIKI GR) FOR SEISMIC RESPONSE ANALYSIS AND HEALTH MONITORING

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ABSTRACT

The paper introduces the instrumentation of the Building D of the University of Macedonia in Thessaloniki, which is a TRITON - LUNITEK special array. This array was installed and being fully operational since March 2020. The array consists of one free field and three 3D accelerometers distributed in various floors connected to a LAN using the facilities of the University. The aim is the recordings of the building's response due to earthquake excitations however, the record of other ground motions as explosions etc. may also provide useful information for the structural health monitoring. Measured response data of structures from ambient and earthquake-induced vibrations offer an opportunity to study quantitatively and qualitatively their dynamic behavior within the resulting vibration levels. (Research and maintenance purposes). Examples of such recordings are presented.

Keywords: instrumented building, structural health monitoring, structural response, University Macedonia

1. INTRODUCTION

The recorded response data from buildings and other instrumented structures can be and are being primarily used to facilitate necessary studies to improve building codes and therefore reduce losses of life and property during damaging earthquakes. Other uses of such data can be in emergency response situations in large urban environments. It is known that the main objective of a seismic instrumentation program for structural systems is to improve our understanding of the behavior and potential for damage of structures under the dynamic loads of earthquakes. As a result of this understanding, updated models, design and construction practices can be modified so that future earthquake damage is minimized [1].
The instrumented building of University of Macedonia is an irregular, nine-storey, pilotis-type, reinforced concrete (R.C.) building that together with another 9 buildings form the building complex of the University of Macedonia, in the center of Thessaloniki, Greece. The building was constructed in the late 1980's, having dimensions of 32.00 m $\times$ 23.70 m and a total height of 32.90 m. The strucutral system of Buıldıng D consists of 20 R.C. columns, reinforced with ∅26 mm longitudinal bars and ∅12/150 mm stirrups. The structural system of all floors consists of Zoellner slabs of 450 mm height. The concrete is classified as B300 (f_{cm} = 25 MPa), whereas the longitudinal reinforcement and stirrups are St III (f_{yk} = 400 MPa).

2. INSTRUMENTATION OF BUILDING D

Building D of the University of Macedonia is equipped with four 3D TRITON type accelerographs of LUNITEK (www.lunitek.it). The instruments are of 24bits resolution and the network is equipped with GPS. Figure (1) depicts a cross section of the instrumented building and the locations of the three accelerographs are shown (left side). In the right side, there are pictures of the instruments. The fourth installation is a free field one located out of the building. Figure (2) includes pictures from the free field installation.

The configuration of this array fulfills the demands for high quality records of the structural response together with a reference ground motion.

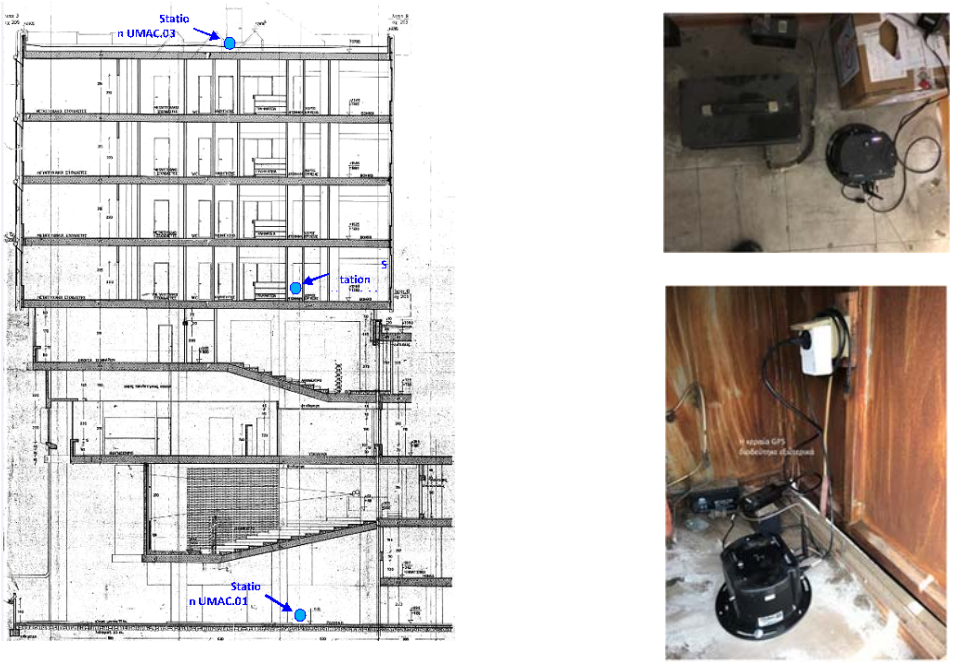

Figure 1. Cross-section of the building D of the University of Macedonia, Thessaloniki GR. The location of the TRITON - LUNITEK special network array along the height of the instrumented Building D is marked with blue dots (left panel). At the right panel there are pictures of two installations at mid-height and at the top of the building.

Figure 2. Cross-section of the building D of the University of Macedonia, Thessaloniki GR. The blue dots denote the locations of the installed instruments (left panel). At the right panel, there are pictures of two installations.

3. SAMPLE RECORDINGS OF THE UNIVERSITY OF MACEDONIA ARRAY

Thessaloniki is located in the proximity of a very active seismic zone and there are reports of damage due to earthquakes since antiquity. Distant large (M≥7.0) earthquakes caused damage in the city. Therefore, any structural array must have the possibility to record the structural response also due to distant events. During the installation period the system recorded motions of several local and distant events. Table (1) depicts for three of them the primary source parameters and epicentral distances from the University of Macedonia. The last column shows the type of the event.

Table 1. Primary source parameters of three events shown in Figure 4

Date	Lat	Lon	Magnitude	Epicentral Dist.	Type
10 August 2020 02:07	40.55	22.57	4.2	34	EQ
26 September 2020 22:50	39.97	24.31	5.3	135	EQ
1 May 2020 16:17	40.46	22.88	1.7	20	Explosion

On May 2 a strong shallow earthquake with magnitude Mw6.6 occurred in the sea region off southern Creta island, that is at 760km epicentral distance and the recordings of the two horizontal components at the free field station are shown in figure 3. Notice the high quality of the record.

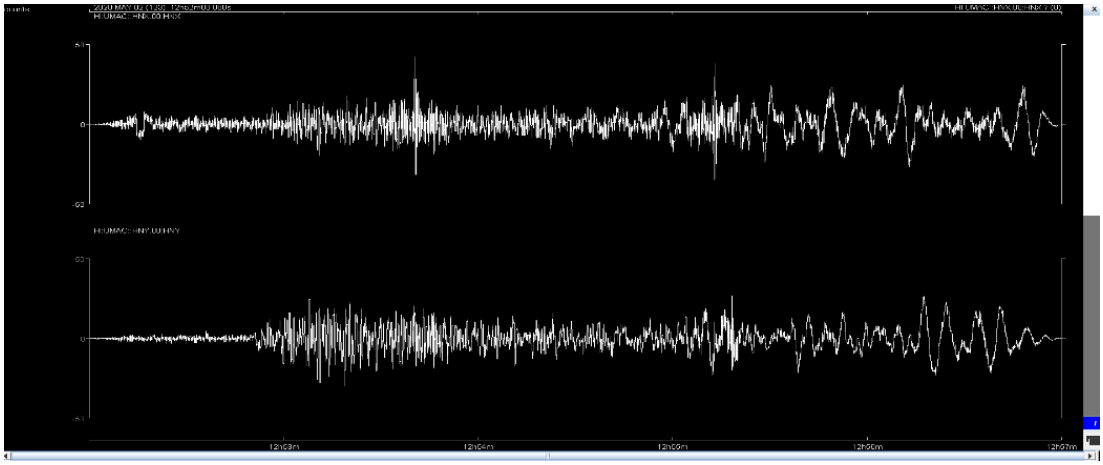

Figure 3. Free field recordings of the horizontal components of the earthquake of May 2, 2020 12:51, M6.6, off southern Creta Island. Notice the high quality of the recordings. Data are band-pass acausal filtered 0.1-25 Hz.

Figure (3) shows the acceleration time histories (first and second column) of the two earthquakes listed in Table (1). The last column are the acceleration time histories of the third event in the Table. These are the recordings of a naval mine explosion in the Gulf of Thessaloniki. Even though this event and the recordings could be considered negligible from the structural point of view (PGA ~0.1 cm/sec^2) and can be clearly seen only on the 2nd and roof floors (Mauro, 2020: personal communication).

4. DISCUSSION

Following the recent trends in building monitoring and monitoring of the structural health of various systems ITSAK instrumented a building of the University of Macedonia. The high quality recordings of various magnitude earthquakes at a wide range of distances promises that the installed network have great capabilities.

Even though there was no strong event in the near field of the installed network, some practical conclusions may derive. The M1.7 (explosion) and another M1.9 event occurred in the close proximity of the installed network, may represent the lower intensity we may detect with the system because the induced vibration amplitude is comparable to the natural resonance amplitude and to the local ambient

noise. This can be verified from the fact that the most noisy sensor is the Near Field: the local ambient vibrations are much stronger than the event vibration

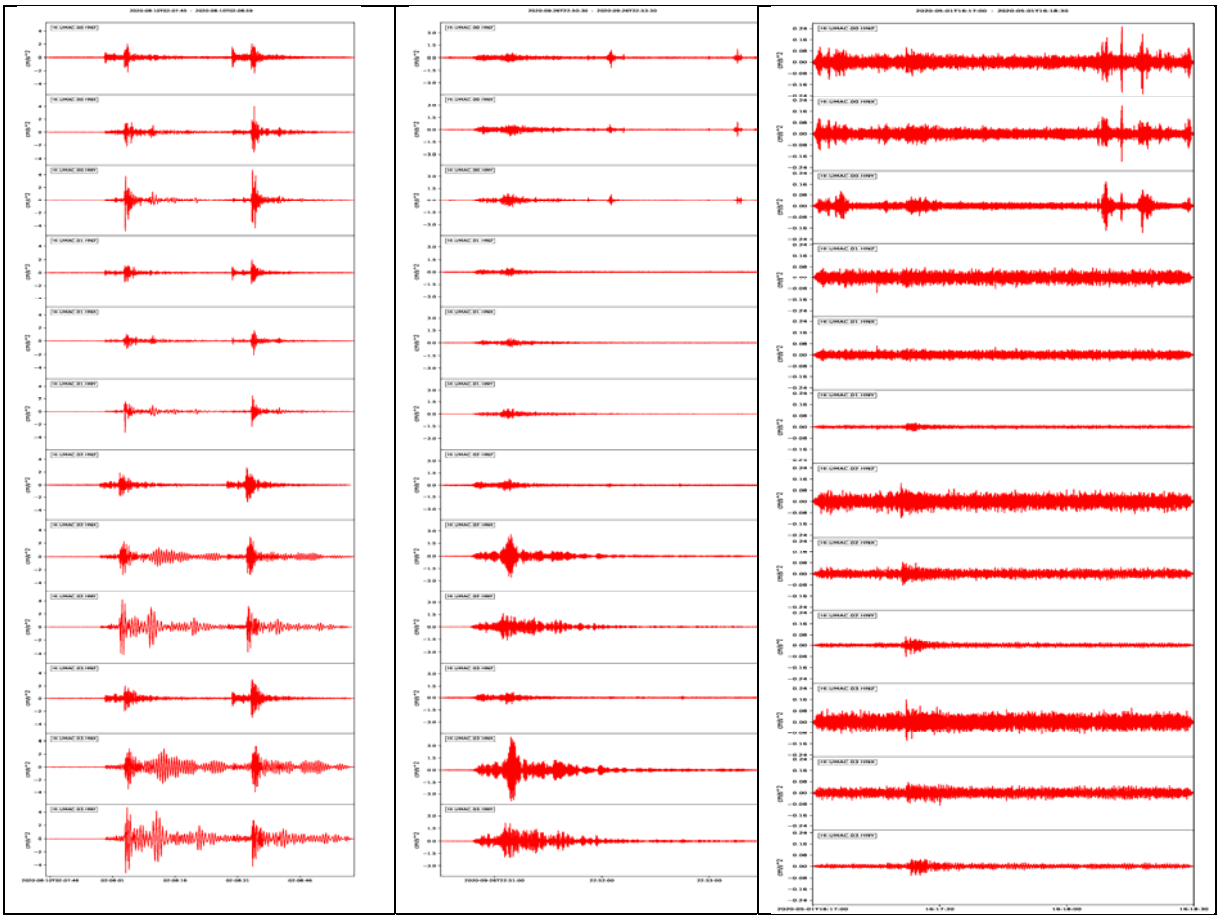

Figure 3. Recordings of the University of C. Macedonia special array. The recordings correspond to the August 10 event M4.2 (left), the September 26 M5.3 (center) and the mine explosion with M 1.7 at 20 km distance (right).

ACKNOWLEDGMENTS

It is acknowledged the support of this work by the project HELPOS – Hellenic System for Lithosphere Monitoring" (MIS 5002697) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund). The support of Dr A. Mauro of Lunitek is greatly appreciated.

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THE 7 MYTHS ABOUT THE COVID- 19 AND THE ORIGIN OF CORONAVIRUS ALONG WITH ITS CONSEQUENCES TO THE ENVIRONMENT.

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ABSTRACT
The coronavirus has already infected more than 20 million people all over the globe and the numbers are still rising. Unfortunately, the flood of information makes it difficult to separate fact from fiction and during the outbreak rumors and misinformation can be dangerous. We present the seven most pervasive myths that are not only misleading but they can be also dangerous. These are: The virus was probably made in a lab, pets can spread the new coronavirus, Vitamin C supplements will stop you from catching COVID-19 , Drinking bleach or other disinfectants can protect you from COVID-19, : 5G networks can spread the new coronavirus, : It's not safe to receive a package from China You can get the coronavirus if you eat at Chinese restaurants in Greece, The vaccination is dangerous. The origin of the coronavirus is traced in the bats and man came too close to them.

Key Words: Coronavirus, myths, 5G, bats, infection

1. INTRODUCTION

As the novel coronavirus continues to infect people around the world, news articles and social media posts about the outbreak continue to spread online. Unfortunately, this relentless flood of information can make it difficult to separate fact from fiction — and during a viral outbreak, rumors and misinformation can be dangerous.
Here we've compiled a list of the most pervasive myths about the novel coronavirus SARS-CoV-2 and COVID-19, the disease it causes, and explained why these rumors are misleading, or just plain wrong. In addition, we will present the origin of the Coronavirus along with its consequences in the environment.

2. MYTHS

Myth 1: The virus was made in a lab

No evidence suggests that the virus is man-made. SARS-CoV-2 closely resembles two other coronaviruses that have triggered outbreaks in recent decades, SARS-CoV and MERS-CoV, and all three viruses seem to have originated in bats. In short, the characteristics of SARS-CoV-2 fall in line with what we know about other naturally occurring coronaviruses that made the jump from animals to people. [1]
A study published March 17 in the journal Nature Medicine also provided strong evidence against the "engineered in a lab" idea. The study found that a key part of SARS-CoV-2, known as the spike protein, would almost certainly have emerged in nature and not as a lab creation. What's more, if scientists were trying to use computer models to engineer a deadly virus based

on the original SARS virus, they likely would not have chosen the mutations that actually appear in SARS-CoV-2. That's because computer simulations show that mutations in SARS-CoV-2 don't seem to work very well at helping the virus bind to human cells. But it turns out, nature is smarter than scientists, and the novel coronavirus found a way to mutate that was better — and completely different— from anything scientists could have predicted or created, the study found.

Myth 2: Pets can spread the new coronavirus

Although pets may contract COVID-19 in rare cases, there is no evidence they can spread it to people.

There have been a few reports of cats and dogs that became infected with COVID-19 after contact with their sick owner. For example, in April, two pet cats in New York tested positive for COVID-19, and the owner of one of these cats was confirmed to have COVID-19 before the cat showed any symptoms.

Even if pets do occasionally become infected, the Centers for Disease Controls(CDC) says there is no evidence that they are playing a significant role in the spread of the virus. And so far, there have been no confirmed reports of people contracting the disease from pets. [2]

Just in case, the CDC recommends that people with COVID-19 have someone else walk and care for their companion animals while they are sick. And people should always wash their hands after snuggling with animals anyway, as companion pets can spread other diseases to people, according to the CDC.

A cat's been infected with the novel coronavirus

A domestic cat in Belgium was confirmed to have COVID-19, the disease caused by the new coronavirus that's spreading across the globe.

Myth 3: Vitamin C supplements will stop you from catching COVID-19

Researchers have yet to find no evidence that vitamin C supplements can render people immune to COVID-19 infection. In fact, for most people, taking extra vitamin C does not even ward off common cold, though it may shorten the duration of a cold if you catch one.

That said, Viamin C serves essential roles in the human body and supports normal immune function. As an antioxidant, the vitamin neutralizes charged particles called free radicals that can damage tissues in the body. It also helps the body synthesize hormones, build collagen and seal off vulnerable connective tissue against pathogens.

So yes, vitamin C should absolutely be included in your daily diet if you want to maintain a healthy immune. But megadosing on supplements is unlikely to lower your risk of catching COVID-19, and may at most give you a "modest" advantage against the virus, should you become infected. No evidence suggests that other so-called immune-boosting supplements — such as zinc, green tea or echinacea — help to prevent COVID-19, either.

Be wary of products being advertised as treatments or cures for the new coronavirus. Since the COVID-19 outbreak began in the United States, the U.S. Food and Drug Administration (FDA) and the Federal Trade Commission (FTC) have already issued warning letters to seven companies for selling fraudulent products that promise to cure, treat or prevent the viral infection.

Myth 4: Drinking bleach or other disinfectants can protect you from COVID-19

You absolutely should not drink bleach or other household disinfectants, and you should also not spray them on your body. These substances are poisonous if ingested, and they can also cause damage to the skin and eyes, according to the World Health Organization [3].

When ingested, sodium hypochlorite (household bleach) can cause what is called "liquefactive necrosis," or a process that results in the transformation of tissue into a liquid viscous mass. The bleach can also damage cells as the sodium reacts with proteins and fats in a person's tissues in a process called saponification (soap), medical doctors reported in 2018 in a publication by the Emergency Medicine Residents Association.
Alarmingly, nearly 4 in 10 American adults in a recent survey reported engaging in dangerous cleaning practices to prevent COVID-19, such as washing food with bleach, using household disinfecting products on their skin or intentionally inhaling vapors from cleaning products.

Myth 5: 5G networks can spread the new coronavirus

Viruses, including SARS-CoV-2, cannot travel on or transmit through radio waves or mobile networks such as 5G networks, according to WHO. The new coronavirus is spread mainly through respiratory droplets that are expelled when an infected person coughs, sneezes or speaks, as well as through contaminated surfaces. WHO also notes that COVID-19 has been spreading in countries that do not have 5G mobile networks.

Myth 6: It's not safe to receive a package from China You can get the coronavirus if you eat at Chinese restaurants in Greece

It is safe to receive letters or packages from China, according to World Health Organization Previous research has found that coronaviruses don't survive long on objects such as letters and packages. Based on what we know about similar coronaviruses such as MERS-CoV and SARS-CoV, experts think this new coronavirus likely survives poorly on surfaces.
A past study found that these related coronaviruses can stay on surfaces such as metal, glass or plastic for as long as nine days, according to a study published Feb. 6 in The Journal of Hospital Infection. But the surfaces present in packaging are not ideal for the virus to survive. For a virus to remain viable, it needs a combination of specific environmental conditions such as temperature, lack of UV exposure and humidity — a combination you won't get in shipping packages, according to Dr. Amesh A. Adalja, Senior Scholar, Johns Hopkins Center for Health Security.
And so "there is likely very low risk of spread from products or packaging that are shipped over a period of days or weeks at ambient temperatures," according to CDC. "Currently, there is no evidence to support transmission of COVID-19 associated with imported goods, and there have not been any cases of COVID-19 in Europe associated with imported goods." Rather, the coronavirus is thought to be most commonly spread through respiratory droplets.

Myth 7: The vaccination is dangerous

This is the biggest of all myths. When the vaccines are ready everybody must be vaccinated so that we can secure immunity.

3. THE ORIGIN OF THE CORONAVIRUS:

Coronaviruses are commonly found in many species of animals all around the world, however, very few of them affect humans. Having coronaviruses found in animals evolve and be able to spread from an animal to humans is possible very rare. This is what took place with two coronaviruses, Middle East respiratory syndrome(MERS)and severe acute respiratory syndrome(SARS). These two coronaviruses are known to cause very severe symptoms of respiratory system problems in humans and called for comprehensive public health responses.

It is believed to have zoonotic origins and has close genetic similarity to bat coronaviruses, suggesting it emerged from a bat-borne virus. There is no evidence yet to link an intermediate animal reservoir, such as a pangolin, to its introduction to humans.
The coronavirus infected man because man destroyed forests and natural environment .as a result of that man came to close to natural environment and thus coronavirus jumped from the buts to humans.

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SURVEY ON ATTITUDES, PERCEPTIONS AND BELIEVES REGARDING COVID-19 AND ITS MANAGEMENT IN GREECE: EARLY FINDINGS

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ABSTRACT

For the purpose of highlighting factors that could allow for more effective policies against COVID-19, the paper presents the results of an internet survey aiming at examining the level of knowledge about COVID-19 and the perception of risk, the sources of information used and also the public opinion on the management of COVID-19 and the stance towards recommended measures. The survey employs an electronic questionnaire of 60 questions, divided into 4 sections based on free access application Google Forms. Analysis of the information from 1.738 questionnaires sheds light to factors that had an effect on the implementation of policies for the protection of public health against COVID-19 and indicates that perceived risk, risk communication and trust to authorities significantly affected the intention of the citizens to comply with protection measures.

Key words: COVID-19, public health policies, risk perception, risk communication, pandemic

1. INTRODUCTION

The COVID-19 pandemic was first manifested in Greece by late February 2020 and has since become a central policy issue. Its management has undergone different phases and was adapted over time according to the course of the disease and the available knowledge. Our focus is the so called “quarantine period” during which the management of the situation involved a series of recommended or compulsory measures to protect public health and to limit the spread of the new virus. These mainly involved restrictions on gatherings and movement and social distancing.

2. OBJECTIVES AND METHODOLOGY

This paper presents the results of a survey aiming at examining the level of knowledge about COVID-19 and the perception of risk, the sources of information used and also the public opinion on the management of COVID-19, with the goal to highlight the factors that, if taken into account, can lead to the development and implementation of more effective policies against COVID-19. The survey was conducted mainly in the period April 2020 and a total of 1.738 persons took part in it. Microsoft Excel was used for statistical processing of the information.

The survey employed an electronic questionnaire of 60 questions in 4 sections, which was based on free access application Google Forms. The questions were closed and scaled (dichotomous, single-choice, multiple-choice and orderly in the form of a LIkert element). Section 1 of the questionnaire refers to public knowledge on COVID-19 and uses closed-ended questions. Section 2 examines sources of information on COVID-19 and uses the Likert scale (3-point, 4-point and 5-point) on a case-by-case basis, with answers scoring on a scale of 1 to 5. Section 3 uses closed-ended and multiple choice questions and Likert scale to identify attitudes, perceptions and the behavior of the participants and their stance towards the official precautionary measures. Section 4 focuses on the demographic profile of participants. The questionnaire was anonymous and included an introductory note explaining the purpose of the survey. The last question "Do you want to add something else that you think is important?" was open and is considered of major importance for the assessment of

validity and reliability of the survey [1]. The link to the questionnaire was first channeled through a Facebook page on civil protection and from it was passed on to other social media.

3. RESULTS AND OUTCOME

3.1 Profile of paricipants

The vast majority of participants are women (68%). Also, the majority belong to the age class 41-65 years (60.9%) and about one third (35.1%) to the class 20-40 years, while only 4% are older than 65 or younger than 20. About two thirds (66.1%) live in a large urban center. Around three quarters (73.5%) are graduates of higher education of which 30.8% hold a postgraduate degree. Most of the participants are employed, as private or civil servants (39.1%), self-employed (14.5%), teachers (9.7%), medical or paramedical staff (6.73%), uniformed forces (3%). About one out of four was reported unemployed or underemployed (11.9%), student (5.9%), retiree (6.7%) and homemaker (0.9%). Three out of four indicate average economic and social status (75.3%) and around 20% indicate low economic level.

3.2 Knowledge on COVID-19 and risk perception

The questionnaire made use of a recent study on clinical manifestations in patients with COVID-19 [2] according to which the most common symptoms were fever (88.7%), cough (67.8%), fatigue (38.1%), sputum production (33.4%), dyspnoea (18, 6%), sore throat (13.9%) and headache (13.6%). As regards knowledge on the symptoms of the disease, the results of the survey largely agree with the above, at least for the most common clinical manifestations. Of interest are the responses about the origin of the specific corona virus with the largest percentage (62%) expressing doubts regarding a natural origin of the virus without anthropogenic intervention (intentional or not), with this percentage slightly increased for women.

Threat from COVID-19 was attributed primarily to the high communicability of the disease (31.70%), followed by: lack of vaccine / antiviral drug (23.48%), probability of causing death to the patient (20.20%), scientific uncertainty regarding the disease (19.10%) and unknown number of exposed persons (3, 74%). As regards perception of risk from COVID-19, the majority of participants believed that the disease is likely to affect themselves or their family but not too severely (M = 2.28 / 3, SD = 0.60) and acknowledged the importance of the recommended precautions, indicating with a certain certainty their intention to comply with them (M = 3.74 / 4, SD = 0.26). They believed that if they do not follow precautionary measures, the chances of getting sick are greatly increased (M = 3.88 / 5, SD = 0.92 while in case of illness, they generally intended to inform their environment (M = 3.78 / 4, SD = 0.45). Women showed more an intention to comply with the measures (M = 3.98/4 in women, M = 3.69 /4 in men).

3.3 Sources of information

Most preferred sources of information were, news websites (M = 3.40/5, SD = 1.15), television (M = 3.0 / 5, SD = 1.24), social media (M = 2.80 / 5, SD = 1.60) and internet search engines (M = 2.79 / 5, SD = 1.30), while the use of the media of state agencies was considered important (M = 2.99 / 5, SD = 1.22). The radio (M = 1.72/5, SD = 0.99), the press (newspapers and magazines) (M = 1.46 / 5, SD = 0.88) as well as acquaintances and friends (M = 1.95 / 5, SD = 0.96) were lower in the preferences of the participants. The average rating of the credibility of information sources was moderate for the mass media (M = 2.88 / 5, SD = 1.10), internet search engines (M = 2.65 / 5, SD = 0.99) and social media (M = 2.11 / 5, SD = 1.11). The information received through official government announcements and especially from the Ministry of Health, was rated higher as regards its credibility (M = 3.24 / 4, SD = 0.64 and M = 3.30 / 4, SD = 0.62) respectively. No differences in this were detected

between the sexes.

3.4 Acceptance of precautionary measures and intention to comply with these

In ranking intention to follow precautionary measures, social distancing was rated higher (M=4.45/5, SD = 0.62) and the use of protective mask was rated lower (M=2.74/5, SD =1.42). Only 45% (42,7% of women and 50,00% of men) considered the use of mask as a recommended precautionary measure. This can be explained by the fact that official recommendations at the time were not in favour of the use of mask by the public and there were shortages of masks in the Greek market.
The participants agree almost entirely with the measures proposed by the Ministry of Health (M = 3.98 / 4, SD = 0.57). The level of satisfaction regarding the measures taken by the local government was significantly lower and was evaluated as moderate (M = 2.60 / 4, SD = 0.89 for the Municipality and M = 2.60 / 4, SD = 0.85 for the Region). Even lower, was the level of satisfaction as regards protection measures by their employers (M = 2.12 / 4, SD = 0.89).
The intention to comply with the precautionary measures employed by the authorities was strong in general. The reasons given by participants (24.22% of the sample) for non-compliance with the precautionary measures are presented in Figure 2. Respectively, Figure 3 shows the reasons for compliance with the measures (based on responses by 98,73% of the sample).

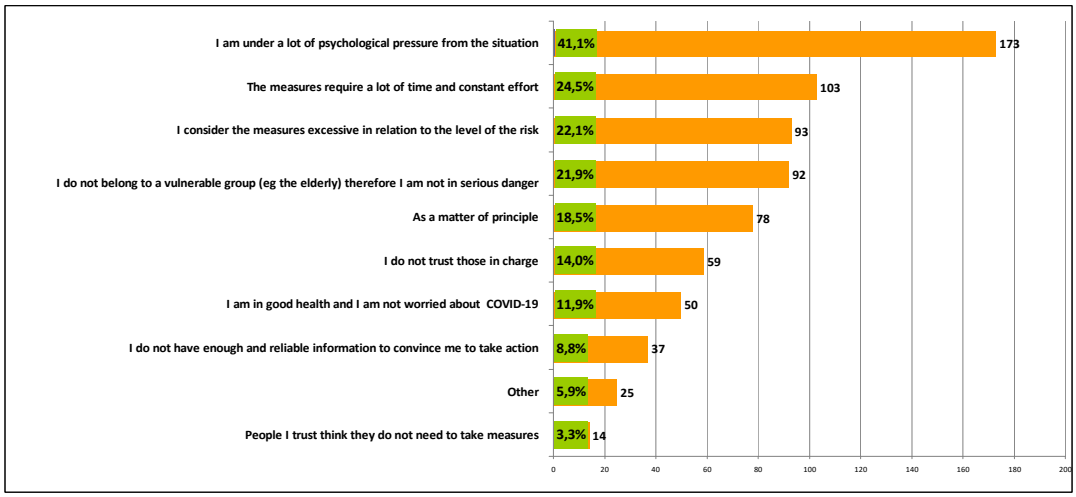

Figure 2. Reasons for no compliance to the indicated precautionary measures.

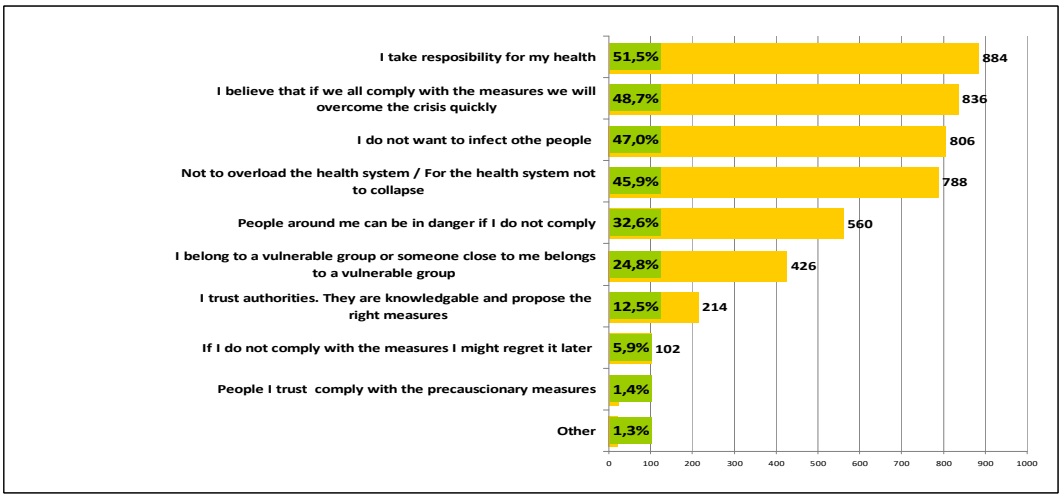

Figure 3. Reasons for no compliance to the indicated measures.

Regarding the length of time, the participants would endure restrictive measures to contain COVID-19, the majority of them responded that they will follow the measures for as long as it takes, while about one out of four indicated willingness to endure measures for 1 to 2 months. In general, restrictions on attending religious services are seen as more endurable and staying at home as less (Table 1).

Table 1. Anticipated time of enduring restrictive measures

Measure	2-3 weeks	1-2 months	3-4 months	As long as it takes	DK / NO	M/4	SD
Restrictions on movement	18,5%	26,5%	5,9%	46,0%	3,2%	**2,82**	1,22
Staying at home	20,7%	23,7%	5,8%	44,8%	5,0%	**2,79**	1,24
Restrictions on recreational activities and entertainment	9,8%	23,4%	8,9%	52,2%	5,8%	**3,10**	1,10
Compulsory nonappearance at the work place, university etc.	11,8%	23,2%	8,0%	48,8%	8,1%	**3,02**	1,14
Restrictions on public gatherings	10,3%	22,6%	9,6%	50,5%	7,0%	**3,08**	1,11
Avoiding close contact (with friends, relatives etc.)	18,6%	24,2%	8,9%	41,9%	6,3%	**2,79**	1,21
Restrictions on attending religious services	7,3%	15,5%	7,9%	61,6%	7,7%	**3,34**	1,02
Restrictions on activities that require physical presence	16,2%	22,5%	9,5%	44,9%	6,9%	**2,89**	1,19

It should be noticed that the very strong acceptance of the official precautionary measures correlates weakly with the length of time the participants are willing to endure those measures. For example, most of the participants agree with the restrictions on movement (M = 3.70 / 4, SD = 0.73) however correlation with the time they can endure this measure is weak (Peterson coefficient = 0.31).
In general, sex played no significant role (<2%) in the results of the survey, while responses by age group differed with regard to disease characteristics, need for more information, recommended precautions etc. Participants who have people with underlying diseases in their family (879 people) assessed as more severe the impacts of the disease.

4. DISCUSSION

No matter the size of the sample (1.738 questionnaires), there is some concern that the outcome may have a bias due to the type of internet. It could be argued that the bias is small given the wide use of social media in Greece nonetheless the paper restricts itself to analysis of findings within the sample under study.
Overall, the research results demonstrate that perceived risk, risk communication and trust to authorities affected the intention of citizens to comply with the precautionary measures. We are convinced that although the survey reflects the situation at the time, further in depth study of the collected information would shed light to factors that must be considered more in order to improve the management of COVID-19 pandemic in Greece and specifically crisis communication, towards better protecting public health and avoiding unnecessary fear. Our aspiration is that the findings will inform public policies for COVID-19 so as to design measures reflecting more the level of risk and better received by the citizens.

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CHANGES IN NITROGEN DIOXIDE LEVELS OVER GREECE AFTER THE OUTBREAK OF COVID-19; A SATELLITE VIEW.

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ABSTRACT

The strict enforcement for near total lockdown of the Greek population due to the Severe Acute Respiratory Syndrome CoronaVirus-2 (COVID-19) pandemic in March 2020 has offered a unique opportunity to study the contribution of vehicular nitrogen dioxide (NO_2) emissions to the country's air quality. S5P/TROPOMI monthly mean NO_2 observations show an average decrease of -3% to -26% [-1% to -27%] with an average of -22% [-11%] for March and April 2020 respectively, compared to the previous year, over the six larger Greek metropolitan areas, attributable mostly to vehicular emission reductions. Significant effects, of approximately -12% [-5%], for shipping emissions over the Aegean Sea as well as surrounding major Greek ports were observed. For the city of Athens, weekly analysis was performed which revealed a marked decline in space-sensed NO_2 load, between -8% and -43%, for seven of the eight weeks studied. Chemical transport modelling, provided by the LOTOS-EUROS CTM, shows that the magnitude of these reductions cannot solely be attributed to the difference in meteorological factors affecting NO_2 levels. Therefore, taking the meteorology into account, the COVID lockdown-related changes in tropospheric NO_2 load were estimated to range between 0% and -37% for the largest Greek cities, with an average of ~ -10% [1].

Keywords: Air quality; nitrogen dioxide;; Sentinel-5P; LOTOS-EUROS; Greece.

1. INTRODUCTION

In the following paper we will discuss the decline in tropospheric nitrogen dioxide (NO_2) levels over Greece during the lockdown enforced by the Severe Acute Respiratory Syndrome CoronaVirus-2, commonly known as COVID-19, pandemic, observed by the satellite instrument space-borne S5P/TROPOMI, here after TROPOMI. We demonstrate the improvement in local and regional air quality due to the reduced nitrogen oxides (NOx) emissions by comparing the relative NO_2 levels for March and April 2019 and 2020, while accounting for differences due to meteorological factors using a Chemical Transport Model, CTM, simulations.

2. MATERIALS AND METHODS

2.1. TROPOMI NO_2 observations

The TROPOMI instrument flying on the Sentinel-5 Precursor (S5P) mission [2] has been providing, since early 2018, global observations of ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, formaldehyde, and methane, as well as aerosol and cloud properties. Its very high spatial resolution [3.5×7 km^2, 3.5×5.5 km^2 since August 2019] and improved signal-to-noise ratio compared to previous space-borne instruments, allows the study of tropospheric pollution from small-scale emission sources and the estimation of very localized emissions from anthropogenic activities. For the purposes of this work, we use the publicly available TROPOMI offline v1.2 and v1.3 for March-April 2019 and for March-April 2020 tropospheric NO_2 data accessed via the Copernicus Open Data Access Hub. Orbital files, between 19° and 30°E and 34° and 42°N, were gridded onto a 0.10x0.05° grid using the Atmospheric Toolbox® for

different temporal scenarios. The data have been filtered, using the quality flag indicator ≥ 75 assuring the data under this flag is restricted to cloud-free (cloud radiance fraction < 0.5) and snow-ice free observations.

2.2. LOTOS-EUROS CTM NO_2 simulations

The open source chemical transport model LOTOS—EUROS v2.2.001 is used to simulate NO_2 columns over Greece for March and April 2019 and 2020. The LOTOS-EUROS model is the national air quality model for the Netherlands [3] and is aimed at air pollution studies in the troposphere simulating gases as well as aerosols. LOTOS-EUROS also participates at the operational Copernicus Atmosphere Monitoring Service (CAMS) consisting one of the seven CTMs that provide the official ensemble air quality forecasting service while it has already been used to investigate NO_2 values [4,5]. A detailed evaluation of the LOTOS-EUROS NO_2 simulations over Greece [6] have showed that the simulations for the surface NO_2 concentration compare favourably to situ concentration measurements, with coefficients between 0.42 to 0.55 for the different air quality stations studied. Furthermore, the simulated NO_2 tropospheric columns show a satisfactory correlation to ground-based MAXDOAS columns, with coefficients between 0.41 and 0.55 for the urban and between 0.58 and 0.64 for remote directions In this work, the simulations follow the domain chosen for the satellite observations, i.e. between 19° and 30° East and 34° and 42° North, with a grid resolution of 0.1°×0.05° (longitude × latitude).

2.3. Comparative Methodology

One would assume it would be sufficient to simply compare the NO_2 levels over Greece for the two periods, assuming that the emission sources have not changed dramatically between 2019 and 2020. However, meteorological conditions, such as wind speeds, temperature inversions and the depth of the boundary layer, often play pivotal roles in local air quality levels [7], and hence the effects that various meteorological parameters have on NO_2 levels cannot be disregarded. To ascertain that the observed decrease in NO_2 levels was not due to different meteorological conditions, relative differences of the simulated NO_2 columns provided by the LOTOS-EUROS model have been calculated and their average magnitude is assumed to be the expected contribution by meteorology. This magnitude hence gives a standard level above which we expect COVID-19 related, i.e. emission-related, reductions. The idea of this thinking is that differences in the satellite observations will contain the intertwined effect on concentrations by differences in emissions as well as by differences in meteorology. For the CTM, the emissions are assumed to be constant for the two periods while the meteorology changes in the input files. In this manner we can isolate the impact of meteorology on the simulated concentrations. We cannot of course exclude the possibility that the LOTOS-EUROS model has biases in the resulting NO_2 column which depend on the meteorological conditions, for example due to uncertainties in mixing under stable conditions, however we expect those to smear out for the spatiotemporal scales studied. In this point we should also note that the satellite observations do not usually cover the entire domain, especially in spring-time months, since in the suggested quality assurance screening only cloud-less observations remain. Even in typically sunny-Greece, spring-time months are rainy months which means that a one-to-one comparison of the satellite observations for the two periods, even on a weekly basis, is most times not possible.

3. RESULTS

The monthly mean TROPOMI tropospheric NO_2 columns, in 10^{15} molecules/cm^2, have been calculated for the two major cities in Greece, the capital city of Athens [37.98° N, 23.72° E] and the second largest city, Thessaloniki [40.64° N, 22.94° E]. These two cities hold approximately half of the country's population, at 4.45 out of 10.8 million inhabitants in Greece [8] and are considered the major traffic emissions hotspots of the country. In ***Figure** 1* these are depicted for March 2019 [left column] and 2020 [right column] for Athens in the first row and Thessaloniki in the second row.

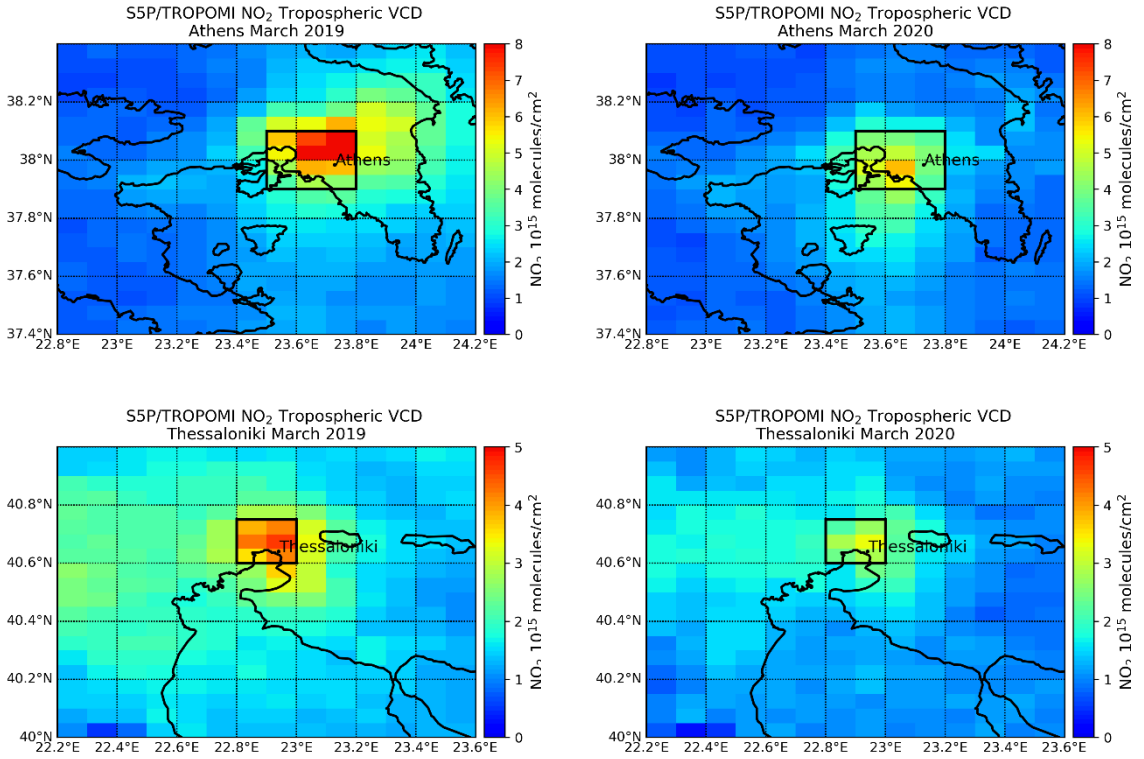

Figure 1**.** Monthly mean TROPOMI tropospheric NO_2 columns, in 10^{15} molecules/cm^2, for March 2019 [left] and March 2020 [right] for two largest cities in Greece. First row, Athens; second row, Thessaloniki.

Apart from the two larger cities, another four cities, spread around the country, were examined in more detail. For comparative purposes, all six major cities in Greece, from left to right, Athens, Thessaloniki, Larisa, Volos, Patra and Heraklio, are analysed in ***Figure*** *2* where the monthly mean TROPOMI tropospheric NO_2 columns, in 10^{15} molecules/cm^2, for March [upper] and April [lower] for the 2019 [blue] and 2020 [orange] are shown. Overall, the NO_2 levels are proportional to its city's population, with Athens and Thessaloniki in the lead and the remaining four presenting similar air quality conditions.

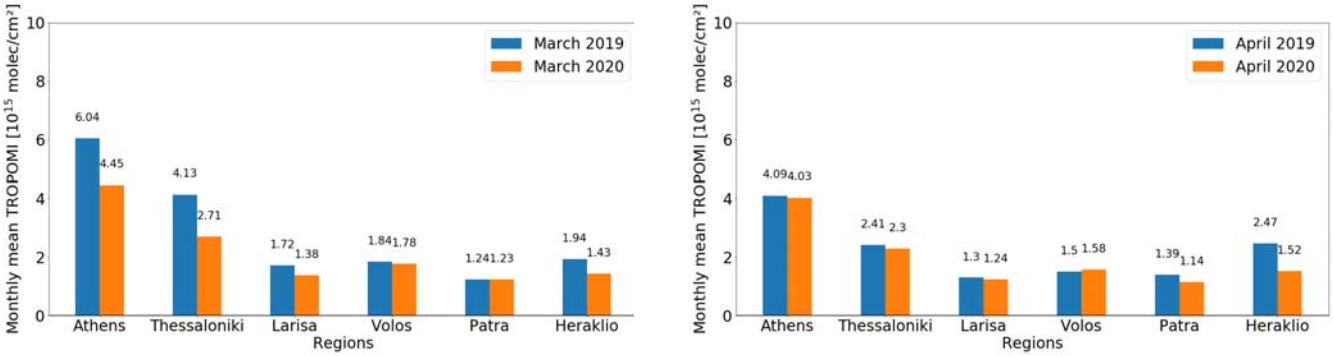

Figure 2**.** Monthly mean TROPOMI tropospheric NO_2 columns, in 10^{15} molecules/cm^2, for March [upper] and April [lower] for the 2019 [blue] and 2020 [orange] for the five major cities in Greece, from left to right, Athens, Thessaloniki, Larisa, Volos, Patra and Heraklio.

As was expected, from the average weekly NO_2 load over Athens sensed by TROPOMI shown in **Figure** 3, left panel, we can infer that the highest decrease due to the COVID-19 preventive measures is indeed observed over the Greek capital city of Athens. The contribution of the meteorological factors to these estimates can be assessed by the equivalent LOTOS-EUROS weekly averages, shown in the right panel of **Figure** 3. In both panels, the 2019 averages are shown in blue and the 2020 ones in orange, for the eight weeks of March and April.

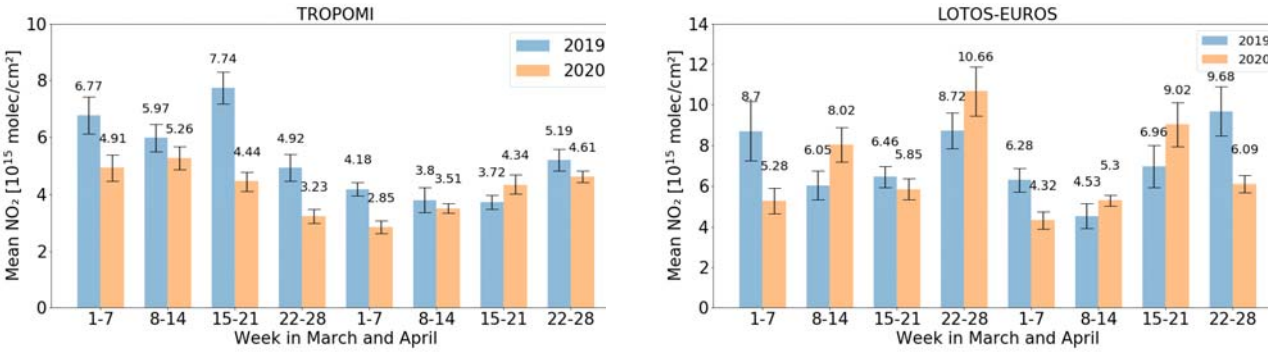

Figure 3. Weekly mean TROPOMI (left) and LOTOS-EUROS (right) tropospheric NO_2 columns, in 10^{15} molecules/cm^2 for Athens.

4. CONCLUSIONS

In this work, Sentinel-5P/TROPOMI tropospheric NO_2 observations were studied in order to examine the possible positive effect on Greek air quality caused the recent COVID-19 pandemic lockdown. The time period between March and April 2020, and the equivalent weeks in 2019, were analyzed and compared for six, largest in population, cities in Greece. In order to eliminate the expected meteorological effects on the observed NO_2 levels, Chemical Transport Modelling simulations, provided by the LOTOS-EUROS CTM, show that the magnitude of these satellite-sensed reductions cannot solely be attributed to the difference in meteorological factors affecting NO_2 levels during March and April 2020 and the equivalent time periods of the previous year. Taking this factor into account, the resulting decline due to the COVID-19 related measures was estimated to range between 0% and -37% for the five largest Greek cities, with an average of -10%.

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THE COVID-19 PANDEMIC INITIAL OUTBREAK IN GREECE IN SPRING 2020. PUBLIC PERCEPTIONS AND BEHAVIOUR

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ABSTRACT

World Health Organization (WHO) has noted that the first lines of defense against infectious diseases, prior to the creation of an effective vaccine, are behavioral ones, besides pharmacological interventions. Especially in the case of SARS-COVID-19 (a new virus and infectious disease), it is of importance to conduct research to investigate the level of knowledge about the disease, perceptions of its severity, perceptions of the effectiveness of personal protective measures and information needs. This quantitative study was conducted in Greece during the initial outbreak in March-April 2020. It was based on a questionnaire structure proposed by the 'Effective Communication in Outbreak Management: development of an evidence-based tool for Europe' (2015) document and was conducted online. Results indicated a high level of knowledge regarding the virus, thus suggesting the efficacity of risk communication at the specific time frame. Levels of reported anxiety and perceived susceptibility were also elevated. Regarding the hand washing measure, participants appeared to both perceive it as beneficial as well as within their capabilities to apply it and with high intention to carry out the measure. Stated cues to action seem to indicate that internal motivating factors pertaining to the protection of others played a major role in adopting specific health preventative behaviors.

Keywords: questionnaire survey, vulnerability, covid-19, health belief model

1. INTRODUCTION

Pandemics have occasionally occurred over the past 300 years, affecting society as a whole on multiple levels including human health and wellbeing, healthcare systems and the economy[1]. Defence against infectious diseases, especially before a vaccine is created, depend largely on the behaviour of the general public, that must apply personal protective measures, along with pharmacological interventions in effect, as WHO has noted[2]. Those include simple but effective measures such as hand hygiene as well as mask wearing and social distancing. Personal perceptions play a crucial role in spreading, preventing, and controlling infectious diseases as they may influence preventative behaviors that individuals are willing and do engage in[3–5]. According to the Health Belief Model, a socio-cognitive model developed to study and predict health-related behaviors as well as design effective interventions, individuals are more likely to engage in specific health-related behaviors as a result of the interaction of multiple factors related to personal perceptions[6]. Especially in the case of SARS-COVID-19 (a new infectious disease), it is important to conduct research to investigate the level of knowledge about the disease, perceptions of its severity, perceptions of the effectiveness of personal protective measures and information needs.

2. METHODOLOGY

The study questionnaire was based on the structure proposed by Effective Communication in Outbreak Management: development of an evidence-based tool for Europe[7] and was conducted using an online

questionnaire through Google Forms software. Invitations to participate in the study were posted in online communities of the National and Kapodistrian University of Athens and social media accounts.
Socio-demographic questions included age, gender, occupational status, marital status, and educational level. Participants were also asked to indicate county of residency, whether they belonged to a high/low risk health group and whether they personally knew someone who has been officially diagnosed with SARS-COVID-19. Five questions explored knowledge regarding SARS-COVID-19 with response options true-false-do not know. A statement regarding official information about disease causation and occurrence of infection was then given. Following that, perception of seriousness of the disease and comparative perceptions of seriousness for other illnesses (flu, heart attack, bladder infection, diabetes, SARS-COVID-19) items required responses on a 5-point Likert scale (6 items). Nine questions pertaining to perception of susceptibility to the disease (as well as comparative perceptions) and extent of anxiety were also assessed on a 5-point Likert scale. Two items explored perception of efficacy and self-efficacy and one item intention to carry out the measure, on a 5-point Likert scale. Motivating factors to adopt the hand washing measure were listed and participants could choose up to three possible answers as well as completing an additional factor not included in the list. Information needs (3 items) followed a similar question format.
Prior to completing the questionnaire, participants were informed of the purpose of the survey, as well as its academic character, using an introductory note. The final questionnaires processed include those of 808 adults. The results presented refer to the completion of the questionnaire for the period from 19/03/20 to 15/04/20. It should be noted that a restriction on the movement of citizens has been in place since 23/03/20. 32.7% of the total sample completed the questionnaire after that date.

Table 1 The questionnaire of the survey

Question
Timestamp
Prefecture-Residence
Prefecture
Region
City/Settlemenet
Age
Sex
Family status
Education
Occupation
Disease COVID-19 is an inflammation of the lungs
SARS-COV-2 is the virus that causes the COVID-19 disease
COVID-19 always gives symptoms
COVID-19 can only be contracted once in a lifetime
There is a vaccine against COVID-19
COVID-19 can be prevented by good hygiene
How severe do you think the situation with the novel coronavirus is?
How serious would you feel your personal situation would be if you were to contract the following diseases in the coming year? [Flu]
How serious would you feel your personal situation would be if you were to contract the following diseases in the coming year? [Heart attak]
How serious would you feel your personal situation would be if you were to contract the following diseases in the coming year? [Bladder infection]
How serious would you feel your personal situation would be if you were to contract the following diseases in the coming year? [Diabetes]
How serious would you feel your personal situation would be if you were to contract the following diseases in the coming year? [COVID-19]
Do you think that you can contract SARS-COVID-19 in the coming year if you do not take any preventive measures?
Let's suppose there is a vaccine available for covid-19 and you don't vaccinate. How possible do you believe it is to contract COVID-19 during the following year?
Would you get vaccinated against SARS-COV-2?
Vaccines against contagious diseases provide protection for (whom)
How large do you think the chance is that you will contract the following diseases in the coming year? [Flu]
How large do you think the chance is that you will contract the following diseases in the coming year? [Heart attack]
How large do you think the chance is that you will contract the following diseases in the coming year? [Diabetes]
How large do you think the chance is that you will contract the following diseases in the coming year? [Bladder infection]
What do you think are the chances that you will contract COVID-19 during the following year?
How concerned are you about contracting SARS-COVID-19?
Do you consider yourself a highly vulnerable person against COVID-19??
Do you think the hygiene measures help prevent the

Question
spread of COVID-19?
Do you think that you will manage to carry out the hygiene guidelines?
Would you apply hygiene behavior as per official guidelines?
Why would you follow the hygiene guidelines?
What would you want to be informed about, concerning COVID-19?

Question
Who would you prefer to inform you?
Which medium would you prefer?
Would you comply to the "stay at home" guideline?
If you don't follow the "stay at home" guideline, that would be because... [reasons]
Has someone in your family or working environment been tested positive for SARS-COV-2?
Would you like to add any comment?

The population of respondents consisted of more women than men of age 18-44, with a BSc level of education or above (87%) and spread across all types of occupation (Fig. 1), coming mainly from Athens (63.4%) and Thessaloniki (8.6%), and 24% from other areas with COVID-19 cases, against 4% from areas of no reported cases. They state (79%) that they do not belong in a high risk group regarding the disease (against 17% stating the opposite and 4% not knowing). Only 1.8% stated they were aware of a COVID-19 case in their environment (family or work). Since -due to general lock-down- the survey was exclusively online, limitations regarding the sample are expected in the demographics.

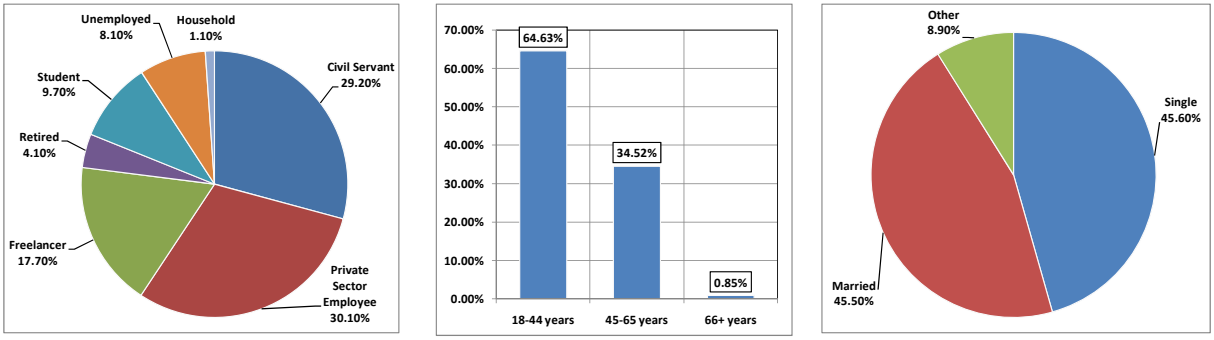

Figure 1. Occupation, age and marital status of respondents. Women were 61.2% of the sample. 1.3% of the sample have completed education stages below the compulsory level for Greece, 11.1% of the 808 people in the sample have a high school diploma, 41.9% of the sample have a higher education degree, 39.3% of the sample hold a Master's degree and 6.5% a PhD.

3. RESULTS AND DISCUSSION

Results indicated a high level of knowledge regarding the virus (except for the question regarding the existence of a vaccine), thus suggesting the efficacy of risk communication at the specific time frame. Although not in high risk groups by majority, respondents reported high levels of anxiety and perceived susceptibility. Regarding the hand washing measure, participants appeared to both perceive it as beneficial as well as within their capabilities to apply it. Similarly, the percentage of intention to carry out the specific measure was high. Stated cues to action seem to indicate that internal motivating factors pertaining to the protection of others played a major role in adopting specific health preventative behaviors (Fig 3). Respondents stated they would self restrict at home, by a majority of 94%. However, there were significant findings in the answer to why they would not follow the self restriction guidelines. Majority of answers relates to financial/professional reasons or psychological issues, but there were also answers relating to lurking perceptions in parts of society “Guidelines permit it”, “I do not believe in the size of the threat”, “God will protect me”, etc) that have a significant importance in the current context (second wave of the pandemic, with observed issues concerning discipline to restrictive measure mandates).

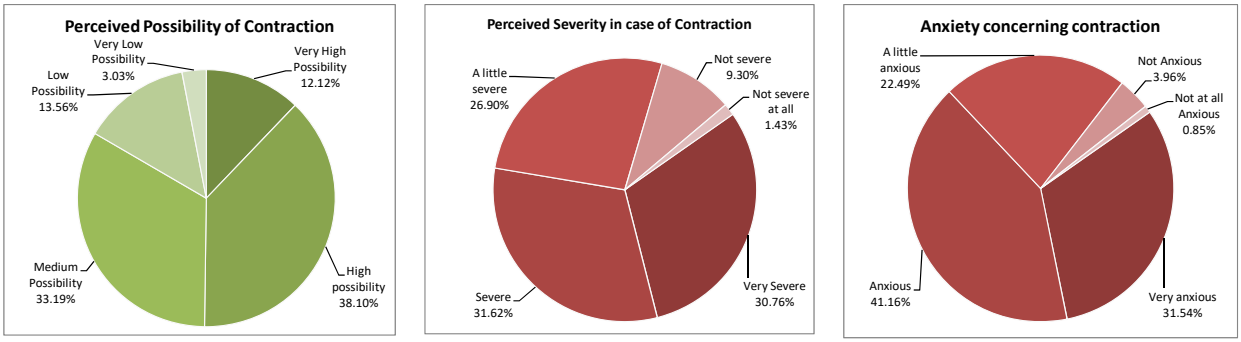

Figure 2. Responds on perceived possibility of contraction for the following year, perceived severity in case of contraction and anxiety for the possibility of contraction**.**

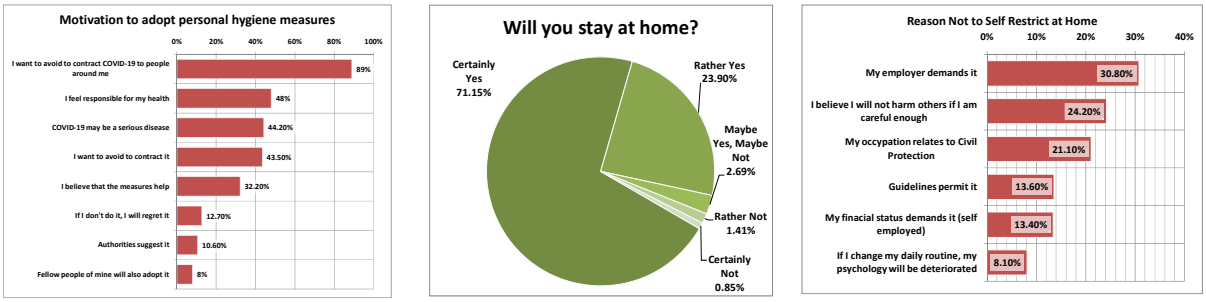

Figure 3. Responds on perceived possibility of contraction for the following year, perceived severity in case of contraction and anxiety for the possibility of contraction**.**

Data were further processed in the context of the Health Belief Model with regression analysis, to predict health preventative behavior as reported. First results indicate a strong influence of self efficacy and rather poor influence of demographic characteristics to behavior, which was rather characteristic of the ambience in the society during the initial outbreak in Greece, and also depicted in the above results.

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#MENOUMESPITI, #MENOUMEASFALEIS, #COVID19GREECE: THE ROLE OF HASHTAG'S LANGUAGE IN THE DISSEMINATION OF INFORMATION IN GREECE

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ABSTRACT
In the current setting of the COVID-19 pandemic people frequently find social media as a convenient way to express their opinions and concerns as well as either approve or criticize the ongoing reality (τεκτενόμενα). The article tries to investigate the role of the language (greek Vs english) of the Twitter hastags in the dissemination of the information during COVID-19, in Greece. With the use of Node Excel we have extracted official hashtags related to corona virus pandemic in greek(lish) and english, (#menoumespiti #menoumeasfaleis and covid19greece) and we compare the use of them. We proceeded with the construction of the semantic network using textual analysis, in order to reveal the relationships between ideas embedded in text. Visualization of the network reveals the centrality or clustering of certain ideas. This framework of study can prove very useful in opinion mining in social media users' opinion mining.

Keywords: Twitter, Social Media, Pandemic, Covid-19, Coronavirus

1. INTRODUCTION

As COVID-19 was spreading rapidly worldwide, the societies faced with social distancing measures, self-quarantines and travel bans. Although the role of social media as a convenient source of information in pandemic situations has often been criticized, the use of online platforms as a mean of communication about coronavirus pandemic increased.

2. OBJECTIVE

I
n this research, we seak to identify the role of the language of the Twitter hashtags in the dissemination of information to the public during the period the COVID-19 pandemic in Greece. More specifically, we compare the topics about the COVID-19 pandemic discussed by Twitter users in Greece and the main categories of their tweets' content in the period of March 2020 till August 2020. We also seak to find who tweets about Greek COVID-19 and how can they be categorized.

3. EXPERIMENTAL METHOD

With the use of Node Excel Pro we have extracted twitter posts in Greek, containing the following hashtags: #menoumespiti #menoume_spiti, #menoumeasfaleis #menoume_asfaleis, #covid19greece. We proceeded with the construction of the semantic network using textual analysis, in order to reveal the relationships between ideas embedded in text. Visualization of the network reveals the centrality or

clustering of certain ideas. This framework of study can prove very useful in opinion mining in social media users' opinion mining.

4. RESULTS

We explore posts in Greek containing the above five hashtags. These posts are categorized as tweets, retweets, replies and mentions. The tweets were posted over a seven month period from March 20/20 to September 20/20. The tag cloud visualizes the most frequent words in all tweets texts. Neglecting the words that are related to the hastags there are some words that are used mostly, such as: agapimena, smixoume, booklover, taxideuoume xana.

5. DISCUSSION

This research is a first step toward understanding the role of the language of the social media's hashtags in the dissemination of information to the public during COVID-19.

6. CONCLUSION

The language of the hashtags seems to have an important role in the dissemination of information during COVID-19 pandemic. While the greek(lish) hashtags remain very common in greek Twittersphere, it the the english hashtag that provide to the worldwide public the opportunity to directly communicate health information.

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THE PERILS OF EARTHQUAKE PREDICTION: A HISTORICAL AND EPISTEMOLOGICAL APPROACH

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ABSTRACT
In this presentation we demonstrate that non-technical and social factors have a prominent role in the risk assesment of natural hazards. We will do so by examining the scientific controversy around earthquake prediction. Earthquake prediction is a privileged case for studying scientific prediction because it is a hotly debated issue among scientists, and it is a field where the public comes face to face with scientific uncertainty. We study the earthquake prediction debate using the methodological tools of history of science, philosophy of science, and sociology of science. We see that the disagreements among scientists regarding earthquake prediction cover a whole spectrum of ontological, epistemological and methodological issues, and they cannot be resolved only by using technical argumentation.

Keywords: earthquake prediction, seismology, history of science, philosophy of science, sociology of science

1. INTRODUCTION

The historian of science and science studies scholar Naomi Oreskes [1], among others, has argued that many major questions in earth science research today are not matters of the behavior of physical systems alone, but of the interaction of physical and social systems. Information and assumptions about human behavior, human institutions and infrastructures, and human reactions and responses, as well as consideration of social and monetary costs, play a role in a whole range of issues that are related with the risk assessment of natural disasters. In light of Oreskes' thesis, risk assessments should include considerations of values, social costs, and other non technical elements. Experts in the humanities and social sciences should: a) demonstrate that an understanding of the social factors that have a prominent role in the risk assesment of natural hazards is of great importance for mitigating natural disasters, and b) ensure that the incorporation of social factors into "physical"models will take place in such a way that will result to reliable knowledge claims.
Seismology offers a privileged case for studying scientific prediction for two reasons. First, because it is a hotly debated issue among scientists, while the disagreements are not only about facts, but include questions concerning the values and presuppositions that scientists hold. Second, because earthquake prediction is a field where the public comes face to face with scientific uncertainty and the ways in which scientists come to grips with this uncertainty and make decisions that affect the broader society.

2. METHOD

The proposed presentation is based on original historical work informed by methodological and theoretical tools supplied by philosophy of science and sociology of science. Its subject matter is the controversy regarding earthquake prediction, and more specifically the VAN method, which took place in

Greece in the last four decades. Since the debate on the VAN method was part of a broader debate regarding erathquake prediction, I have examined, in addition to the work of Greek scientists, the views of scientists from the international scientific community.

3. RESULTS AND DISCUSSION

Our study of the case of earthquake prediction has led us to the following results.

The disagreements among scientists regarding earthquake prediction cover a whole spectrum of ontological, epistemological and methodological issues [2]. The situation becomes even more complex in the face of intense battles over what it means to have an earthquake prediction as such. This is the first issue I wish to address. Does 'earthquake prediction' mean the prediction of an earthquake a few days or weeks before its occurrence (short-term prediction)? Or does it mean the prediction of an earthquake a few years before it takes place (medium-term prediction)? Earthquake prediction encompasses short-term, middle-term, and long-term predictions: Short-term predictions are issued a few days to a few weeks before an earthquake occurs; medium-term predictions are issued a couple of years to at most a decade before an earthquake occurs; while in long-term predictions an earthquake is expected to happen decades after it has been predicted. Although this inclusive definition of earthquake prediction seems to be clear-cut, things are not quite so. Depending on their research agenda, scientists often advance diverging notions of prediction. There are scientists [3] who claim that only short-term prediction qualifies as earthquake prediction, since medium-term prediction is just a statistical estimate of the probability of the occurrence of an earthquake in a certain area. On the other hand, there are scientists [4] who support the view that short-term prediction is absolutely unfeasible, and the only sort of prediction that can be derived from scientific knowledge is medium-term prediction.

What we just mentioned is related to the following question: Which is the right strategy in the pursuit of earthquake prediction? In this question there are two possible answers. First: although it is widely acknowledged that earthquakes happen due to the movement of tectonic plates, there is not a coherent theory about what happens in the preparation phase of an earthquake and why an earthquake happens when it happens, and has the magnitude it has. So what is needed for achieving earthquake prediction is a better understanding of earthquakes as a phenomenon; in other words, what is needed is more basic seismological research. Second: For another school of thought what is required for effective earthquake prediction is knowledge of reliable precursory phenomena. A better understanding of the phenomenon is welcome, but it cannot provide a solution to the problem of earthquake prediction. As Sheila Jasanoff [5], a prominent science studies scholar, has put it: "In technically grounded controversies in the policy domain, the central question most often is what is going to count as relevant knowledge in the first place; who possesses the right sorts of knowledge is secondary". Each of the strategies that we just presented is related to different kinds of "relevant knowledge". In the first case, the relevant knowledge is provided by seismological research; while, in the second, it is provided by a search for reliable precursory phenomena.

Another question we would like to address is the following: When is an earthquake prediction considered successful? In [6] I have shown that the answer to this question in not unambiguous. I reached this conclusion by studying the VAN method, a method of short-term earthquake prediction that was proposed by three Greek scientists (Varotsos, Alexopoulos, Nomicos). For two decades, the VAN method was the major focus of a wider controversy around the feasibility of short-term earthquake prediction [7, 8]. This made it the subject of intense evaluation efforts [9, 10]. In the course of those efforts the scientific community confronted the fact that the available conceptual, methodological, and technical tools did not suffice for the evaluation of the VAN method; and this is true for all the methods of earthquake prediction that have been proposed until now.

A further major issue is the predictability of the earthquake phenomenon. As we saw in the previous section, the level of predictability of a phenomenon can be a contested issue, as the values endorsed by scientists often influence the position that they adopt on this issue. The predictability of earthquakes is entangled with the very definition of prediction. For the proponents of medium-term prediction earthquakes are predictable in the medium-term, but non-predictable or even unpredictable in the short-term. Furthermore, there are scientists who believe that the earthquake phenomenon is totally unpredictable. This issue has serious implications about the role that seismology can play in public policy regarding the mitigation of earthquake hazards.

Most of the above mentioned problems are related to the central issue of accuracy. A crucial question is the following: Accuracy for what purpose? Earthquake prediction is more than an intellectual exercise. It is the solution to a problem that has severe social consequences. Not surprisingly, the opponents of earthquake prediction hold the view that if an earthquake prediction method is to be considered useful it must lead to the evacuation of populated areas. In this case mistakes are not allowed and the accuracy must be very high, as the evacuation of big modern cities is not an easy task and the social, economic, and political consequences of such an action are unknown. The proponents of earthquake prediction, on the other hand, know that there is no prediction method accurate enough to lead to the evacuation of populated areas. Rather, a credible prediction can help people to take measures of self-protection, and governments to be alert and take other types of measures, such as shutting down nuclear reactors. From this point of view, the accuracy of the VAN method is sufficiently high and the method can prove to be very useful.

4. CONCLUSIONS

Earthquake prediction is an extremely complex scientific problem that remains unsolved. Besides the physical and technical obstacles there are difficulties that are related to social factors that are at play not only in the broader community but inside the scientific community as well. The fields of history of science, philosophy of science and sociology of science can prove very useful in recognizing the social factors that are crucial for understanding what exactly the problem of earthquake prediction is and how it can be solved.

This presentation is part of a wider project on the history and epistemology of prediction in the physical sciences (http://perilsofprediction.gr/), led by Prof. Theodore Arabatzis.

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TOWARDS AN EARTHQUAKE EARLY WARNING AND REAL-TIME SEISMIC RISK ASSESSMENT SYSTEM FOR SCHOOL BUILDINGS

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ABSTRACT

The civil protection against earthquakes and other natural hazards is a subject of first priority, especially in Greece. Here, we briefly describe the main components of an innovative system for earthquake early warning and real-time risk assessment of school buildings against earthquakes, which has an open architecture to be directly extended for other critical infrastructures and natural disasters. This work is implemented in the framework of *SafeSchools* project, funded by the General Secretary of Research (https://safeschools.web.auth.gr/). The system combines data from the national broadband weak and strong motion networks, from on-site classical and new-designed sensors at school buildings, supported by appropriate software, to provide: (a) early detection of the incoming earthquake, in terms of magnitude and location (early warning), (b) automatic estimation of the seismic motion characteristics in target sites, (c) real time assessment of expected damage in school buildings, and (d) warning to selected end-users for the incoming event and the intensity of the expected damage. These estimations provide a timeline of few seconds in order to take critical safety measures for the humans (pupils, employees) and the infrastructure affected. At the same time, the system allows the monitoring and assessment of the real structural "health" and safety of the school buildings in case of future earthquakes, performing an advanced vulnerability evaluation. This innovative system is already installed and operable, at selected schools, in the city of Thessaloniki.

Keywords: Earthquake Early warning, Real-time risk assessment, Seismic network, Critical School buildings, Structure-specific fragility curves, Permanent and temporary instrumentation array

1. INTRODUCTION

Seismic risk mitigation is a complex task, which requires the cooperation of scientists, engineers and decision makers. In the last two decades, a new approach to the short-term risk mitigation has emerged, founded on the concept of earthquake early warning (EEW) systems. They are based on seismic networks that integrate rapid telemetry and automatic processing, in order to provide fast and reliable information on earthquake parameters (location, time and magnitude) and on the expected ground motion, supporting and improving the emergency response. Thanks to continuous theoretical and computational improvements, the reporting time of these systems has been reduced to few seconds after the earthquake initiation, making it possible, in certain conditions, to provide earthquake information and potential warning before the ground shaking has actually reached a certain target. If a rapid detection system is

implemented close to a seismogenic zone, an alarm can be issued to a distant region before the seismic waves actually hit the target. This concept is the basis of the so-called regional EEW systems, where data from a seismic network next to the epicentral are used to rapidly detect and locate an earthquake, determine its magnitude and predict the ground motion at a specified target, using ‘‘a priori’’ known, ground motion prediction equations. However, what really matters is not simply the knowledge of the magnitude and the location of the coming earthquake, but the actual damage to a target building or aggregate of buildings, which depend and on the actual vulnerability of the structures. *SafeSchools* is combining the two technologies, i.e. EEW systems and building vulnerability, to assess in real time conditions the real damaging potential and losses of an earthquake to a specific building. The *SafeSchools* system combines an early warning and a risk assessment tool. It is designed to address the early detection of the epicentre and the magnitude of the incoming earthquake; the automatic estimation of the seismic ground motion characteristics at a target site and the real time risk assessment of expected damage and losses in critical buildings. In this pilot implementation at schools units, providing early warning to selected end-users i.e. civil protection authorities and school administrators, for the incoming strong seismic event and the intensity of the expected damage and losses. This pilot system has been installed and is currently up and running at selected school units of Thessaloniki.

2. SAFESCHOOLS SYSTEM

2.1. Earthquake Early Warning modules

In the framework of this work, PRESTo (PRobabilistic and Evolutionary early warning SysTem) [1] software platform for regional earthquake early warning is utilized. PRESTo comprises several subsystems, integrated in a single, easy-to-manage execution. First, the inputs, i.e. the ground motion data and the end-user configuration data (including the seismic network description and velocity model), are defined. Ground motion data are normally streamed in real-time from the stations using a SeisComP server via the SeedLink protocol, or SAC files, in order to provide a simulation mode whereby waveforms of past events can be played back into the system.

Figure 1. Seismic network monitoring the broader area of Thessaloniki.

The vertical components of the data streams are continually analysed to detect P-waves arrivals. After arrivals at different stations have triggered a new event, a chain of modules produces a probability density function for location and magnitude based on recently developed algorithms. Each target site is promptly

informed of the most likely location and magnitude (and related uncertainties) and of the expected peak ground motion (PGA, PGV and I) it will experience in a few seconds. Following the time evolution of location and magnitude estimates, the computation of the expected peak ground motion using appropriate ground motion prediction equations (GMPEs), and of their uncertainties, is evolutionary as well, i.e. the parameters are updated whenever the estimates of location and/or magnitude change. The proposed EEW regional system is configured to include the unified national network of seismographs (http://geophysics.geo.auth.gr/ss/ethniko-diktyo_en.htm#1) as well as the accelerometric stations of the Research Unit of Soil Dynamics and Geotechnical Earthquake Engineering of the Laboratory of Soil Dynamics and Earthquake Engineering of AUTH (SDGEE, http://sdgee.civil.auth.gr/) of the broader area of Thessaloniki (Figure 1) and allows the continuous ground motion data flow.

2.2. Real-time risk assessment modulus

The proposed real-time risk assessment system for critical buildings, described in Figure 2, is based on the early detection of the expected peak ground motion using PRESTo and local soil conditions at the target site (e.g. school building), as well as the structural vulnerability of the building itself. The direct structural damages and human losses are then subsequently computed and, depending on the risk level, an alarm is issued few seconds before the onset of the strong ground shaking, enabling the initiation of automatic safety procedures. The vulnerability of the critical building is defined in terms of fragility curves or a single vulnerability curve. The former, express the probability of exceeding a certain damage state as a function of the seismic intensity while the latter provides the total damage index quantified in cost terms as the ratio of cost of repair to cost of replacement taking values from 0: no damage (cost of repair equals 0) to 1: complete damage (cost of repair equals the cost of replacement). The vulnerability of each specific critical building is evaluated combining through a comprehensive methodology, numerical analysis and field monitoring data, enhancing thus the reliability in the risk assessment procedure. Figures 3 and 4 present the setup of the monitoring systems installed in a school unit and the building specific fragility curves developed for this specific building. The assessment of the dynamic characteristics of the buildings, allowing the accurate evaluation of the fragility curves [2, 3], is made using ambient noise measurements recorded by a temporary seismic network deployed inside the buildings. The modal identification results are used to update and better constrain the initial numerical model of the building, which is based on the available design and construction documentation plans. Three-dimensional incremental dynamic analysis of the updated nonlinear model of the building is then performed to derive the fragility curves for the structure, in its present conditions. Structure-specific fragility curves and vulnerability curves are derived in terms of peak ground acceleration (PGA) (Figure 4). The derived vulnerability functions are inserted to the unified system to assess in real time the damage and losses of each critical building. In particular, based on the outputs of the EEW on the location of each building (i.e. the expected peak ground motion considering site effects), the system is able to estimate the expected damage level providing also a warning to the end users for the incoming earthquake event and the level of expected intensity and risk. The proposed system allows a timeline of few seconds in order to take critical safety measures for the building itself, the students and the employees, reducing in that way the expected seismic risk. At the same time, the system allows the advanced monitoring of the real structural 'health' and safety of the buildings in case of future earthquakes using a permanent instrumentation array consisting of digital high-precision accelerometers (ETNA2, Kinemetrics Inc.) and low-cost seismic instruments (Micro-Electro-Mechanical Systems - MEMS). The system is installed and operates in selected schools of Thessaloniki. This pilot application, a part of the obvious benefits for the specific buildings and the citizens, will allow the optimal design of an appropriate business plan for a successful extension and commercial exploitation of the proposed system, connecting research and innovation with entrepreneurship.

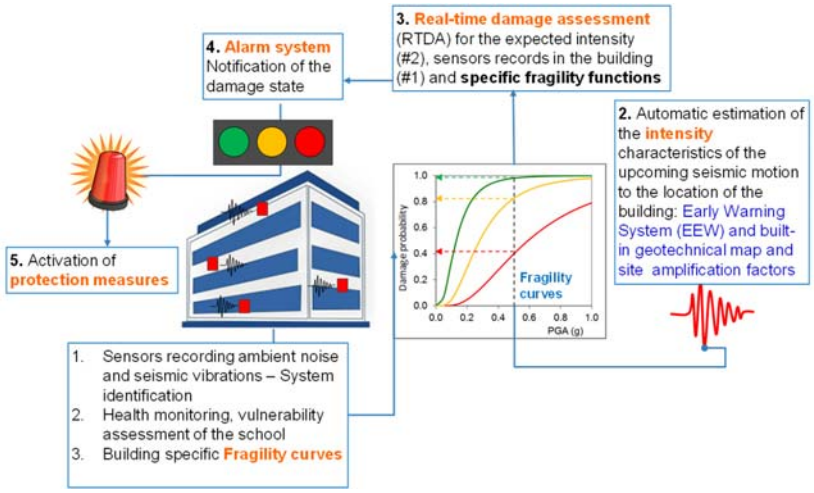

Figure 2. Real-time risk assessment framework.

Figure 3. Temporary (a) and permanent (b) seismic stations.

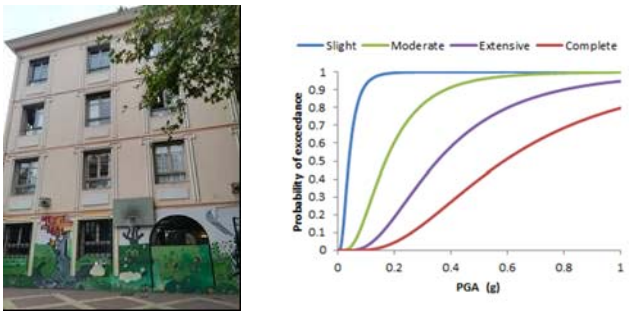

Figure 4. View of the 43d elementary school building (a) and derived building-specific fragility curves (b).

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NOWCASTİNG AN EXTREME FLASH FLOOD EVENT: THE CASE OF MANDRA, GREECE

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ABSTRACT
Severe hydrometeorological hazards such as floods, droughts, and thunderstorms are expected to increase in the future due to climate change. Due to the significant impacts of these phenomena, it is essential to develop new and advanced early warning systems for advance preparation of the population and local authorities (civil protection, government agencies, etc.). In very short time-periods (up to 6 h), small-scale phenomena can be described accurately by adopting a "nowcasting" approach, providing reliable short-term forecasts and warnings. To this end, a novel nowcasting system is presented in this study, combining a data assimilation system (LAPS), a large amount of observed data, including X-band dual-polarization (XPOL) radar precipitation measurements, the Chemical Hydrological Atmospheric Ocean wave System (CHAOS), and the WRF-Hydro model. The system is evaluated on a case study of the catastrophic flash flood event that occurred in the sub-urban area of Mandra in Western Attica, Greece, on 15 November 2017. The update of the simulations with assimilated radar data improved the initial precipitation description and led to an improved simulation of the evolution of the phenomenon. Comparison with flood data from the FloodHub Service showed that the nowcasting system could have provided reliable early warning of the flood event at least 1 hour in advance, giving vital time to the local authorities to mobilize and even prevent fatalities and injuries to the local population.

Keywords: nowcasting; data assimilation; flash flood; weather radar; LAPS.

1. INTRODUCTION

Reliable forecasts of extreme weather events at all scales, on high spatial and temporal resolution are of great importance to reduce the risks and mitigate the effects of natural disasters [1]. Various early warning systems have been developed for advance preparation of the population and local authorities (civil protection, governmental agencies, etc) to mitigate the effects of extreme weather. To this end, Meteoalarm system, designed to provide accurate information for advance preparation of severe weather impacts over Europe. The more recent Copernicus Emergency Management Service (EMS, regulation 377/2014) provides information for emergency response related to various types of natural hazards to human-made disasters. EMS also supports various prevention, preparedness, response, and recovery activities. Most early warning systems rely on advanced data assimilation models in which the state of the atmosphere is estimated through a combination of computer simulations and real time observations. The purpose of this process is to combine past knowledge of the system, in the form of conventional numerical weather model fields, and new information about the system, in the form of

current observations [2] to provide nowcasts. The term nowcasting describes weather forecasts in a very short time horizon, up to 3-6 hours ahead, on high spatiotemporal resolutions [3] and usually focuses on the estimation of precipitation. Precipitation can be measured either directly with the use of ground-based instruments (for example rain gauges) or indirectly with the use of remotesensing techniques like radar systems, Earth-observing satellites, TRMM (Tropical Rainfall Measuring Mission), and GPM (Global Precipitation Measurement).

This study presents a novel nowcasting methodology able to assess very short-term precipitation and discharge predictions in the case study of the catastrophic flash flood event that occurred in the sub-urban area of Mandra in Western Attica, Greece, on 15 November 2017. It is based on a complex combination of a data assimilation system with the Chemical Hydrological Atmospheric Ocean wave System (CHAOS) [4-6] currently including, among others, the WRF-Hydro version 3.0 model [7] as hydrological component. The data assimilation system uses CHAOS atmospheric forecasts as background fields assimilating various surface, upper air and remote sensing observations, so as to force WRF-Hydro, finally creating a "state-of-the-art", efficient, and reliable early warning system for hydrometeorological hazards [8].

2. MODELING SYSTEMS AND METHODOLOGY

In the morning of 15 November 2017, a severe thunderstorm caused a flash flood in the town of Mandra in Western Attica. Mandra is located 40 km west of Athens and is an industrial town, with a population of approximately 13,000 people. The town is located at the apex of an alluvial fan, formed by two streams at the western part of the Thriassio plain, which meet at the southeastern edge of the town to form a stream that ends at the Gulf of Elefsina. Agia Aikaterini, Soures and Sarantapotamos streams near Mandra are presented in Figure 1, in the context of the greater area. Human-induced morphological changes in Mandra, in combination with the high rainfall rate, played a key role in the triggering and evolution of the flood.

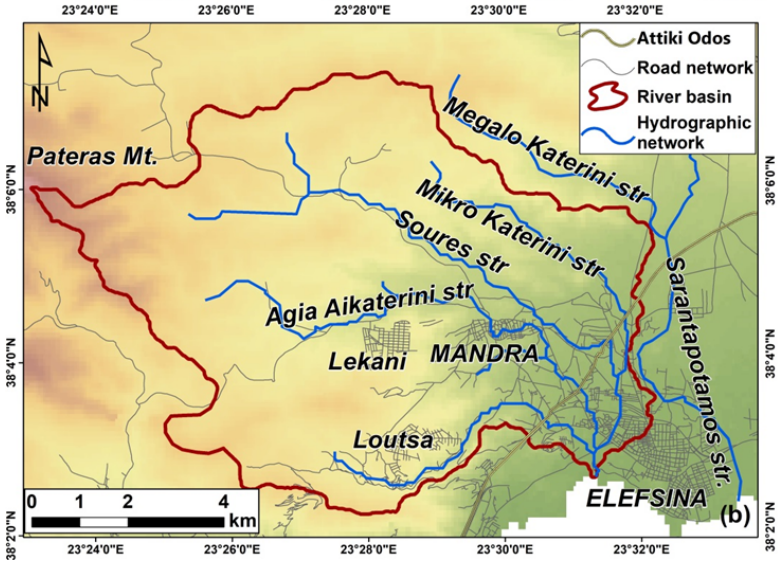

Figure 1. The main drainage basins include the Soures and Agia Aikaterini streams that pass through the buildings and roads.

The development of the early warning system presented here is based on the combination of highly accurate and reliable measurements, a well-known and established data assimilation system coupled with an advanced hydrometeorological model. NOAA's Local Analysis and Prediction System (LAPS) is a mesoscale assimilation system that combines diverse observations (in-situ measurements, remote sensing estimations and others) with background data to generate a spatially distributed, three-dimensional representation of atmospheric conditions [9]. Latest developments expand LAPS nowcast capabilities by utilizing a flexible forward-in-time advection scheme. LAPS is applied in nowcasting mode for the case study of Mandra (Figure 3), assimilating XPOL radar data with regional surface and upper-air observations on gridded model data to produce objective analyses alongside with their nowcasts in a 3-h forecast window. The soil and hydrological processes were simulated by the WRF-Hydro version 3.0 model, which is the hydrological component of the CHAOS modelling system. WRF-Hydro was configured on a domain covering the drainage basin of Mandra at the fine horizontal grid spacing of 50 m × 50 m.

3. RESULTS AND DISCUSSION

WRF-Hydro started on 15 November at 04:00 UTC, with a 4-h forecast window up to 08:00 UTC on hourly output increment, using hourly accumulated precipitation forcing from the LAPS advected fields, valid for 05:00 to 08:00 UTC. WRF-Hydro started one hour before because LAPS provides hourly accumulations for 05:00 to 08:00 UTC starting from 4:00 UTC in this case. As Figure 2a depicts, the LAPS analysis for the accumulated precipitation from 04:00 to 05:00 UTC indicated heavy rainfall at the southeastern slopes of the Pateras Mountain. The amount of rain led to significant discharges of 100–110 m^3s^{-1} in the Soures stream and 70–75 m^3s^{-1} in the Agia Aikaterini stream, at the time of the flood. The system was able to provide a very clear prediction, one hour, at least, prior to the flooding event, which is considered to be a significant time window for preparedness.

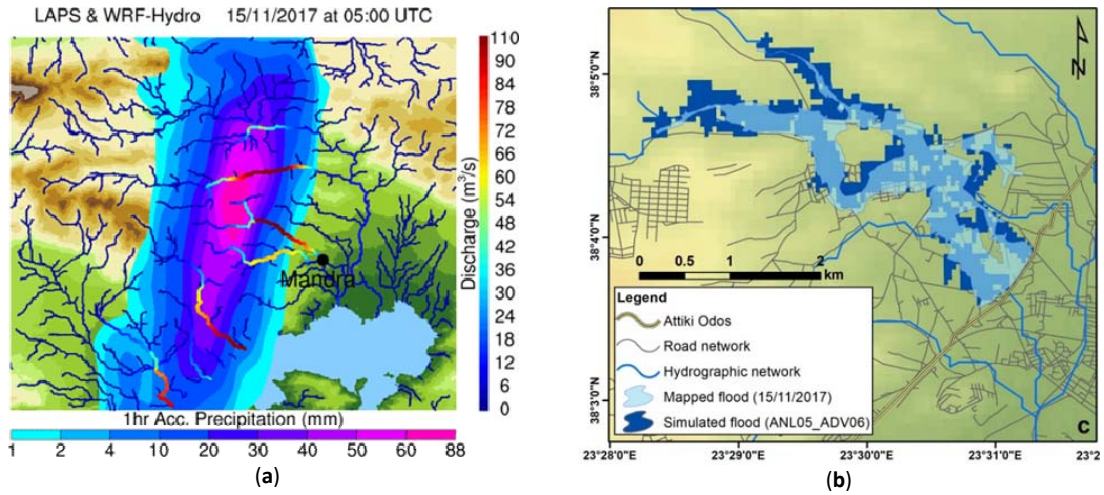

Figure 2. (a) LAPS-estimated 1-h accumulated precipitation for 04:00-05:00 UTC superimposed with the WRF-Hydro-simulated discharges at 05:00 UTC. Streams with order 4 or higher are presented here. WRF-Hydro started on 15 November at 04:00 UTC using hourly accumulated precipitation forcing from the LAPS advected fields, valid for 05:00 to 08:00 UTC. (b) Flood extent estimated using water level results of the WRF-Hydro simulation (in dark blue). Flood extent mapped by the FloodHub group of the BEYOND project is also shown in light blue.

Figure 2b demonstrates the maximum flood extent estimated using the water level results of the WRF-Hydro simulation for 06:00 UTC (dubbed ANL05_ADV06). A comparison was made at the flood peak, against the observed flood extent, taken from the FloodHUB service of BEYOND (Building a Centre of Excellence for Earth Observation based monitoring of Natural Disasters). Flood extent chart (Figure 2b) shows that LAPS-WRF Hydro system could have provided reliable early warning of the flood event at least 1-h in advance, giving vital time to the local authorities to mobilize and even prevent fatalities and injuries to the local population. It should be noted that the evaluation was restricted to the area upstream of the "Attiki Odos" highway and only the sixth-order streams were used.

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CELL BROADCAST MESSAGES AS PUBLIC WARNING SYSTEM IN GREECE AFTER MESSAGE, WHAT ?

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ABSTRACT

Citizens' Alert System (112 Greek P.W.S.) with cell broadcast technology is a reality. More than 10 local messages and more than 4 national messages already have been broadcasted.
The agitation generated after the first national cell broadcast message at 11th of March 2020 and the other two messages at the same month, was intense.
The evening, unknown, scary messages that were received on the mobile devices of the civils in Greek territory and the question "why did I receive this message or messages?" were the main topics on social media for several days. as well as the wonder of some others who never received them.
The objective of the research that was conducted was primarily to highlight the issues and malfunctions of the new public warning system, presented during the three broadcasts in March 2020. We dare to collect the feedback that should have been collected by the institution transmitting the broadcasts.
The research was conducted in a form of a questionnaire, created in Microsoft Forms.
Summarizing the result of the questionnaire for all three broadcasts, we can observe the acceptance of the method from the general public, but we can also see quite big percentage of civilians that haven' t received a message or messages.

Thematic Area: Public Warning System

Keywords: Cell Broadcast Message (C.B.M.) in Greece, Public Warning System (P.W.S.), Protective Action Initiation (P.A.I.) Time.

1. INTRODUCTION

Two years ago, to SafeKozani 2018, we have presented a new method of public warning system, that of cell broadcast [1], which had already been used in many countries worldwide. In Greece there was the necessary infrastructure, but the application of the method was delayed. Today after the two civil protection trial broadcasts in 12th of July 2019 in Marousi, Athens and on the 31st of July 2019 in Syros Island, over 10 local and 4 national broadcasts had been transmitted. After the first national broadcast on 11th of March 2020 there were various reactions received from the civilians, such as anxiety, fear and even terror in some cases. Moreover, many of them never received the message. Let' s not forget that except from the two areas where the trial and the first real broadcast was transmitted in Attica (2), no one else in Greece had ever received a similar message.
The two following messages from civil protection were those5 transmitted in a national scope, which were transmitted in a short time compared to others, on 17th and 22nd of March 2020 specifically. The issue of the non-received messages by a lot of civilians was still there, although the reactions of those who received it started to get milder.
According to Christos Komninos and Paraskevi Soulopoulou [2], civilians should be trained on how to use and get used to the new warning system, but that never happened. The opportunity to collect feedback was given when the three national wide broadcasts were transmitted on 11th, 17th and 22nd

of March 2020. The truth is, that we hoped civil protection would take an advantage of this opportunity and collect feedback. The former wasn't achieved, so we decided to do so.

2. OBJECTIVE

After each broadcasted message on March 2020, the most basic question was "…why didn' t I receive the message?". So, as our first objective we set finding out how many people received these messages, how they felt and how they reacted when they received the messages.
As a second objective we recorded citizen's opinion about the cell broadcast messages and their suggestions on the new public warning system. Then we had to compare the results with the results of an earlier questionnaire by Paraskevi Soulopoulou [3]. Finally, we tried to make our first attempt to search for correlations between the variables of the questionnaire looking for the reasons for not receiving the messages.

3. RESEARCH

3.1. Experimental method

The experimental method used belongs to the category of quantitative – descriptive research and It was conducted in a form of a questionnaire. The results were downloaded to an Excel file, where some micro-interventions were made to the data, so that we can process them in SPSS.

3.2. Questionnaire

The questionnaire titled entitled "Σύστημα Συναγερμού Πολιτών (ΣΥ.Σ.Π.) στην Ελλάδα / Public Warning System (P.W.S.) in GREECE" created with Microsoft Forms in Greek and English language and posted on the link https://forms.office.com/Pages/ResponsePage.aspx?id=DQSIkWdsW0yxEjajBLZtrQAAAAAAAAAAAAZAAJqScKhUQlBJNVhKV0xQMlhINUdFWDFNV1FOTjA3WC4u from 10th of May 2020 until 24th of May 2020. Our goal was to collect a respectable number of responses from people with disabilities, but our efforts did not work out.
We received 509 replies with an average response time of 05:56. The evaluation of the questionnaire was 4.27/5.00.
With the calculator.net, we found out the margin of error 5.16 (Confidence Level: 98%, Sample Size: 509, Population Proportion: 50% and Population Size: 11,000,000). This means, in this case, there is a 98% chance that the real value is within ±5.16% of the measured/surveyed value (4). Please note that the questionnaire was anonymous (without name and e-mail).

4. RESULTS

4.1. Percentage of received messages

It is impressive the similarities of all three messages (chart 1).
We note that about one in three citizens (i.e. from 28 to 38 citizens out of 100 if we calculate the error range about of ±5%) had not received the message. The percentage is extremely high and require special attention and research.

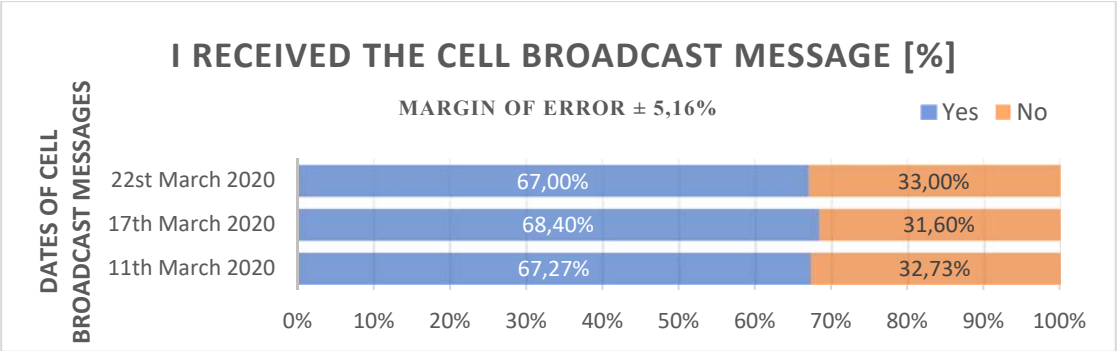

Chart 1: The [%] of received of the messages on 11th,17th and 21st of March 2020 in Greece

4.2. P.A.I. Time

There is almost a delay between receiving an emergency alert from the citizen and initiating protective action. This time difference is known as protective action initiation time (P.A.I.).
An important area when searching for the design or improvement of an P.W.S. message is intended to shorten this period of time [4].
So, in the questionnaire we tried to capture the P.A.I. time (chart 2[A]) and citizen's feelings after every message (chart 2[B]). As we can see, while citizens gain experience in cell broadcast messages, the P.A.I. time starts to improve. Also, we noticed that the feelings of horror and stress have a downward trend. However, there is an increase in the feeling of indifference, a negative factor for a public warning system.

4.3. Citizen' opinion

Citizens were asked «What I feel about C.B. message». They believe are useful, but only one in two think they need to be trained. (chart 3).
According to Paraskevi Soulopoulou [3], at September of 2018 people believed that they must be informed and often trained at the new P.W.S. (86.14%) and the C.B. messages are useful (>80%).

4.4. Reasons for not received the C.B. messages

One of the reasons that the 30% of the citizens did not receive the c.b. messages is the mobile devices. Our model explains 4% of the volatility (receiving messages – mobile's brand). We' re in search of more correlations.

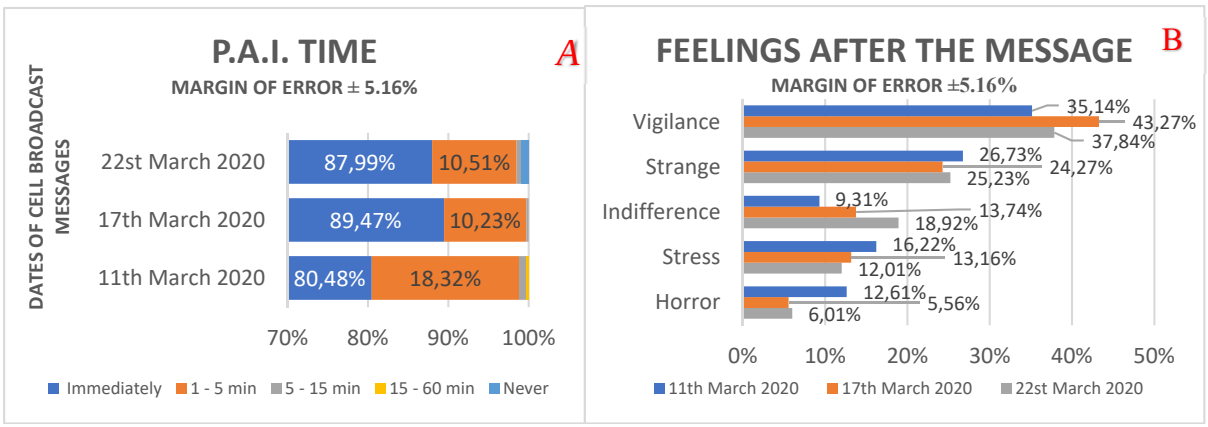

Chart 2: [A] The P.A.I. Time of the messages and [B] Feelings after the messages on 11th,17th and 21st of March 2020 in Greece

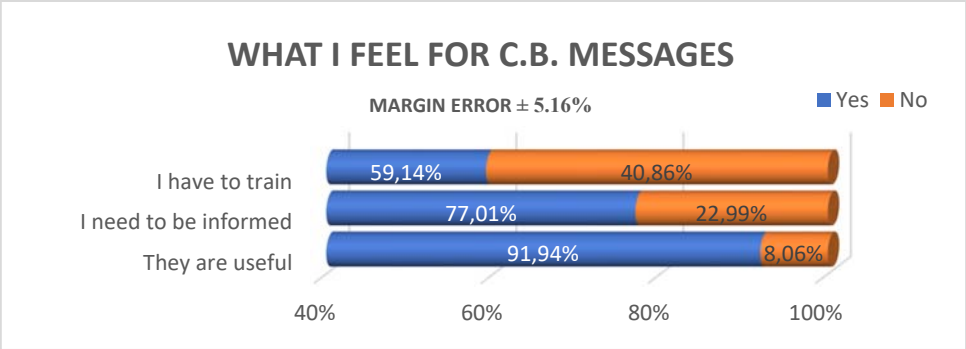

Chart 3: Citizen' opinion about C.B. messages in Greece (March of 2020)

5. CONCLUSIONS

The two main problems at the Greek public warning system messages are:

1. Very high P.A.I. time
2. The small percentage of messages received by citizens

To start with, we should focus on the immediate training and continuous education of citizens, paying great attention to the citizens' feedback through questionnaires [1] at the civil' s protection web page, as in crisis.nl, Dutch civil' s protection web page [6].

As far as the second problem concerns, we should study, each feedback's questionnaire, whereby asking the appropriate questions, that will give us the factors that greatly affect the reception of c.b. messages. Such can be mobile's firmware, the geographical coverage of mobiles' phone antennas etc. What we can say for sure is that we are still at the beginning. Small and steady steps need to be taken to make the new p.w.s. The Netherlands took about 10 years to perfect it.

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ESTABLISHMENT OF A TRANSNATIONAL CIVIL PROTECTION EARLY WARNING SYSTEM IN ADRION TERRITORIES: PROJECT "TRANSCPEARLYWARNING"

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ABSTRACT

The project with the acronym TRANSCPEARLYWARNING ("Establishment of Transnational Civil Protection Early Warning System to improve the resilience of ADRION territories to natural and man-made risks") aims at further harmonisation of Civil Protection Early Warning systems in ADRION regions so as to increase the level of prediction, forecasting, alert and response to risks and at improving information exchange and coordination with the EU Civil Protection Mechanism. To this end: a) it employs an innovative and holistic networking approach supporting the whole system of Civil Protection, with a lever effect also after the end of the project activities, b) it keeps open real-time update channels on risk occurrences by collecting and using information provided, and c) it implements a Raising Awareness intervention regarding emergencies.

Change to the current situation is pursued through the promotion of homogenization among early warning legislation, regulation and processes, the reinforcement of coordination and cooperation of ADRION Civil Protection authorities and the establishment of ADRION Early Warning Platform, and convergence of civil protection in IPA countries to EU Civil Protection standards by transferring experiences and lessons learnt.

Keywords: emergency evacuation, organised preventive population displacement, Greece

1. INTRODUCTION

Early warning for civil protection is in many respects a challenging endeavour [1]. At a great extent, it is based on scientific knowledge on hazard forecasting and prediction which has need of accurate, appropriate and timely data and is still faced with much uncertainty at least for some hazards. It employs ICTs of various sorts among them monitoring tools, decision support systems and information visualisation, in order to make the most of the available scientific information. It relates with risk communication that besides the technical aspects has noteworthy human, cultural and social dimensions that are context dependant. It may have significant economic and geopolitical consequences. It calls for legal, regulatory and institutional arrangements and raises matters of legitimacy and liability especially in case of false or no alarm or inadequate warning. It falls within the formal responsibilities of civil protection and other administrative structures but also involves stakeholders from the public sector, the private sector and the civil society, including the general public.

Given the range of technological, historical, organisational and legal, political an economic, international, cultural and societal factors affecting early warning [2], it is not surprising that legislation, regulations and procedures concerning early warning and also systems and technologies in place in different countries present considerable disparities and early warning is more advanced in some countries and regions than in others [3].

2. THE PROFILE OF TRANSCPEARLYWARNING PROJECT

Starting from ADRION countries and regions, TRANSCPEARLYWARNING project targets to enhance the level of uniformity, homogeneity and similarity of existing Civil Protection Early Warning systems, efficiently integrating them to predict risks, issue alert levels and improve exchange of information with EU CP Mechanism. More specifically, the project aims at increasing the cooperation level among National Civil Protection institutions throughout the entire lifecycle of natural and man-made risks from early warning to relief assistance and better ensuring urgent responses by EU Civil Protection Mechanism, when requested. This translates into increasing the overall capacity of ADRION Civil Protection Organizations to transnationally operate in tackling natural and man-made disasters in a territory as politically fragmented as Adriatic Ionian basin, reducing the exposure of the populations to the impact of hazards and increasing the overall readiness of Civil Protection authorities and communities to respond to hazards in a timely and efficient manner.
The project is funded in the framework of INTERREG ADRION Programme, Priority "Sustainable Region". ADRION covers eight Partner States, of which four are EU Member States (Croatia, Greece, Italy and Slovenia), three are candidate countries (Albania, Montenegro, Serbia) and one is a potential candidate country (Bosnia and Herzegovina). A total of 11 partners from 7 countries, coordinated by the Region of Molise (Italy), contribute to it (Figure 1).

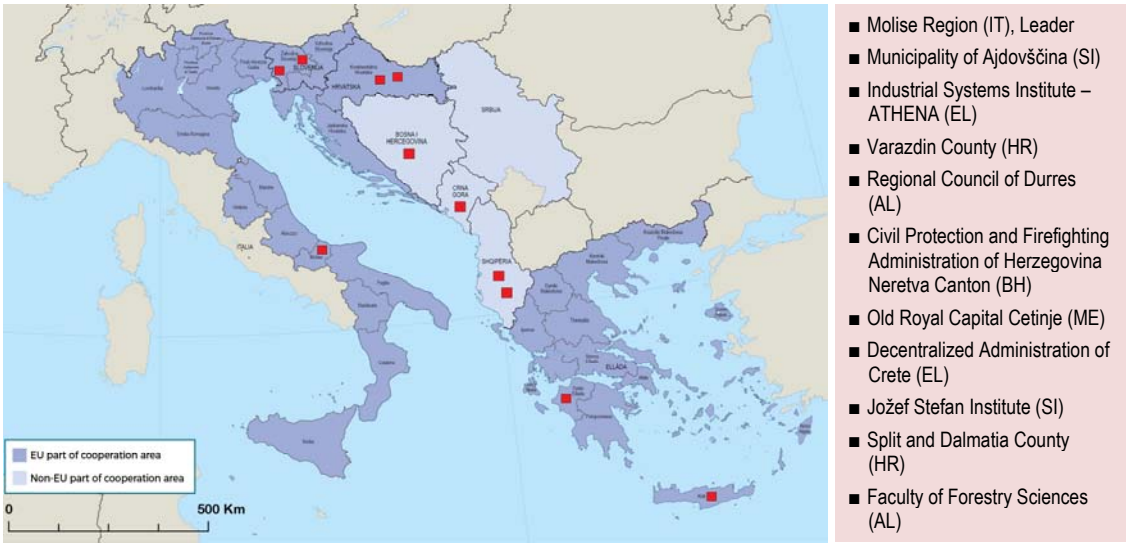

Figure 1. The partners in TRANSCPEARLYWARNING project and their countries of origin

3. OBJECTIVES AND METHODOLOGY

The overall objective of TRANSCPEARLYWARNING project is to increase cooperation level among national civil protection institutions in addressing natural and man-made risks right from the early warning stage and better ensuring EU Civil Protection Mechanism intervention. This is targeted through: an innovative and holistic networking approach with a lever effect also after the end of the project activities supporting the whole system of Civil Protection; keeping open a real-time update channel on risk occurrences by collecting and using information provided; the implementation of a Raising Awareness intervention of emergencies. Change to the current situation is expected through the promotion of homogenization among early warning legislation and processes, the reinforcement of

coordination and cooperation of ADRION Civil protection chains of command and control, and convergence of IPA CP operation to EU CP standards by transfer of experiences and lessons learnt. The following three interrelated objectives are set.

The first objective is to promote the harmonization of early warning current legislation, regulations and procedures among ADRION Countries by increasing their level of uniformity and similarity. To this end the current early warning civil protection legislation, regulations and procedures in all participating countries will be examined so as to identify potential adjustments necessary to increase their overall level of efficiency and to detect areas for potential enhancement of the operational civil protection early warning models by the introduction of new technologies. At the end of the project, all the above will be made available to all ADRION National and Regional Civil Protection institutions so as to become a uniform legislative and regulatory basis in line with the EU principle of co-operation and subsidiarity.

The second objective is to reinforce the coordination and cooperation of CP chains of command and control in early warning among ADRION countries. For this the project establishes the Adrion Early Warning Platform, a semantically enriched web enabled platform, which allows for the collection and sharing of heterogeneous data from different data sources of existing early warning risk management systems and networks and for issuing alarms based on appropriate thresholds so as to trigger the preparedness or response system of all involved ADRION Civil Protection Authorities and Operational Centres through making available to the CP chain of command and control the same risk scenarios at the same time and in accordance to the early warning legislation and regulations of each country.

The third objective is to promote the EU Civil Protection standards among CP Institutions of IPA countries[1]. To this end the project will promote the transfer of experiences, lessons learnt and best practices from EU member states that have already achieved or are on the way to achieve, a good level of integration with EU standards and complementarity with EU Civil Protection Mechanism to IPA Countries (associated or not with the EU Civil Protection Mechanism) that have started recently on this path. EU best practices can help to leverage the IPA area to a different status with reference to forecasting and prediction of hazards and specifically Early Warning. Aiming at a uniform and effective overall civil protection, the project will facilitate this transfer by organizing and directly carrying out peer reviews, capacity building interventions and conferences in the involved IPA Countries by ERDF (European Regional Development Fund) partners.

4. EXPECTED OUTCOMES

The main project outputs include a Civil Protection Early Warning Model, a Civil Protection Early Warning System and a Civil Protection Early Warning System Strategic Outline.

Civil Protection Early Warning Model represents a conceptual model for the homogenization of different early warning processes, legislation frameworks and systems existing in ADRION area. This conceptual model will provide the knowledge necessary to elaborate the second output, the Civil Protection Early Warning System.

Civil Protection Early Warning System is a joint system of rules, processes and a semantically enriched web enabled platform that allows Civil Protection authorities of the EUSAIR countries to coordinate and cooperate in monitoring emergencies and issuing alerts, in addition to their participation in the EU Civil Protection Mechanism. There is commitment of the research partners assigned with the development of the system to maintain the platform well after the project end integrating it in their portfolios. Furthermore, the Civil

[1] More on IPA (Instrument for Pre-Accession Assistance) at:
https://ec.europa.eu/regional_policy/archive/thefunds/ipa/index_en.cfm

Protection Early Warning System is expected to be further used since effort will be placed in incorporating it into Civil Protection regional and national legislation and regulations.
The Civil Protection Early Warning System Strategic Outline is a set of policy recommendations for more efficient, harmonized and homogeneous civil protection early warning regulatory frameworks (legislations and operational rules) that accompanied by an adoption plan, will indicate to Civil Protection Departments/Directorates and national/regional policy makers' bodies the path towards its progressive adoption. A Memorandum of Understanding is expected to enhance their commitment to pursue policy change in the area long after the end of the project.

Figure 2. The logo and the website of the project TRANSCPEARLYWARNING

TRANSCPEARLYWARNING is scheduled to run from March 2020 to August 2022 therefore it is at its initial stage. The kick-off Meeting took place online on September 17 and 23, 2020. More information on its progress and results can be found at the project's website (Figure 2) at: https://transcpearlywarning.adrioninterreg.eu/.

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EXPLORING DEFORMATION PATTERNS OF THE METHANA VOLCANO IN GREECE USING COPERNICUS SENTINEL-1 MTINSAR, GNSS/GPS AND SEISMIC DATA

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ABSTRACT

The Methana volcano in Greece belongs to the western part of the Hellenic Volcanic Arc, where the African and Eurasian tectonic plates converge at a rate of ~30 mm/year. The peninsula is composed mainly by Late Pliocene – Pleistocene andesitic and dacitic lava domes. Volcanic activity in Methana lasted until 1700, when a submarine eruption occurred north of Kameni Chora. Present day active geothermal springs are reported mainly in the eastern and the northern part of the peninsula. The broader region is dominated by NE–SW normal faults, whereas N–S, E–W and NNE–SSW striking normal faults are also recognizable in the area, and characterized by low seismic activity, chiefly with shallow events. This study aims to detect surface deformation in Methana based on a long stack of 99 Sentinel-1 C-band Synthetic Aperture Radar (SAR) images acquired along ascending track 102 in the period 3/2015 to 8/2019. A Multi-Temporal Interferometric SAR (MTInSAR) processing approach is exploited using the Interferometric Point Target Analysis (IPTA) method. Satellite Geodetic data (GNSS/GPS) from permanent stations (2 sites) and benchmark surveying (measuring period 2006-2019) are used as reference to calibrate the MTInSAR data analysis, as well as to validate MTInSAR results accuracy. MTInSAR and geodetic results are combined with geological, seismological and geomorphological data, to better understand the observed potential ground deformation patterns and trends.

Keywords: *MT-InSAR, ground deformation, volcano monitoring; GNSS, seismicity*

1. INTRODUCTION - OBJECTIVE

The Methana peninsula is the westernmost dormant but geodynamically and hydrothermally active volcanic system of the south Aegean volcanic [1]. The peninsula is connected with the north-eastern coast of Peloponnesus by a narrow gooseneck-shaped isthmus and stretches for approximately 44 km^2 northward into the Saronic Gulf (Figure 1).

The objective of this study is to explore the deformation patterns of the Methana Volcano, using MTInSAR, GNSS and seismicity analysis.

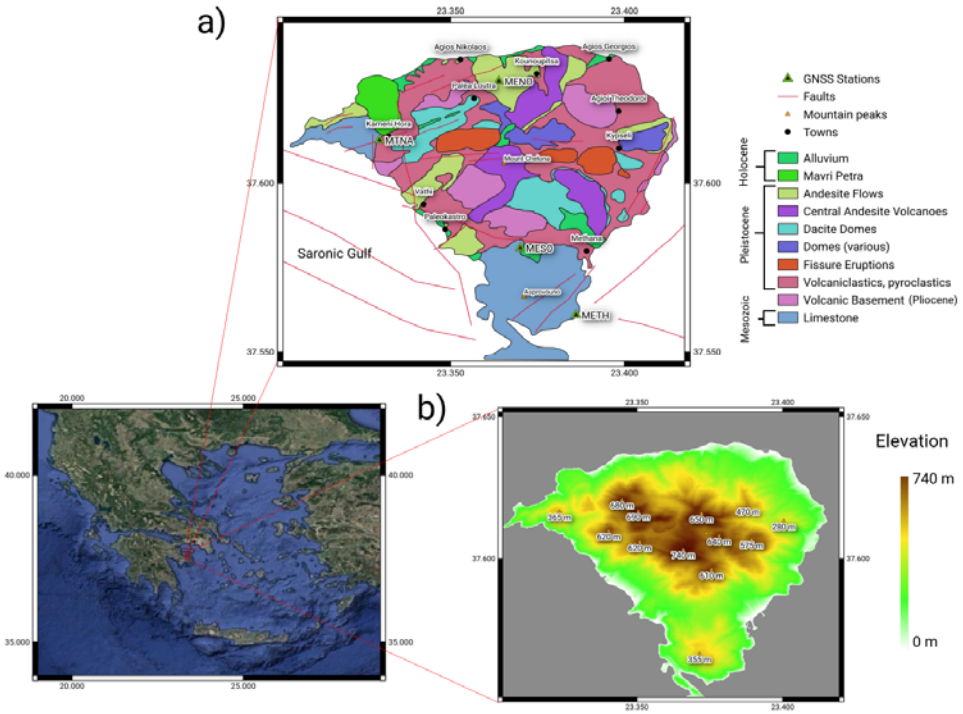

Figure 1. (**a**) Simplified geological map of the Methana peninsula, Greece (modified after [2-4]) and (**b**) topography from 5.5 m resolution digital surface model by the Hellenic Mapping and Cadastral Organisation.

2. EXPERIMENTAL METHODS

2.1. SAR Data and Multi-Temporal InSAR Processing

99 SAR scenes acquired by the Copernicus Sentinel-1A and Sentinel-1B satellites in ascending mode (relative orbit 102), covering the time period from March 2015 to August 2019, were used. The stack was processed using an advanced MT-InSAR approach, an extension of the Differential InSAR (DInSAR; e.g., [5,6]) technique, based on the phase comparison of multiple SAR images and allowing estimation of land deformation along the SAR sensor line-of-sight (LOS) direction with up to millimetre precision (e.g., [7]). MT-InSAR methods exploit either Persistent (PS) or Distributed (DS) Scatterers.

2.2. GNSS Continuous Monitoring Data and GPS Benchmark Surveying

A small network of two benchmark stations was established in 2006 in Methana (Figure 1) [8]. These two stations were part of a larger GPS network in the north-western part of the Hellenic Volcanic Arc (including the island of Aegina and the volcanic area of Susaki) aiming to study the ground deformation of this area. The stations in Methana were located in the northern (MENO) and southern (MESO) parts of the peninsula and were reoccupied several times up to December 2019. All measurements took place approximately within the same period of the year (usually late October to December) in an effort to minimize seasonal phenomena.

In early 2015, a continuous GNSS (cGNSS) station was also established in the Lygourio (LYGO) close to Methana peninsula as part of the HxGN SmartNet (https://gr.nrtk.eu/), that, ever since, has acted as local reference station. In addition, since August 2019, cGNSS data were available from a station (MTNA) located in the western part of Methana peninsula as part of the GNSS network of the Institute of

Geodynamics, National Observatory of Athens (NOA). Horizontal velocity results from two more cGNSS stations were also available from the National Technical University of Athens (NTUA), i.e., station METH installed in 2004 in the southern sector of Methana peninsula, and from [9], i.e., station 010A located to the south-east of Methana peninsula, at Poros.
The available 30-s data from the two cGNSS stations (i.e., LYGO and MTNA) that were included in this study were processed separately on a daily basis together with several other cGNSS stations located in Greece as part of a regional network.

2.3. Seismological Data and Processing

The seismological data were obtained from the seismological laboratory of the National and Kapodistrian University of Athens (NKUA; http://dggsl.geol.uoa.gr/en_index.html), and divided into two time periods. The first one coincided with the time period that the GNSS data cover, i.e., January 2006 to August 2019, while the second period covered the time span of the interferometric processing, i.e., March 2015 to August 2019.

3. RESULTS AND DISCUSSION

Aiming to better define the local deformation in Methana peninsula using GNSS data, the regional velocity vector (as it was estimated in LYGO cGNSS station) was subtracted from the two local GPS benchmark stations. The more evident differential behaviour between the northern (MESO) and the southern station (MENO) is evident in the vertical component with the southern station exhibiting noticeable subsidence. The GPS displacement vectors were used for validation and calibration of MT-InSAR results.
MT-InSAR processing resulted in 4769 PS targets and 6234 DS targets (Figure 2). Most of the targets are located at low altitudes (up to ~100–150 m for PS and up to ~350–400 m for DS), where there are urban settlements, and also on geological formations which exhibit high coherence, such as volcanoclasts. PS targets have a coherence greater than 0.70, while the DS have coherence greater than 0.79.
The observations from the Seismic Data Analysis show lack of strong seismic events (Mw > 4) or intense seismicity in the area of Methana in 2015-2019, therefore the observed ground deformation could not be associated with the recorded seismicity. In-depth interpretation and outcomes from the MT-InSAR, GNSS and sesmic analysis are described and discussed in the full research paper [10].

4. CONCLUSIONS

Based on the integrated data analysis, the general conclusion is that the ground motions observed are compatible with the anticipated “low” volcanic activity of Methana. Although the volcano does not show clear signs of activity in recent years, it is a hotspot of potential concern given that it is adjacent to very high-density population areas, including Athens and the surrounding major towns. The interpreted low level of activity is clearly the initial baseline above which further investigations need to be conducted.

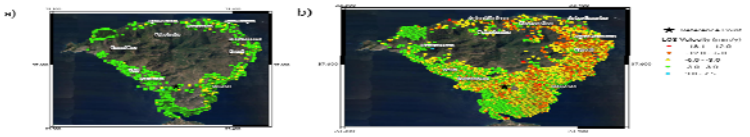

Figure 2. Line-of-sight (LOS) deformation velocity in 2015–2019 from the Multi-Temporal Interferometric Synthetic Aperture Radar (MT-InSAR) analysis for the (**a**) Persistent Scatterers (PS) and (**b**) Distributed Scatterers (DS) datasets, overlapped onto satellite optical imagery (©2020 TerraMetrics,©2020 Google). Source: [10].

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NATURAL DISASTERS: APPLICATIONS FOR ONLINE MONITORING IN ORDER TO ON TIME FORECASTING AND EARLY WARNING

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ABSTRACT

According to the annual survey carried out by Swiss SIGMA[1], of the disasters that took place in 2019, the natural ones were the main and largest. In addition, the decade 2010-2019 was the warmest. From the natural disasters[2], Hydrometeorological and Geological cause the largest economic disasters, while as the history data shows, these disasters have doubled during the last five years. Natural phenomena that cause these disasters could not be avoided of course, but with the latest technology development it is now possible for many disasters to be detected early enough so that they can be better managed. Careful planning and forecasting these phenomena, along with real-time monitoring, authorities can certainly reduce the catastrophic consequences. Technological evolution in computer science, as well as telecommunications introduce new trends in forecasting, monitoring with the use of sensors and create opportunities for managing extreme events caused by natural disasters Examples could be monitoring of water level / supply / quality or even small movements in large structures (such as dams). The last twenty years in Greece we have seen an increase in infrastructure investments, including the construction of highways and roads, dams and bridges. The environmental impact of human activities would not be visible without the observation and interpretation of the monitoring data using remote sensors[3]. This paper presents the experience of Metrica SA in environmental applications, with focus on measurements, which have been acquired in the field[4] of forecasting, on line monitoring, real time data for management of natural disasters. Some of the implemented projects that will be presented have been implemented in collaboration with private companies and public authorities.

Keywords: Natural Disasters, forecasting, on-line monitoring, Φυσικές καταστροφές, disaster management, telecommunications, sensors, IoT applications, climate change, measurements, field measurements.

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THE 19 JULY 2019 M_W5.1 ATTICA EARTHQUAKE: A MULTIDISCIPLINARY APPROACH

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ABSTRACT

This paper presents a joint analysis of relocation of earthquake epicenter and aftershock sequence, macroseismic intensity assignment and distribution, strong motion data analysis and a fault model regarding the 19 July 2019 Athens, Greece M_w5.1 earthquake. This earthquake ruptured a blind, south-dipping normal fault at the north-western edge of Thriassion plane, at a distance of 23 km WNW of the center of Athens. The 2019 rupture is located inside an area of the 1999 fault plane that experienced 5-20 cm of afterslip in the period 1999-2001. The maximum macroseismic intensities reached I_{EMS98}=7.5 and scarce negligible damage and intensity up to 5-6 was reported near the epicenter. Moderate structural damage and maximum intensities were observed at distances 12-15 km east and ESE of the epicenter, in agreement with the MMI values distribution, possibly as a site-effect result from the alluvial formations alongside the banks of Kifissos River. In addition, a cutoff of seismic energy occurred east of Aigaleo Mt., imposing a stopping phase in the time histories of both the 1999 and 2019 earthquakes.

Key words: Athens, Attica, earthquake, macroseismic intensity, strong motion data, fault model

1. INTRODUCTION

On 19 July 2019, 11:13 GMT (14:13 local time), a strong, damaging earthquake with magnitude Mw=5.1 (Figure 1) and 10 km depth (NKUA solution) struck Athens, causing damage to its western suburbs. This moderate event signalled a general alarm in the whole metropolitan area with people rushing out of buildings, resulting in interruption of mobile communication for at least 2 hours and heavy traffic jams. The epicenter was located a few km north of Magoula (west Attica) and it is associated with a normal fault. Firstly, this work deals with the improvement of hypocentral locations via nonlinear relocation. Secondly, we present the collection and processing of macroseismic data. Next, we discuss the analysis of strong motion recordings of the mainshock. Lastly, we combine macroseismic and instrumental data in order to evaluate parameters of ground motion that affect the macroseismic field towards a better understanding of seismic risk in the broader metropolitan area of Athens.

2. RELOCATION OF MAIN SHOCK AND AFTERSHOCK SEQUENCE

For the period 19 July 2019 - 6 September 2019, 154 aftershocks were relocated using phase data from HUSN (Hellenic Unified Seismic Network) and a temporary local network comprising six stations installed by NOA & NKUA. The aftershocks are distributed in an overall ESE-WNW direction and tend to form two clusters, one near the mainshock and a smaller one to the SE. This pattern agrees with the ESE-WNW orientation of the nodal planes of the moment tensor solutions. Thus, an ESE-WNW, south-dipping normal fault is the causative fault.

3. MACROSEISMIC DATA COLLECTION, VULNERABILITY AND INTENSITY ASSIGNMENT

Macroseismic information was collected through all possible practices: in situ damage observations and questionnaire reports, damage inspections and online reports. Evidence of minor rock falls along the road network to the SE of the epicenter was observed. No landslides were triggered and no bedrock scarp or outcropping fault plane or surface breaks were observed, as expected due to the moderate magnitude of the mainshock.

Most macroseismic information is reported from the prefecture of Attica, with the majority of intensities greater than 5 confined within this region. Three data sources, i.e. EMSC (geocoded thumbnail integer intensity values, accompanied by descriptive testimonies of felt reports and comments, Bossu et al. 2020), NKUA (geocoded EMS98 intensity values assigned from the in situ collected questionnaire reports and damage photos, following the traditional macroseismic surveys practice) and GDAEFK (initial and final safety inspections conducted by teams of engineers) were used and elaborated. All damaged buildings were classified according to the vulnerability assessment principles and vulnerability table proposed by EMS98.

Geographical coordinates of intensity sites and geocoded addresses allowed for their grouping within grid cells (Van Noten et al. 2017). The dense population distribution of Athens metropolitan affected area allowed the final selection of grid cells size at 4.957 km^2, each containing a number of intensity values ranging from 3 to 40 or damaged buildings, from 1 to 210. With such a configuration 31 grid cells were considered, each containing more than 3 damaged buildings belonging to a variety of vulnerability classes. Intensity re-assignment by expert judgement was also performed for those cells containing averaged intensity and damaged buildings.

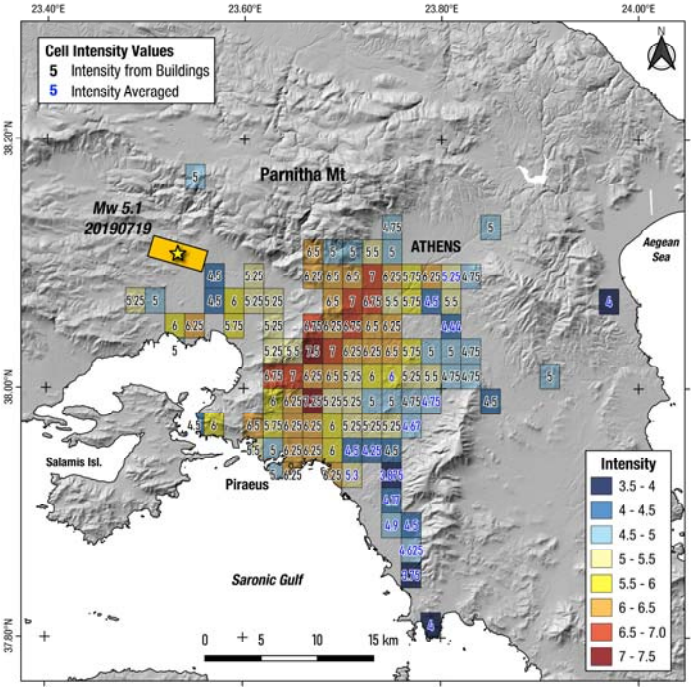

Figure 1. Macroseismic intensity distribution of the Athens 19 July 2019 Mw5.1 earthquake

4. GROUND MOTION PATTERN

Ground motion parameters of the mainshock were investigated using acceleration waveforms of 27 stations. Several Intensity Measures (IMs) were extracted, each of which could relate to structural damage and consequently affect the macroseismic field. Given the multitude of the

observations, we could reasonably presume complex geology beneath the epicentral area, leading to de-amplification of the seismic wave. Predominant period of strong ground motion at small epicentral distances (<30 km) ranges ~0.1-0.5 s (frequencies 2-10 Hz), hazardous for low-and middle-rise buildings, as is the majority of the exposed assets of the Athens metropolitan area. Site effects were investigated by means of HVSR. An important observation from the analysis of strong motion recordings is that highest IMs are distributed SE of the epicenter, at azimuths between N100° and N150°, sub-parallel to the strike of the causative fault (i.e. N110°) (Figure 2), likely implying for source directivity effects.

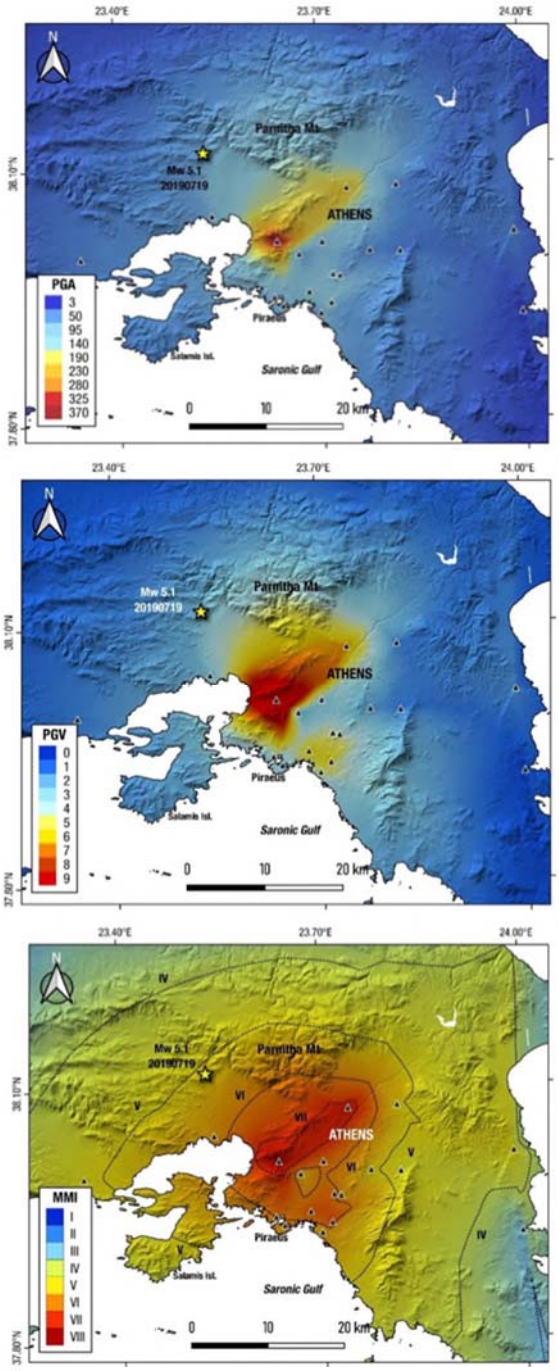

Figure 2. Spatial distribution of PGA (top), MMI (middle) and PGV (bottom) for the mainshock

5. RESULTS AND DISCUSSION

The close relation of the 2019 to the 1999 event is apparent through their overlap observed in the spatial distribution of their aftershocks. The area covered by the 2019 aftershocks is considerably smaller, indicating that the activated western fault segment is smaller than the 1999 eastern one, in accordance with moment magnitude difference. The 2019 aftershock distribution is clustered around the 2019 mainshock, and mostly towards the north and updip. Moreover, our field survey did not provide evidence of any surface breaks due to this earthquake, so the rupture did not reach the surface.

A uniform-slip fault model indicates that a rectangle of 5 km length (±1 km) by 4 km width (±1km) may fit the size of the seismic source. We put forward two models, one with the hypocentre coinciding with the slip-centroid (2019-1 in Figure 3) and a second model with the hypocentre at the middle of the bottom-fault line as suggested by the relocated aftershocks. Regarding the strike/dip of the fault plane, the orientation of the source is ESE-WNW (N106°E) and the dip-angle is 61°-52° towards south.

This fault geometry and location inside the upper crust of Parnitha resembles greatly the 1999 seismic source geometry. Indeed, the two 2019 fault planes do overlap with the 1999 modelled ruptures (Figure 3), mostly towards the western termination of it. Therefore, it is suggested that the 2019 earthquake ruptured the Parnitha normal fault and it can be considered as the western continuation of the 1999 event.

6. CONCLUSIONS

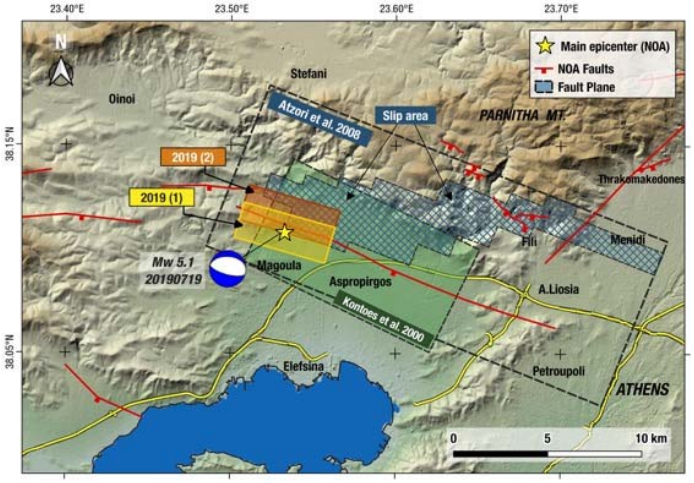

Figure 3. Relief map showing surface projections of seismic fault planes (geodetic solutions) for the 2019 and 1999 Athens earthquakes.

The macroseismic field shows an eclectic pattern to the southeast of the epicentre. However, structural damage and maximum intensity I_{max}= 7.5 was observed in the direction of the fault strike, at larger distances 12-15 km E and ESE of the epicenter, in consistency with the instrumental IM's distribution, which also appear increased in this direction. Damage due to near-field strong motion is related to the long-period wavefield. During the 1999 earthquake, intensities 8 and 9 were assigned at equally large epicentral distances inside the Athens basin. The mainshock strong motion recordings analysis indicated systematically larger excitations to the SE of the epicenter, while the HVSR curves site-effects were likely the cause for observed irregularities at strong motion recordings and damage. At stations located SE of the epicenter, the velocity histories are characterized by forward directivity. Significant durations were found shorter to the SE of the epicenter, corresponding to high-amplitude acceleration, while the large rise times on the other azimuths correspond to low-amplitude waveforms. Therefore, it is reasonable to presume a SE source propagation for the mainshock. Radiation pattern and local soil conditions which can affect seismic energy could play an additional role. A cutoff of seismic energy occurs east of Aigaleo Mt., recognized as a stopping phase in the time histories of the 1999 and 2019 earthquakes. If this is the case, Aigaleo Mt. is likely a shield of Athens metropolis from local seismic sources from the west. Alternatively, large excitations along the eastern foot of Aigaleo Mt. may be due to site-effects from the alluvial formations alongside the Kifissos River banks, where heaviest damage occurred during the two events. The latter is supported by high intensities 6 – 7.5 and slope failure effects along the western Kifissos riverbeds during the current event, and by similar pattern of high intensities observed during the 1981 Alkyonides and the 1999 Athens earthquakes.
The 2019 rupture is located inside an area at the western part of the 1999 fault plane that experienced 5-20 cm of afterslip during the period 1999-2001.

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SEISMIC RISK ASSESSMENT OF THE CITY OF SERRES USING THE OPENQUAKE PLATFORM

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ABSTRACT

Seismic risk assessment at city scale has always been a useful tool for pre-earthquake planning, investment management and for retrofit prioritisation at the aftermath of a seismic event. Many methodologies are available for hazard analysis and seismic vulnerability estimation based on fragility curves available in literature. However, due to the different assumptions and principles of the available methodologies, the results may exhibit great variations. Recently, the Global Earthquake Model (GEM) foundation developed and released online the OpenQuake engine, an open-source software for seismic hazard and risk analysis, making the seismic hazard and risk analysis feasible accounting for average and aggregated losses. A research project (SeiVAS) has recently been completed in Serres (northern Greece) providing vulnerability and risk assessment results for the building stock at city scale. Different seismic scenarios have been studied and available fragility curves have been utilized for the risk assessment. In order to compare the results of the SeiVAS project with recently proposed methodologies it was decided to proceed with the seismic risk assessment analysis of the building stock in Serres using the OpenQuake engine. The seismic hazard and the scenarios selected are presented, along with the exposure and the fragility curves used for the assessment. Risk analysis is performed at city scale and repair costs are estimated. Comparative results are presented and discussed, highlighting the different assumptions and principles of each analysis.

Keywords: Seismic risk, assessment, building stock, fragility curves, loss estimation

1. INTRODUCTION

Seismic risk analysis provides valuable information for the local authorities, including economic and human loss estimation for several risk scenarios. In order to estimate seismic risk at city scale, the seismic hazard and fragility for the exposure should be estimated. For the seismic hazard analysis, seismological and geological data are accounted for. For the seismic vulnerability assessement, fragility curves have been proposed in the literature, mainly based on empirical, analytical, or combined (hybrid) approaches. Based on hazard analysis and fragility models, seismic risk and economic losses are estimated, consisting a quantitative criterion for retrofit prioritization. The scope of this paper is to provide comparative results for the seismic risk assessment of the city of Serres (northern Greece), based on current state-of-the art tools and practices. Therefore, the widely used, OpenQuake platform is utilised along with recently developed fragility models to estimate the seismic risk and the associated losses for the city of Serres. The results are compared to the outcome of a former, national research project, highlighting the impact of different assumptions on the risk analysis.

2. HAZARD ASSESSMENT

The first step towards the identification of the most detrimental earthquake scenarios in the investigated area is to perform a region-specific seismic hazard analysis at bedrock level, taking into

account seismic sources in the broader area and suitable ground motion prediction equations based on properly validated available seismological information. The study results in several seismic scenarios, four (4) of which are considered as most prominent for the examined case-study, as discussed in the deliverables of the SeiVAS project [1]. One-dimensional soil dynamic response analysis that follows, employing the selected scenarios for various earthquake return periods, leads to the estimation of the seismic motion at the soil surface. It is important to mention that, based on geological, geotechnical and geophysical data [2, 3], the examined area is divided to four different zones, representing the different observed soil deposit properties and obtained response parameters in different city locations.

3. EXPOSURE

The collection of reliable data regarding the structural properties of the building stock in an urban area is usually the most time-demanding task required for the development of seismic loss estimation scenarios. In the case of Serres, existing data from local authorities such as the City Planning Office archives of the Serres Municipality were rather limited focusing mainly on recently constructed buildings, and missing critical information for the seismic performance of each structure. Within the framework of the SeiVAS project, an effort that started a few years ago combining the aforementioned information with targeted in-situ inspections, resulted in an adequate recording of a representative sample covering nearly 25% of the building stock of the city (2436 buildings). Recorded data including information tailored for the seismic assessment such as material, structural system, code design, infill walls pattern etc., have been processed with an in-house developed software application and visualized using GIS technologies [4, 5]. All buildings have initially been assigned to the building typologies adopted by the AUTh team in their studies [6, 7] and then to the taxonomy proposed by the Global Earthquake Model (GEM) [8], as presented in Table 1.

Table 1. AUTh and GEM typology correspondence, including number of buildings and built area

AUTh	GEM	Num.	Area	AUTh	GEM	Num.	Area
RC4.2LH	CR_LDUAL-DUH_H2	126	50346	RC3.1LH	CR_LFINF-DUH_H2	36	9763
RC4.2MH	CR_LDUAL-DUH_H5	135	162436	RC3.1LL	CR_LFINF-DUL_H2	326	84147
RC4.3MH		126	155511	RC3.1ML	CR_LFINF-DUL_H5	153	238375
RC4.2LL	CR_LDUAL-DUL_H2	108	37475	RC3.2MH	CR_LFINF-DUL_H5_SOS	27	31117
RC4.2ML	CR_LDUAL-DUL_H5	170	267479	RC3.1LM	CR_LFINF-DUM_H2	89	27981
RC4.2LM	CR_LDUAL-DUM_H2	72	26374	Mas3+	MUR_LWAL-DNO_H3	43	14364
RC4.2MM	CR_LDUAL-DUM_H5	69	99630	MBr12	MUR-CL99_LWAL-DNO_H2	677	75916
RC4.3MM		76	108322	MSt12	MUR-STDRE_LWAL-DNO_H2	203	25093

4. FRAGILITY CURVES

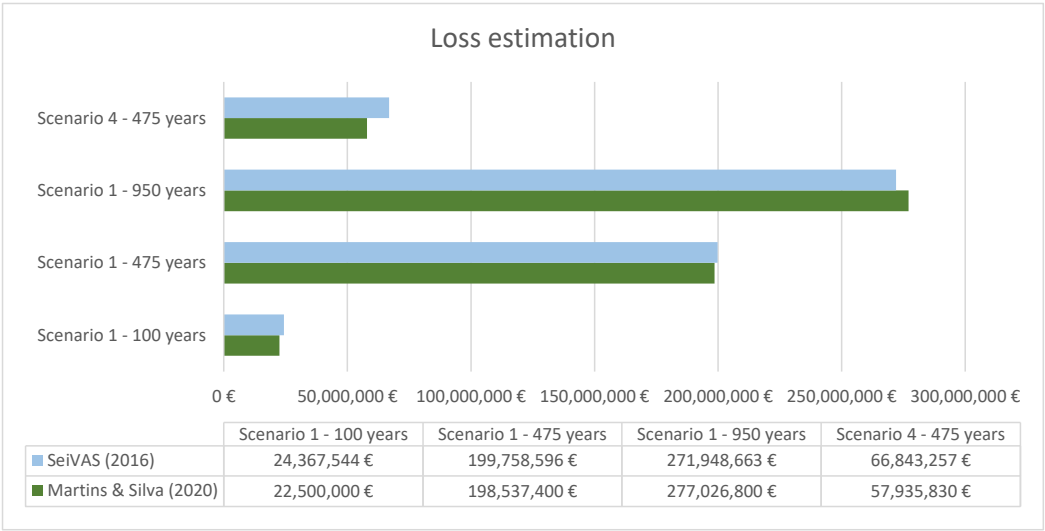
The methodology adopted in the SeiVAS project was based on the fragility curves derived by the AUTh team using a hybrid procedure that combines results of of inelastic analyses of typical structures for each class with actual damage statistics gathered after past earthquakes in Greece. In the present study it was decided to apply the fragility and vulnerability models proposed in a very recent paper by Martins and Silva [9] including building classes that seem to correspond well to the building stock of Greek cities. Four damage states have been considered ranging from slight (DS1) to complete damage (DS4) and the construction of the fragility functions was based on nonlinear dynamic analyses performed on equivalent SDOF oscillators considering the building-to-building and the record-to-record variability. The probability of exceeding a set of damage states was estimated through cloud analysis and considering the uncertainty in the definition of the damage criterion. Depending on the building classes dynamic properties, four intensities measures (PGA, SA(0.3 s), SA(0.6 s) and SA(1.0 s)) have been considered. It is

recalled that the AUTh approach adopts five damage states and fragility curves are derived in terms of peak ground acceleration [6].

5. SEISMIC RISK ASSESSMENT SCENARIOS

The calculations for the risk assessment in the present study have been carried out using the OpenQuake engine [10] and the fragility and vulnerability models proposed by Martins and Silva [9]. For the main seismic scenario (S1) developed in the SeiVAS project, results are provided for all return periods (i.e. 100, 475 and 950 years), while for the S4 scenario (not including the neotectonic fault in Serres and corresponding to peak ground accelerations close to the current seismic code design level [11]) the 475 years return period was only examined. The spatial distribution of damage in terms of the Martins and Silva model damage states is presented in Figure 1.

Figure 1. Spatial distribution of damage in the city of Serres (return period of 475 years). The size of the pies corresponds to the total build area in each cell (**a**) Scenario S1 (main); (**b**) Scenario S4



	Scenario 1 - 100 years	Scenario 1 - 475 years	Scenario 1 - 950 years	Scenario 4 - 475 years
SeiVAS (2016)	24,367,544 €	199,758,596 €	271,948,663 €	66,843,257 €
Martins & Silva (2020)	22,500,000 €	198,537,400 €	277,026,800 €	57,935,830 €

Figure 2. Repair cost estimation using the Martins and Silva [9] models in comparison with the SeiVAS project results [5]

Figure 2 presents the loss estimation in terms of repair cost, assuming 800€/m^2. It should be noted that these values correspond to the sample of the building stock used in the study (about 25%), therefore the total results for the whole city should be multiplied with a number close to 4. Repair cost results are also found in very good agreement to those obtained within the framework of the SeiVAS project using the fragility curves derived by the AUTh team [5].

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Resilient communications and UAV fleet for future Search & Rescue operations

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ABSTRACT

In modern search & rescue (SAR) operations, rapid deployment, situational awareness and first responder (FR) safety are the most important prerequisites for a successful outcome. In the EU project CURSOR autonomous robotic assets, geophones and resilient communications are developed and combined to augment the operational capacity of FR teams and to improve the probabilities of recovering as many live victims as possible from the disaster area. In this work, two such platforms are described as part of the CURSOR project (H2020), offering high mobility and multiple capabilities: the Emergency Gateway, a robust portable communications hub for worksite deployment, and the Drone Fleet, a multi-drone, multi-role assembly of aerial drones for area mapping, continuous monitoring and heavyweight transportation of sensing equipment and tools. These technologies are currently under development and already prototyped as part of the SAR Kit of the CURSOR project, which is to begin field testing activities next year.

Keywords: Search and Rescue (SAR), resilient networking, worksite communications, Unmanned Aerial Vehicle (UAV), drone, emergency responder, earthquake.

1. INTRODUCTION

During the last decade the advancements in various technological fields including electronics miniaturization and ruggedization, resilient wireless communications, battery efficiency and capacity, etc, have enabled the design of communication & networking equipment and Unmanned Aerial Vehicles (UAVs) for SAR operations. UAVs are used today to establish a quick overview of the disaster area with visual and night-vision cameras, assisting in the detection of trapped victims with thermal/infra-red cameras, as well as acting as temporary communication relays in the field. These functionalities rely on establishing resilient data links between the aerial assets and the First Responder (FR) teams inside the disaster area, as well as between the FRs and the Command Center. Novel designs for autonomous UAVs and portable networking hubs, specifically tailored to the highly demanding environment of a disaster area are two of the technologies developed by CURSOR[1] for SAR operations. These new technologies improve the rapid deployment, the situational awareness and the safety of the FR teams, augmenting the Common Operational Picture (COP) for all the assets in the field.

[1] This work is supported by the project CURSOR, which has received funding from the European Union's Horizon 2020 (H2020) programme under grant agreement No:832790.

2. WORKSITE COMMUNICATIONS AND AERIAL ASSETS

Two components from the SAR Kit of the CURSOR project are described below. Specifically, the Emergency Gateway (EG) is the proposed solution for portable and resilient worksite communications, coupled with Multiple-source Data Fusion Engine (MDFE), and Drone Fleet (DF) is the multi-drone approach for UAV-based operations.

1.1. Portable and resilient worksite communications

In every disaster event, emergency response efforts rely on portable, reliable and efficient communications technologies between the FRs inside the worksites and the Command Center. Moreover, technologies that require stable and high-capacity data links, such as aerial drones, extend these requirements even more. In the SAR Kit of the CURSOR project, the communications between the disaster worksite components and the Command Center (UCC/OSOCC) is performed by the Emergency Gateway (EG). In its core, the EG is a modern computing platform that incorporates various network communication technologies required by the deployed components, packed in a portable computing platform inside a ruggedized case. The functionalities of the EG include:

- Seamless interoperability and ubiquitous connectivity via Wireless Ad-Hoc Networking.
- Security-by-design on all offered communication channels (authenticated and encrypted).
- Resilient operation in the harsh environment and degraded R/F signal in a disaster worksite.
- Central EGs connected to power generators and UPS units; portable battery-operated EG.
- Gateway to the World Wide Web (internet access) and other local services & deployed components.
- Easy deployment and operation: small form factor, switch on and forget.

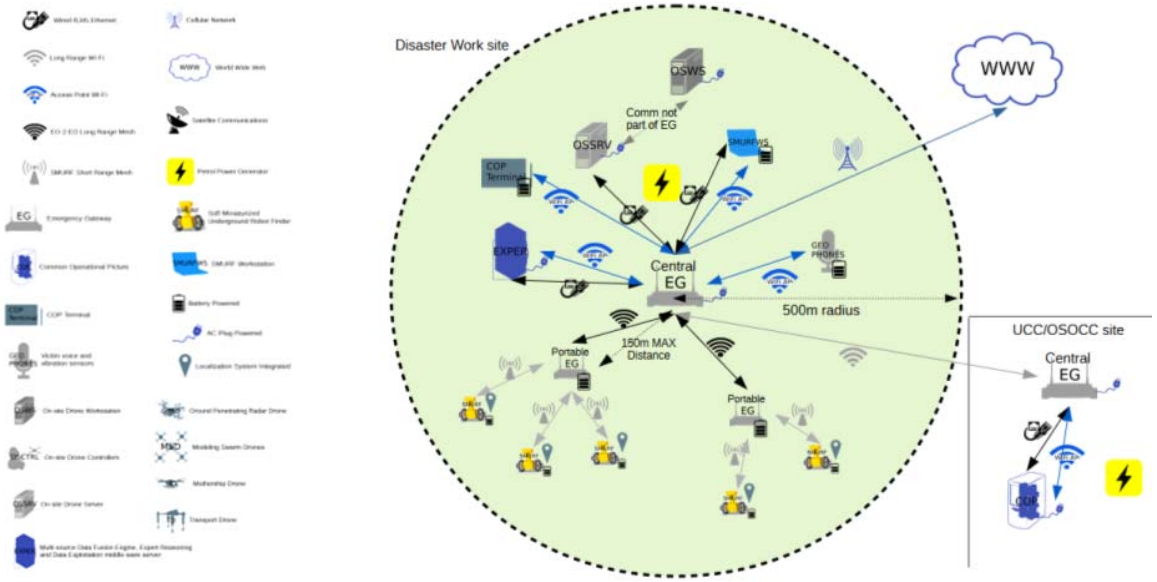

Figure 1. Overview of multiple Emergency Gateway deployments with a central EG and multiple portable EGs, providing resilient data links between all the deployed SAR Kit components inside the worksite area.

The EG design is targeted for rapid deployment, ease of use and robustness at all levels. The system is comprised by a computing board, a storage device that contains the operating system and allows limited storage and a series of modular network communication components. The absolute minimum is the

inclusion of a wireless network card for the 2.4-5 GHz WiFi Access Point and Mesh networking. This allows direct connectivity of EGs and other deployed components in a common WLAN, including aerial drones, mobile user terminals, geophones, etc. plus routing network traffic to the Internet when necessary/permitted. The Internet connectivity is provided by Cellular Modem network cards (main & backup), set up to work in 4G LTE networks of different providers. Connection of a wired device via RJ45 cable to the gateway is also possible. For extra redundancy of the Internet connection, it is possible to use external Satellite Internet Connection via an antenna dish and a modem. This feature is extremely useful in large-scale disaster areas where the LTE networking is unavailable, at the cost of having a slightly more complex deployment. The whole device can be carried by members of the FR team, in order to be deployed on demand and cover larger areas, thus partitioning the number of components communicating with each deployed EG. Smaller EG configurations can be carried by FR members in a backpack and a central EG can provide the link with Command Center and the Internet (see Figure 1).

1.2. Multiple-source Data Fusion Engine (MDFE)

Several data fusion architectures have been proposed in the literature to deal with data fusion challenges for capturing reliable, valuable and accurate information in massive data like the Joint Directors of Laboratories (JDL), the Luo and Kay's and the Dasarathy's architectures. Traditional data fusion techniques include probabilistic fusion, evidential belief reasoning fusion (e.g., Dempster-Shafer & complexity reduction) and fuzzy set theory-based fusion. In CURSOR, a Multiple-source Data Fusion Engine (MDFE) developed to fuse heterogeneous data sources and information generated from CURSOR *in situ* sensors, providing a semi-empirical probabilistic indication of detection (alerts & heatmaps) and the location of the trapped victims. More analytically, a fusion framework is established for collecting, parsing, integrating, and fusing heterogeneous data of different size, type, velocity and veracity; as well as a data publication process to a middleware stack via Message Brokers. Considering a 3-level fusion architecture, machine learning (ML) algorithms are applied to evaluate the high quality of collected data (signal level data fusion), extract features (feature level information fusion) and support a data-driven decision making (decision level fusion). Furthermore, feature-selection approaches, combining machine learning with optimization algorithms are implemented for identifying decision variables, facilitating feature engineering & extraction, and human-in-the-loop approaches for knowledge discovery.

1.3. UAV: Drone Fleet (DF)

An important component of the SAR Kit in the CURSOR project is the Drone Fleet (DF) of UAVs, consisting of (see Figure 2) [2]:

1. **Mothership Drone (MD)**: a tethered drone with HD zoom video camera, flood lights, megaphone and WiFi access point, serving as 24/7 "Eye in the Sky" over the disaster area;
2. **Modeling Swarm Drones (MSD)**: five drones in swarm formation, generating a photogrammetric 3D model of the disaster zone, as well as a 2D orthomap; in "FR mode" individual drones can provide local situational awareness;
3. **GPR-equipped drone (GPRD)**: a ground penetrating radar (GPR) unit mounted to a drone, identifying alive buried victims;
4. **Transport Drone (TD)**: a heavy-lifting drone, carrying a container filled with sensor-equipped UGVs (SMURF units) or other equipment and tools to deployed FR teams.

In order to tackle the challenges brought on by a disaster event in a large urban area (e.g. earthquake), it was decided that for the DF a combination of two UAV types will be used:

(a) one common drone airframe (GAIA 160) for heavy-lifting tasks (transporting ground penetrating radar (GPR) for making radargrams; transporting and unloading ground-based miniaturized robots with multiple sensors (Soft Miniaturized Underground Robot Finder – SMURF) to be released on scene, and as tethered drone for 24/7 area monitoring;
(b) one common airframe (DJI Mavic Pro) for a swarm of fast, small drones providing mapping and advanced situational awareness (3D model of disaster area).

The MD system employs a 30x optical HD zoom-camera with encrypted HD video transmission, floodlights, a megaphone system (125 dB) and a WiFi access point. The GPRD system is a GAIA160 drone with the GPR sensor hanging from a cable on a remotely controlled winch. The GPR is able to detect survivors buried under several meter of debris by differentiating between slight movement, strong movement and breathing. The GPRD also employs radiometric Flir 640 and RGB HD cameras and floodlights. In TD mode, the GAIA160 drone is equipped with HD video camera, thermal camera, as well as floodlights and a megaphone. The TD is able to carry a special container for unloading SMURFs at selected sites to identify victims buried under rubble. The MSD system is comprised of altogether five DJI Mavic Pro (MP) drones operating as a swarm, with three intelligent flight modes are incorporated: (a) Obstacle Avoidance, (b) Active Track (objects), (c) TapFly ("point and fly" mode).

(a) **(b)** **(c)**

Figure 2. Components of the Drone Fleet (DF) in the CURSOR project: (**a**) Mothership Drone (MD); (**b**) GPR Drone (GPRD) and Transport Drone (TD); (**c**) Modeling Swarm Drone (MSD).

The DF system enables crisis managers to identify risks and emergencies due to damaged structures (e.g., zooming into buildings), to detect survivors under rubble (e.g., radargram), and to provide communication services (e.g., alerting via megaphone; WiFi access point). The different types of data provided by the DF are integrated into the COP for the mission area. Using the DF to create a 3D model from aerial photogrammetry, the camera is mounted on a drone of the MSD fleet and can be moved vertically and horizontally. Multiple overlapping photos of the ground or object to be modeled are taken along an autonomously programmed flight path, with a precise scan zone overlap of 80% to 90%.

3. CONCLUSIONS

Modern technological advancements in field communications and aerial drones will enable the use of such assets in an autonomous and effective way within the context of real-world SAR operations. The highly demanding environment of such missions requires improved performance and autonomy, as well as complementarity with the standard operational procedures applied by FRs. The CURSOR SAR Kit will provide such technologies, which are already prototyped and at the beginning of field tests.

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THE COOPERATION BETWEEN CIVIL PROTECTION AND CAVE RESCUE TEAMS: THE EXAMPLE OF SARCHOS

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ABSTRACT
This paper deals with the way in which the Greek Civil Protection team cooperated with the Greek Cave Rescue team during the crisis in the Chonos cave near the village of Sarchos in the region of Heraclion in Crete in November 2002, when cavers were trapped after a siphon was flooded. The presentation points out the organizing weaknesses of the rescue expedition and displays the solutions that were given during the crisis. In comparison with the cave rescue cases of the Tham Luang cave in Thailand in the summer of 2018 and the Riesending cave in Bavaria in the summer of 2014, the paper underlines the importance of an especially trained cave rescue team in such cases.

Keywords: Civil Protection, Cave Rescue, crisis management, rescue teams' cooperation, Sarchos, Tham Luang, Riesending.

1. INTRODUCTION

The aid of Civil Protection is needed in a wide variety of incidents. In some of cases a collaboration with more specific rescue teams is required. In the very particular environment of a cave, the team that is asked to cooperate with Civil Protection is the Cave Rescue Team. One may argue that cave rescue incidents are rare; however, cavers know that this is not exactly so. Every now and then, a cave rescue case is made known worldwide through the media. Such is the case of the incident in the Tham Luang cave in Thailand in July 2018, or the incident in the Riesending cave in Bavaria four years earlier, in June 2014.

2. METHODOLOGY

This presentation uses three different cave rescue incidents, a local one (that of the Chonos cave near the village of Sarchos in the region of Heraclion in Crete in November 2002) as well as the two cases mentioned above, in order to prove the importance of a specialized rescue team in such cases. A focus on the organization of these cave rescue expeditions reveals the weaknesses of the administration but also the solutions that were given eventually.

3. CASE STUDY

In the case of Sarchos, where cavers were trapped after a siphon was flooded, there was at first a laudable attempt by the special forces of the Fire Department and the Army to penetrate into the siphon (sump), but they did not manage to go through, due to their lack of experience in such environments as well as due to the given circumstances at the specific cave. The coordination was originally given exclusively to an Officer of the Fire Department,

following the protocol. However, due to the particularity of the environment and the necessary participation of cavers in the operation, it was agreed that Kostas Zoupis, a member of SP.EL.E.O. caving club, should take part in the coordination. The outcome was a satisfactory cooperation of all the people involved, with the eventual rescue of the trapped cavers [1].

In the case of the Tham Luang cave in Thailand, where 12 pupils with their teacher were trapped, the coordination was originally given to the Army. Thanks to the publicity that was given to the incident by the media, and after the involvement of cavers from the UK, there was a global mobilization and participation, which brought the desired outcome. (The cavers of the rescue team were mainly from the USA and the UK, but there were also others from Australia, as well as individual cave divers from all over the world.) However, before this global call for help, an Officer of the Army lost his life, due to his lack of training and experience in such environments [2].

In the case of Riesending, a deep cave in the Bavarian Alps, a caver was injured. Due to the cave's depth, the participation of people other than cavers (and experienced ones, too) was impossible. The coordination was taken on by the cave rescue team, who were capable of handling this type of incidents. Moreover, this incident brought out the need for specialized doctors or nurses who will be able to deal with such cases [3].

4. CONCLUSIONS

By analysing the different cave rescue incidents, the need for the collaboration of all parts involved is brought out. The solutions that were given involved a mixed administrative plan, and this is indeed what is needed in such cases. Civil Protection may provide and organize whatever is needed outside the cave, but inside the cave the organization should be given to a team of well-trained and experienced cave rescuers, which, in the case of Greece, is the cave rescue team of the Hellenic Federation of Speleology.

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SMART BOOTS, FUSION ENGINE AND AERIAL ASSETS FOR ENHANCED SITUATIONAL AWARENESS AND SAFETY IN SEARCH & RESCUE OPERATIONS

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ABSTRACT

Innovative technologies can enhance operational capabilities of First Responders (FRs) during Search & Rescue (SAR) operations, while at the same time increasing safety levels. The INGENIOUS project[1] (EU Horizon 2020) aims at developing, integrating, testing and validating a next generation SAR toolkit for collaborative response, which ensures high level of protection and augmented operational capacity in disaster situations. In this paper, a subset of components of the toolkit mostly focused on increasing situational awareness and safety are described: the Fusion Engine (FE), which receives data from multiple sources, stores and analyzes them for integration purposes regarding situational awareness and sends them to the Common Operational Picture (COP) as well as the mobile FR terminals; the Smart Boots (SB), which collect data of individual FRs and provide information regarding their health status and alerts; the Modular Airborne Camera System (MACS); the Multi-purpose Autonomous eXploring (MAX) drone for indoor/outdoor mapping and assessment of unknown environments; and the Micro INdoor drones (MINs) used for FRs indoor localization. The functionalities of these components, as well as the first prototypes developed and currently under lab and field test, are presented in this paper.

Keywords: Search and Rescue (SAR), fusion engine, smart boots, Unmanned Aerial Vehicle (UAV), drone, first responder, tactical awareness.

1. INTRODUCTION

As technology advances, innovative technologies for SAR operations are developed and tested from public safety agencies. One of the core requirements to improve the efficiency of these operations is

[1] This work is supported by the projects INGENIOUS, which has received funding from the European Union's Horizon 2020 (H2020) programme under grant agreement No:833435.

enhancement of situational awareness, both for the FR teams and the Command Center. On the other hand, due to the high risk of exposure in hazard and life-threatening situations, FRs' mandate for safety is crucial. As part of the INGENIOUS project [1], we develop a SAR Toolkit, which aims at improving situational awareness, while setting FR safety as a first priority.

In this paper, a partial list of the SAR Toolkit components is presented, mostly focused on providing enhanced situational awareness and safety but not exclusively; the Fusion Engine (FE), which acts as a bridge between the operations on the field and the commanders, providing functionalities related to collection and analysis of data and information; the Smart boots (SB), which collect data and biometrics of individual FRs and provides information regarding the health status; the Modular Airborne Camera System (MACS) carried by a fixed wings drone that has extended flight time capacity and speed in order to deliver a large-scale mapping of the disaster area; the Multi-purpose Autonomous eXploring (MAX) drone for indoor/outdoor mapping and assessment of unknown environments; and the Micro INdoor drones (MINs) used for FRs indoor localization.

2. FUSION ENGINE (FE) AS THE FOCAL POINT OF DATA FROM MULTISENSORY DEPLOYED SYSTEMS

The FE is the focal point where all received data collected from the INGENIOUS sensors and applications are gathered, stored, and collectively processed. By processing those data sets, the FE extracts valuable information regarding the tactical situation and the FRs' health status. There are two main tasks for the FE (see Figure 1): (1) Collect, validate and store and forward data to the Expert Reasoning (ER) modules and remote services for decision support and early warnings generation. A distributed streaming platform (Apache Kafka) is used for real-time data handling allowing publish/subscribe to streams of records, store streams of records in a fault-tolerant way, and process streams of records as they occur; (2) Process and merge the collected data to create increased situational awareness and support decision making for the operation. A workflow management system (Apache Airflow) manages and monitors the scheduling and execution of all internal tasks. Fusion depends on the particular data characteristics while data correlation between different sources requires metadata such as timestamp and georeferenced location.

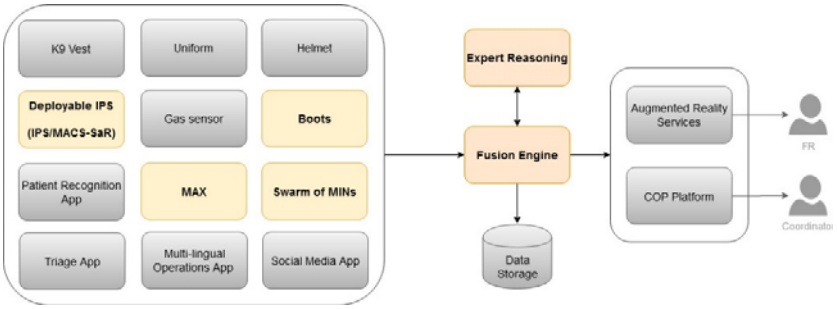

Figure 1. Overview of the FE: Collect data, validate and store, perform fusion via smart algorithms and present them to FR and commanders for increasing their situational awareness.

So far, the functionalities provided by the FE include: (a) **Map zone classification**, where danger areas of worksite where increased temperature and dangerous gases have been identified will be shown as colored zones aiding the situational assessment; (b) **Areas of interest identification**, in which unvisited places/rooms of buildings will be identified, marked and displayed accordingly to facilitate the coordination among FRs; and (c) **FRs health warning system**, in which monitoring and assessing the health status of FRs will take place and produce alerts when warning health levels are reached or when safety protocols are not adhered.

3. SMART BOOTS (SB) FOR HEALTH STATUS MONITORING

The SB component is a novel situational awareness tool for FR and SAR operations. The operational FR safety boots become smart with the use of custom-build electronic multi-sensor insoles. Hosting several embedded sensors in the wearable insole form factor, SB can inform the FR or (via the FE) the team leader, in real time, about the health status of an individual team member while operating in the field. A warning or alert can be raised based on the information collected from the sensors. Sensors like accelerometer, gyroscope and magnetometer are responsible to determine the orientation of the FR. In addition, flexible force sensors are used to determine if a FR is putting pressure on the insole as well as the force distribution across each foot. Edge processing algorithms combine and analyze all sensor data to detect any irregularities or inconsistencies that will raise appropriate alerts, e.g. prolonged immobilization or asymmetric walking indicating injuries, or excessive force combined with high g-forces indicating a dangerous fall. The electronic insoles are battery-powered and can be charged wirelessly without the need to remove from boot. The use of low-power electronics and communication modules allow autonomy for long missions on a single charge.

4. AERIAL ASSETS FOR ENHANCED POSITIONING AND ASSESSMENT OF UNKNOWN ENVIRONMENTS

Within INGENIOUS, a combined on-ground –and drone multi-sensor system for FR real-time localization and rapid environmental mapping is developed. This enhances the FR orientation capabilities in the field and leads to better sounding, investigation and documentation of structural fault, e.g. damaged buildings after an earthquake. The Integrated Positioning System (IPS) device carried by FRs, estimates the FR position in action in a combined indoor and outdoor environment while performs a smaller scale environmental mapping. Aerial assets contributing at different levels towards the direction of indoor and outdoor mapping, localization and positioning of FRs/assets are described in the following.

(a) (b) (c)

Figure 2. (a) MACS Camera system module mounted in front of the fixed-wings drone, (b) MAX under development, (c) The Crazyflie 2.1 platform used for the MINs.

4.1. Modular Airborne Camera System (MACS) for large scale area mapping

While the IPS is used indoors to provide small scale mapping, the complementary Modular Airborne Camera System (MACS) that equips a a vertical take-off and landing (VTOL) fixed-wing drone is deployed to associate previous data and provide large scale mapping. Based on a metric camera system, the first prototype of the drone-based real-time mapping camera incorporates an industrial camera, a dual-frequency GNSS (Global Navigation Satellite System) receiver including inertial-aided attitude processing (INS), and an embedded computer responsible for time synchronization, image acquisition and real-time image processing. In this configuration the system allows to capture up to 4 raw images per second which can be stored on a removable storage device. The weight is 1.4 kg (including embedded PC, camera, IMU, GNSS receiver, GNSS antenna, power management and structure) and the dimensions are 10 x 14 x 20 cm^3. A fixed-wing drone (see Figure 2 (a)) is used as carrier providing a flight time of approximately 90 minutes at cruise speeds between 80km/h and 140km/h. Thus, the carrier is capable to travel a distance of up to 105 km per battery charge. It is specified with maximum takeoff weight of

14kg including a payload of up to 2 kg and has a wingspan of 3.5 m. It can operate at wind speeds of up to 8 m/s and temperatures between 0°C and 35°C. While its typical flight operation altitude is in the range between 100 m and 300 m above ground level, it is capable of operating at altitudes up to 3,000 m above sea level. The operational range is only limited by the maximum flight time because the autopilot system allows fully automated flights beyond visual line of sight (BVLOS).

4.2. Multi-purpose Autonomous eXploring (MAX) drone for indoor/outdoor mapping

The MAX is the FR's extra companion that assists in the exploration and assessment of potentially dangerous buildings. Using a variety of sensors and an on-board distributed computational system, MAX will be able to navigate and explore an environment completely on its own while sending multi-sensor data (video, infrared images, gas sensor readings, temperature measurements, etc.) to a ground control station where it can be visualized and processed further. By creating 3D maps and locating itself in the previously unseen environment, MAX will keep track of explored and unexplored areas and optimize data collection to avoid over-assessment of previously visited places and to highlight the parts of the buildings where MAX could not reach or its sensors were not able to observe. In essence, MAX gives the FRs a detailed look inside the building while they are busy doing other things.

MAX airframe size is 43 x 43 cm^2, with a payload capacity of about 600 grams (battery excluded). The maximal flight time of a fully loaded platform of this size is limited to 10-15 minutes. The MAX with some of its sensors is presented in Figure 2 (b); a 360 degrees lidar (laser scanner), a forward-looking stereo camera and a number of sonars used for navigation and obstacle avoidance, visual and thermal cameras used to supply data for building assessment and scene understanding.

4.3. Micro INdoor drones (MINs) for indoor localization

The MINs are intended as small and disposable devices to aid the indoor localization (GPS denied environment) of the FRs (see Figure 2 (c)). The MINs will achieve this objective by working in a swarm fashion, that is, a group of MINs will enter the building before the FRs and will disperse within the building in order to create a mesh network which will be used to localize the FRs in the building by triangulation techniques. Each MIN will be a node of the mesh network and each MIN will carry an Ultra-Wide Band (UWB) beacon to be used to localize the FRs wearing a UWB receiver.

The MIN size is 9 x 9 cm^2, weights 27 grams with a payload of 15 grams and provides of almost 7 mins of flight. Each MIN is equipped with: UWB sensors: to track the motion of an FR carrying an FR receiver within the building; Ranger sensor: laser sensor to sense obstacles nearby and avoid them while flying; An optical camera: pointed downwards to support odometry and estimate the position of the MIN.

5. CONCLUSIONS

The INGENIOUS components presented in this paper are developed and customized for use within the context of real-world SAR operations, enhancing situational awareness and safety. The highly demanding environment of such operations requires improved performance and autonomy. The INGENIOUS project SAR Toolkit will provide such technologies, which are already prototyped and currently under ongoing lab and field tests.

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THE FLASHOVER: DESCRIPTION AND FIREFIGHTER TACTICS

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ABSTRACT
The flashover is the sudden transition from a localized structure fire in an enclosed space, such as the room of a house to the combustion of exposed fuel surfaces within that enclosure. It is one of the most frequently discussed incidents in fire engineering an fireservice confined space fire topics. It is, however, a fact that due to the development of more sophisticated passive and active fire protection measures in buildings and other confined spaces, the number of fire incidents including flashovers is smaller than it was in previous decades. As a result, the on-hands experience of young firefighters in such incidents is rather limited. The purpose of this paper is to provide useful information to firefighters and civilians about the flashover, the factors influencing its development, its effects and some basic preventive measures. In detail, understanding the changing smoke conditions, proper ventilation firefighter tactics and the importance of cooling down the hot upper layer gases inside a closed space below their ignition temperature are some of the most important parameters influencing a flashover. It is extremely important that part of the firefighters training must include recognizing flashover conditions, which can, in turn, can save lives.

Keywords: Flashover, Structure Fires, Confined Space Fires, Fireservice, Rapid Fire Progress.

1. INTRODUCTION

Enclosure or confined space fires are some of the most usual cases frequently handled by firefighters during their service. A confined space fire takes place inside structures such as blocks of houses, garages, single-family homes and commercial buildings. Common potential sources of ignition are smoker's materials, electric/gas heaters, cooking, lighting equipment, short circuit and static electricity. The consequences of such fire incidents most of the times involve people and structures. These kinds of emergencies can result into firemen and civilian deaths, fire injuries and property damage. Currently, the reported data about this phenomenon in Europe is very poor. This is because there is not a common database which involves all European countries and most of the fire services do not document such situations [1]. It is, therefore, estimated that that 35% of fires located in several cities around the world are structure fires, as shown in the Figure 1 below.
The flashover is the stage during a fire development at which the contents and the gases in a confined space reach their ingition temperatures, resulting in flames breaking up at almost all at once all over the surfaces. It takes place during a short time interval when a room under fire goes from mostly being filled with cold air to mostly being filled with hot fire gases, and the heat generation rate inside that room exceeds its ability to loose heat at its boundaries. The occurence of flashover within a room of a building is of considerable interest, since it is a sign of greatly increased risk to the firefighters operating in that fire scene, as well as to the occupants of other rooms whithin that building [3].

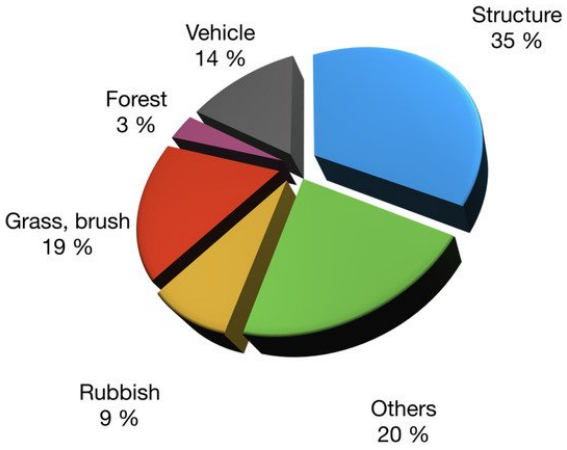

Figure 1. Distribution of fires by types [2]

Figure 2. Flashover occurence during an experimental compartment fire [4]

In order to get a better understanding of the flashover, recognize pre-flashover conditions and the factors affecting its acceleration or deceleration during a compartment fire, in the following chapters there will be presented useful information about the flashover types, factors affecting its development and some of the most common firefighter tactics to avoid it or to aggregate its development in time. Most of the information provided here are based on theoretical data and on empirical knowledge gained from experience on fire incidents.

2. FLASHOVER TYPES

There are a few different types of flashovers that exist. Depending on their charactristics, they are categorized into the hot rich flashover, the rich flashover, the delayed flashover and the lean flashover. All of them are, though, considered as a rapid fire progress in enclosure firesThe cause of a *hot rich flashover* is the *thermal radiation feedback*. This is the result of the natural tendency towards reaching a

balance inside of a structure. . Thıs is the most common type of a rapid fire progress which firefighters run into on a fireground. The rich flashover refers to the ignition of flammable gases with a rich fuel-to-air-ratio, being at the highest levels of the flammability range, while the delayed flashover occurs when the smoke cloud inside a compartment fire ignites outside of its room of origin. The lean flashover includes the gases inside a confined space fire mixing with the oxygen at the right level to ignite those gases on the upper smoke layer above the firefighters' heads. This results into whisps of flames occuring in the smoke. In that case, the flashover is just some seconds before occuring.

3. FACTORS AFFECTING FLASHOVER DEVELOPMENT

The time occurrence of a flashover is one of the most important events throughout an enclosure fire development. There are several factors involved into the development of a flashover, and the timelines associated with the occurrence of this phenomenon. These are the room / compartment size and shape, the building type and occupancy, the heat release rates of the objects included in that building, the natural or forced ventilation applied, and the use of water from firefighters in order to keep the hot gases below their flammability limit.

4. FIREFIGHTING TACTICS

Upon arrival at the fire scene, the extent of a building fire may vary from case to case. In the Figure 3 below, some indicative statistics about the stage of a building fire progress are given. As can be seen, there is an increased possibility that firemen arriving at scene will have to deal with a fire developed in the confined space environment around the initial ignition source, while the cases where the fire has spread to several rooms or several fire cells are lesser. It is, therefore, extremely important that firefighters must be well aware of identifying the signs and symptoms of a flashover, and they must also be trained in order to recognize smoke characteristics and apply the safest method of attack, including ventilation operations.
Factors need to be considered from firemen operating the fire scene include the identification of smoke characteristics, understand the fire dynamics of *ceiling gas layers* and *floor gas layers* during a fire in a confined space, the environmental conditions, especially the ambient temperature and the direction of blowing wind, the proper horizontal or vertical ventilation tactics and door entry procedures, and the use of water control techniques to keep the hot ceiling gases temperatures below their flammability limit. It is also very important for firefighters to be able to recognize the signs and symptoms of an upcoming flashover, such as the rollover and the feel of intense heat below their personal protective equipment, and being able to read the volume and speed of the smoke in the confined space.

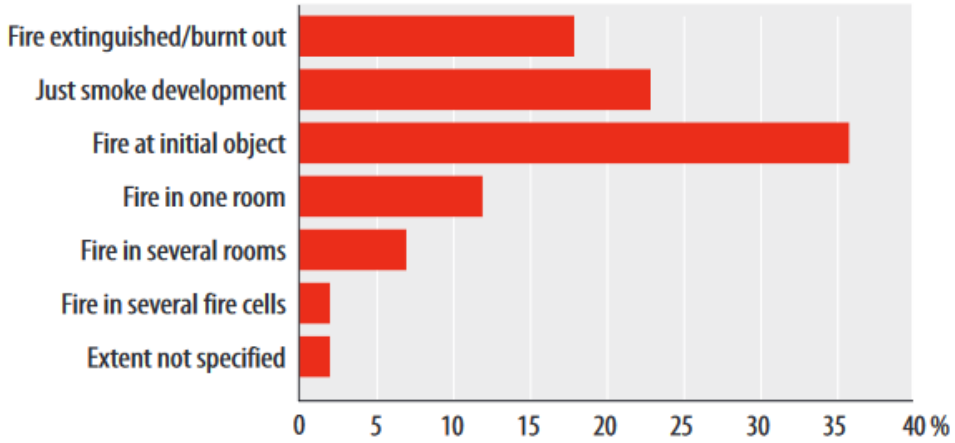

Figure 3. Percentage distribution indicating the extent of a building fire by the time the fire service arrives at the scene [6]

CONCLUSIONS

The flashover is one of the most dangerous processes wich may occure during a fire in a closed space. The purpose of this paper is to provide some basic information about the flashover occurence, recognition of its signs and symptoms, and some effective measures such as door entry procedures and understanding smoke characteristics which can help firemen to stay off from a flashover incident, or even to gain some important time to operate inside a building under fire, or even to escape from a confined space structure fire which may lead to a flashover.

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ENABLING GESTURE-BASED CONTROLS FOR FIRST RESPONDERS AND K9 UNITS

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ABSTRACT

Search & Rescue (SAR) operations often require the full attention and movement-dedication of First Responders (FR) in specific high-priority tasks, other than controlling a device or generating a message. In this work, novel technologies of wearables for FRs and K9 units in SAR operations are presented. The first goal is to provide alternative and complementary, low-overhead means of messaging in highly-demanding environments. The second goal is to use such platforms as control apparatus that significantly lowers the workload for FRs when controlling complex equipment like robots. These technologies are currently under development and already prototyped as part of the SAR Kit of the FASTER project, which is to begin field testing activities this year.

Keywords: Search and Rescue (SAR), gesture recognition, motion-based control, Unmanned Aerial Vehicle (UAV), emergency responder, earthquake, drone.

1. INTRODUCTION

A First Responder (FR) team operating as a Search & Rescue (SAR) unit inside a disaster area must be able to prioritize safety, mobility, and situational awareness over-focusing on user interfaces in applications and screens [1-3]. Users like to be able to operate several devices in a hands-free manner and, specifically for FRs, handling K9 units is typically based on “translating” the dog reaction according to its training by the FR. Regarding Unmanned Ground/Aerial Vehicles (UxV), suppliers provide users with cumbersome remote controllers that require both hands to be operated smoothly. Additionally, controlling such vehicles requires some kind of experience and is not straightforward. In contrast, FRs would like to be able to navigate the UxVs accurately by employing simple and ergonomic gestures. Based on these requirements, the FASTER[1] project proposes solutions that are capable of collecting data from gestures performed by the FRs, detect canines’ activity and barking by applying Machine Learning algorithms and, subsequently, forwarding these data for further processing, direct device control (UxV) or immediate alerts. The following sections provide an insight into such solutions, currently being developed in the project.

2. WEARABLE DEVICES AND GESTURE RECOGNITION

2.1. Wearable devices for humans

[1] This work is supported by the project FASTER, which has received funding from the European Union's Horizon 2020 (H2020) programme under grant agreement No:833507.

In FASTER, humans use wearables in order to communicate with gestures in the field of action [4]. The use of gestures to generate messages is considered for two reasons in FASTER: (a) use when in immediate danger without engaging his/ her mobile phone; and (b) when environmental noise is high and oral commands are not likely to be delivered successfully. For the former, the training of an Artificial Intelligence (AI) smart wearable framework named MORSE (MOvement Recognition for firSt rEsponders) is implemented. This framework tracks the FR arm movements, looking for certain predefined ones, in order to map them to pre-defined messages or alerts, therefore creating personal awareness messages and notifications. The generated alerts are typically broadcasted in the area near the FR, but they can also be forwarded inside the FASTER architecture to be used for situational awareness update.

To achieve the needed performance characteristics, after concluding with the selection of the tracking gestures, the algorithm is trained with datasets generated by different people that each, repeatedly, performs the selected set of gestures (see Figure 1). For MORSE, the smartwatch that is selected for use in FASTER is the Fossil Gen 5 smartwatch. At the same time, for reporting specific events using gestures, a mission management smartwatch application leveraging on the Wear OS built-in gesture recognition that counts only two selected gestures is being developed. This approach preserves low battery consumption and, hence, achieves higher device autonomy, which is of paramount importance in emergency scenarios. In addition, the design and development of a gesture recognition model are able to run in smartwatch devices exploiting the device's inertial sensors, increasing the number of available gestures for the mission management application. As a result, both solutions will be accompanied by specially designed applications that run on smartwatches and smartphones, supporting WearOS. Especially for MORSE, two applications will be developed: one for training the algorithm and one for use by the First Responders during the pilots and the evaluations tests.

Apart from wearables, FASTER also provides a Smart Textile Framework (STF) solution, which is a mobile application that collects data from a smart textile prototype. To this end, STF monitors the biometrics and environmental data from many sensors embedded on the FRs' undergarment and outside of their uniform in a transparent and modular way. Through the STF, alerts are generated and sent to the FR smartphone, e.g when a biometric measurement is outside the "safe" range. These alerts are also delivered to other components in the FASTER architecture (e.g., Scene Analysis from IoT Sensor Data module, or the Portable Command Center) to decide whether further actions are required.

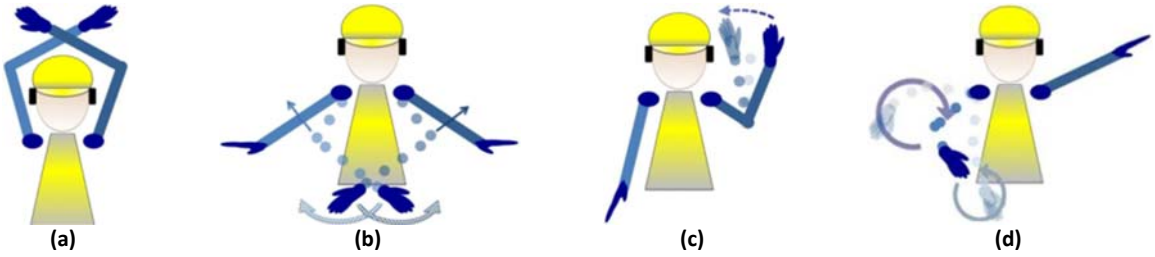

Figure 1. Gestures for recognition by the MORSE component: (a) "Recommend stop", (b) "Emergency contained", (c) "Recommend evacuation", (d) "Fire indication". The "distress" gesture is custom (not displayed here).

2.2. Wearable Devices for Animals

FASTER also develops wearable devices tailored to animals, specifically K9 units trained for SAR operations in disaster areas. A neck-mounted, wearable device for animals is designed and developed where a specially designed AI algorithm to detect barking of the K9 unit and recognize its activity whenever a dog performs a movement that can be translated to a specific action, e.g. detecting a victim

in debris. This algorithm runs in the computing unit in the dog's collar and results to the playback of predefined audio messages, by a speaker also embedded in the dog's collar. This apparatus is used for informing a detected victim that help is on the way and provide support until the FR team arrives. To extend the collar's coverage, a Base Station is also being considered as an intermediate hop node between the collar and access to FASTER's main infrastructure. The wearable device for animals is also able to broadcast the location of the K9 unit, information that is displayed by a specially designed application that helps the FR to track the dog's movement by displaying its location on a map.

2.3. UAV gesture control

FRs employ UAVs to assist them in several tasks while operating, including risk detection and victim localization. Typical UAV remote controllers tend to be heavy and cumbersome, require both hands to operate and have a significant learning curve. This is often contrary to the needs of FRs who may need to carry other important equipment and need to keep their hands free during a mission for other tasks. Considering the above, FASTER will introduce vision-based gesture control allowing FRs to fly UAVs in an intuitive and effective manner, without compromising their freedom of movement, safety, and ability to carry out their mission.

Figure 2. Controlling a UAV with finger-based gestures in a simulated environment.

FASTER has already identified a set of initial requirements [5], which have been used to drive the process of selecting the appropriate modes of control as well as the individual gestures to be used. In particular, two different modes of control were identified, which allow UAV control with simple gestures using a single hand: finger-based control defines a minimal set of gestures that correspond to controlling, one at a time, throttle, yaw and pitch forward; while palm-based control directs the UAV to follow the attitude and lateral movement of the user's palm, allowing for all UAV control combinations.
The initial implementation of FASTER's gesture recognition module for both control modes is based on LeapMotion, an infrared hand tracking peripheral. The two control modes were implemented in a UAV flight simulation environment, gamified with the inclusion of in-game collectible objects which define a path users can try to navigate using gestures. The resulting application, shown in Figure 2, provided the means to evaluate gesture controls a user study, with the participation of both FRs and members of the general populace. Palm-based control proved more effective, more intuitive, and easier to learn among a pool of testers; finger-based control can be useful for slow, precise maneuvers in tight spaces.
Following positive feedback from the user study as reported in [5], gesture control has been connected to a DJI Mavic 2 Enterprise Dual (M2ED) UAV for evaluation in a real scenario (Figure 3). Regarding the technical setup, the LeapMotion controller is connected to a laptop running a Unity app, which recognizes users' hand position and orientation via the LeapMotion SDK and translates them into UAV

commands. The UAV is controlled by a mobile device connected to the remote controller and running DJI's mobile SDK. Early test flights with both novice and experienced FR UAV pilots indicate that gestures provide easier and more intuitive control compared to the hand-held controller while allowing the same range of control and maneuvering.

Figure 3. Pitching forward (left) and backward (right) with the DJI Mavic 2 using palm-based gestures.

3. CONCLUSIONS

Modern wearable devices with significant computing power in small sizes enable the implementation of novel technologies for low-overhead messaging, alerting and control for work-overloaded FR teams operating inside a disaster area. For wearables for humans, a set of pre-selected gestures are used to train an AI-based component called MORSE. This approach is supplemented by the STF, a textile-integrated system of sensors that provide biometric and environmental measurements. In addition, similar wearable solutions are being developed for the K9 units for recognizing canine activity by designing and developing a neck-mounted collar equipped with sensors (e.g., accelerometer, gyroscope, camera) and an SBC (i.e, a Raspberry pi) to collect and process data related with the identification of a possible victim during action [1]. In terms of control, gesture-based UAV commands can be more intuitive and reduce the clutter of equipment carried by FR pilots on the field. More of these next-generation human-computer interaction prototypes are expected to be developed in the near future.

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NOVEL SYSTEMS FOR DETECTION AND MONITORING OF DANGEROUS SUBSTANCES IN WATER ENVIRONMENTAL SENSITIVE AREAS

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ABSTRACT

This publication presents the innovative system of autonomous robotic boats and their ability to detection heavy metals in surface waters. Initially, reference is made to the technology used and then the results of copper and lead detection in two Greek water bodies, Lake Koumondourou and river Asopos, are presented.

Keywords: INTCATCH, Robotic boats, Heavy Metals, Dangerous Substances

1. INTRODUCTION

Within the framework of INTCATCH H2020 project, the application of the robotic boats and their integrated sensors allowed monitoring and sampling of water quality in a large area of a catchment with far greater frequency than current sampling methods. By using the continuous monitoring system, potential sources and pollution pathways could be identified and the results provided EYDAP the opportunity to have a more comprehensive picture of the quality of the water body in real time and take immediate countermeasures. The possible effect from anthropogenic pollution can be thoroughly investigated with the use of the robotic boats and their integrated innovative systems. The INTCATCH autonomous boats through demonstration activities in Greek catchments [1] provoked a paradigm shift in the monitoring of physicochemical parameters, with regard to water quality and trophic status. Besides their basic sensors kit, the autonomous and radio controlled boats were equipped with an innovative Heavy Metal System [3], which was tested in Lake Koumoundourou and Asopos River (Figure1).

Lake Koumoundourou, is located on the northern side of the Gulf of Elefsina, within an industrial area. Its surface is 1m higher than the surface of the sea and has an area of 143 acres. Marine and freshwater from muddy sources are mixed, creating a wetland, brackish environment that has many characteristics in common with the formation of a coastal lagoon. The Asopos is a river in Greece that flows along the borderline between Boeotia and Attica counties [1]. Actually, in antiquity it formed the natural border between the cities of Thebes and Plataea. Along the Asopos River human activities –mainly agricultural and industrial ones take place. Those activities produce effluents resulting in polluting the river, aquifer

and soil of the area. The above-mentioned situation forms a negative but typical example of the impact to both humans and environment caused from non-sustainable use of natural resources

Figure 1. HM boat campaign in Asopos river, Oropos

2. EXPERIMENTAL METHOD

The INTCATCH architecture is divided in 4 main components: Bluebox, E-board, smartphone and tablet. The Bluebox communicates directly with the sensors and is responsible for interpreting the electrical signals, converting them to significant values and uploading the data to the Cloud database for permanent storage via a 3G connection. The E-Board is controlled by an Arduino Due that reads the physicochemical values from the Bluebox via a serial port and sends them to the smartphone, via a custom protocol via USB. The smartphone is the main computer unit of the boat. It controls all the autonomous behaviors of the platform and communicates with the tablet via WiFi to show the sensor values in real time and to receive commands from the operator. The tablet is an interface for the operator to control the vessel, displays the state of the vessel (eg position on the map) and the sensor values and allows the user to manage the data collection mission [2]. The architecture and components of the INTCATCH are shown in figure 2.

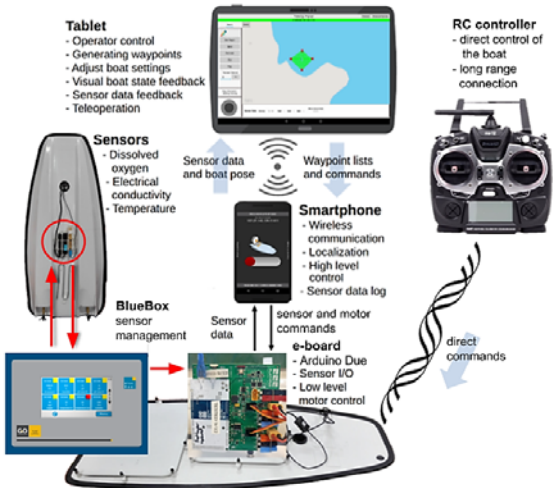

Figure 2. Architecture of the boat control system showing options for manual RC control and autonomous operation through the Control App running on the tablet (Bloisi,D. 2020).

2.1. Boat Equipment

The basic sensor kit for INTCATCH boats includes DO, pH and EC and a more specialized ISA sensor (UV / VIS Spectra in the range 200 - 720 nm). Additional sensors: chlorophyll and hydrocarbons and innovative sensors: Heavy metals (copper and lead), Escherichia Coli, Pesticides / Toxicity, Genomic analysis. A sampler is placed at the back place of the boat and contains 4 jars, of a volume of 500 ml each that can be activated individually with the tablet or independently [2].

2.2. Square Wave Anodic Stripping Voltammetry

This method consists of the several sequential steps [3]:

1. Conditioning step: a positive (or at least 0.0 V) potential is applied to the working electrode.
2. Deposition step: It is characterized by a deposition potential that is applied in order to reduce metal onto the working electrode surface. Depending on the exact value of the deposition potential, certain metals in free ionic form (or any specie/compound in real sample able to be reduced) will be reduced and deposited onto the working electrode surface. Deposition of the metals onto an electrode is a mass transport-based process. Usually, only a very thin interface between a sample and electrode participate in the reaction, so in flow through mode or under stirring conditions an increase of the signal can be observed.
3. Equilibration step: the role of this step is to allow the homogenization of the ion's concentrations within the electrode surface boundaries.
4. Stripping step: metals that were reduced onto electrode during the deposition step are now released (oxidized) as a square-wave is applied within the specific potential range. Oxidation for each metal occurs under the specific potential value, so the final voltammogram represents various peaks at different potentials and records electrical current proportional to the concentration of the metals. The voltammograms then need to be interpreted using software to measure the height or integrate the area under the peak, which is compared to standard concentrations, to calculate metal concentrations in the sample solution.

The steps of this method require a measuring system composed by a potentiostat, sensing electrode system (sensors), flow cell, peristaltic pump, software and a data processing system [3].

3. RESULTS AND DISCUSSION

3.1. Lake Koumoundourou

The Heavy Metals system was firstly tested in Lake Koumoundourou (28/05). The presentation was organized by Athens Water Supply and Sewerage Company (EYDAP S.A.) and the Institute of Marine Biological Resources and Inland Waters (IMBRIW) of the Hellenic Centre for Marine Research (HCMR). The outcome of the above deployment on demand was that EYDAP chose the Lake as a test area for the HM system. Therefore, on Tuesday, July 2nd, 2019, water samples collected from Lake Koumoundourou at three stations near the shore (demo, pumping and dam station). The HM system was tested successfully in the laboratory for Lake Koumoundourou and representative results are shown in Table 1, indicating the presence of free ions of Lead and Copper in low concentrations, close to the Limit of Quantification of SW-ASV method.

Table 1. Results of HM boat for Pb and Cu, Lake Koumoundourou 2/7/2019

No	Sample Name	Pb* (μg/L)	Cu** (μg/L)
1	koumoundourou demo station	8.06	< LOD
2		< LOD	< LOD
3	koumoundourou pumping station	< LOD	< LOD
4		20.0	26.6
5	koumoundourou dam station	12.3	8.83
6		8.09	< LOD

*Pb: LOD= 4 μg/L LOQ=14 μg/L **Cu LOD=7 μg/L LOQ=22 μg/L

3.2 Asopos River

On October 11th, a campaign was performed with the HM boat in Asopos river in collaboration with Laboratory of Environmental Chemistry of the National and Kapodistrian University of Athens (LEC-NKUA) (Figure 1). The calibration curves for Pb and Cu are shown in Figure 3. Measurements were conducted in real time in Asopos estuary with the results shown on Table 2.

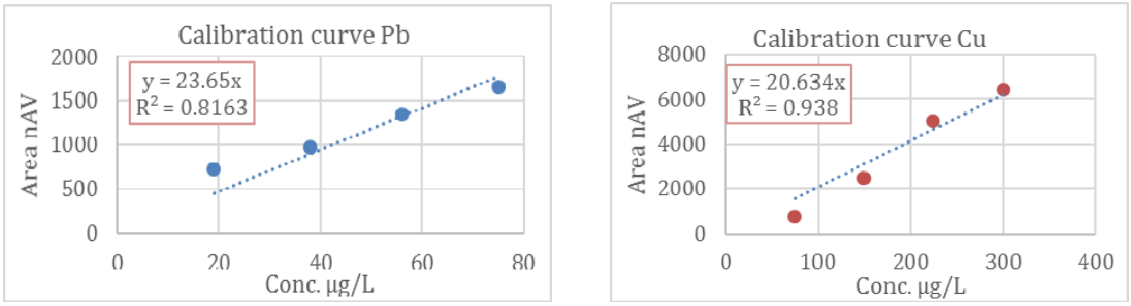

Figure 3. Calibration Curves for Pb and Cu, 11/10/2019

Table 2. Results of HM boat campaign for Pb and Cu, Asopos River 11/10/2019

No	Sample Name	*Pb^{2+} (µg/L)	**Cu^{2+} (µg/L)
1	Asopos river estuary (field campaign)	10.48	< LOD
2		<LOD	
3		7.63	
4		10.36	
5		10.81	

*Pb: LOD= 4 µg/L LOQ=14 µg/L **Cu LOD=7 µg/L LOQ=22 µg/L

4. CONCLUSION

The developed integrated system performs positively in terms of in-situ detection of concentration changes for Pb and Cu in surface water bodies in the range of several µg/L (4µg/L and 7µg/L respectively). This detection sensitivity can enable addressing certain INTCATCH challenges such as detection of point contamination from road runoffs, misconnections and cross connections, but it is not sufficient for measuring the accurate concentrations of these metals in aquatic environment [3]. The analytical method shows a lack of selectivity due to influences from various ingredients in water and from concentrations rate of other metals. Based on, the above observations further development work is ongoing between three project partners involved (ICN2, GOSYS and BOKU) towards the goal of enhancing sensitivity and minimizing/avoiding interferences, using the fingerprinting approach.

ACKNOWLEDGEMENT

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MARITIME ACCIDENTS AND ENVIRONMENTAL HAZARDS. CREATING A DYNAMIC MODEL FOR PREDICTING MARITIME ACCIDENTS AND ENVIRONMENTAL POLLUTION

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ABSTRACT
Several areas of Greek territorial waters, although environmentally sensitive, have already been heavily burdened by oil pollutants caused by marine accidents. The morphology of the sea area (narrow waters, shallow waters near bays and ports), specific weather phenomena and increased traffic in certain marine routes, make the risk of an accident with environmental effects of this nature even greater. Data so far has shown that maritime accidents and especially in the unique Greek maritime area will occur.

Keywords: maritime accidents, oil pollution, environmentally safe shipping, dynamic model

1. INTRODUCTION

Greek territorial waters with the Aegean Sea as their centre form one of the main naval connecting links in the world. Their characteristics are the key geographical location, the extremely rich and special marine environment with a large coastline, the thousands of islands, as well as the intense activity of ships. To the importance of Greek waters and more specifically, in the Aegean, is added the circulation of a significant number of merchant ships that transport goods from the Mediterranean to the Black Sea and vice versa, as well as passenger ships that connect Greek islands with Turkey. The study of accidents in Greece is of the utmost importance, mainly at the environmental level, since Greece is consistently one of the main naval and merchant fleet forces in the world, with its territorial waters hosting huge numbers of ships every day, with flags from all over the globe [1, 2].
Moreover Greek maritime areas can be characterized as pillars of the Greek economy and society, with a large percentage of Greeks making a living either directly or indirectly from them and the wealth they offer. Therefore, it has become obvious that a possible accident with direct environmental impact on the Greek seas, will cause impeccable damage to the social, economic, environmental and cultural sectors of Greece and the wider region of the Eastern Mediterranean basin.
One of the most destructive forms of water pollution is the release of liquid oil into the marine ecosystem. Oil spills due to human activity can be caused by the release of crude oil from ships, oil rigs and oil products such as gasoline and diesel.
There is, therefore, an urgent need to predict and avoid accidents that result in oil losses in the Greek maritime waters. In the context of this effort, a dynamic model is attempted to integrate the existing knowledge and experience gained around accidents of this nature in order to ensure environmentally safe shipping in Greek territorial waters.
In order to fulfill the above project, the goal was to study and understand previous maritime accidents, at Greek and international level, and to identify the causes and factors that led to maritime accidents with losses of oil pollutants. Another goal, at the urging of agreed guidelines, is to understand the nature of

these accidents, determine their frequency, and the extent of the multi-level damage they can cause in all areas that will hit the country's viability.

2. ANALYSIS

In the event of a maritime accident with a direct consequence of oil pollution, there are a number of laws and protocols that specify the steps to deal with and repair it. The current model will be fully harmonized with these guides and is built based on them.

As previously mentioned, one of the most destructive forms of water pollution is the release of crude oil from ships and oil rigs. The release of oil from ships can result from various types of maritime accidents such as: damage caused by current weather conditions, sinks, groundings, collisions, fires, explosions, damage or failure to the ship structure, losses due to hostilities and conflicts and motley accidents.

It is worth noting that the cases of collision and grounding accidents have attracted the interest of experts in because of their severe consequences when it comes to oil pollution. This resulted in the creation of separate rules through the International Convention for the Prevention of Pollution from Ships as they have the most severe environmental impact. For this reason these two types of accidents will be researched extensively and their possible impact will be considered more severe compared to other types of accidents.

Numerous accidents, such as Macondo, have shown that marine accidents with oil spills can also occur from offshore oil platforms. These accidents have shown that they have had very serious consequences for the lives and health of workers, environmental pollution as well as direct and indirect financial losses [3].

In the event of an oil spill, the resulting oil spill gradually spreads throughout the marine area and then undergoes a series of chemical and physical changes. Most of the processes that take place such as evaporation, dispersion, dissolution and sedimentation contribute to the removal of oil from the sea surface. While other procedures promote its concentration at the accident site such as mouse oil grill and increase viscosity. The quantity, the type of oil, the prevailing weather conditions and the condition of the sea affect the speed of the processes. The marine environment also eliminates the remaining parts of the oil slicks through the long-term process of biodegradation [4].

Indicatively, some of the most basic methods of oil spill repair are mentioned: Trapping of the oil spill with floating dams, use of chemical dispersants, use of absorbent substances, mechanical dispersion of the stain, natural self-dissolution of the stain in cases where no repair is required, cleaning the polluted coastline with various mechanical or manual means and capping and recovering devices [5].

The model under construction is based on two parts. The first part is to calculate the probability of an oil spill accident and its probable extent. The second part concerns the financial nature of the accident and the available ways to deal with it with the aim of the best financial solution in terms of rehabilitation based on cost-benefit analysis of real accidents.

The first step for the construction of this model is the collection of data from all stages of dealing with and rehabilitating maritime accidents of this nature that have occurred in Greek and international territorial waters. An important factor is to find as much data as possible so that the risk identification and assessment steps are reliable. The aim of this quantitative analysis is to create a clear picture of the influence of all the unchanging factors of a ship that can lead to an accident due to oil spill in Greek territorial waters and to determine the possible cost of its restoration.

The first and most important step in terms of risk analysis is to identify the potential problems that all stakeholders will face. The nature and extent of the hazards will depend on various factors, such as the category of the ship, the way the ship is built, its size, its operation, the external effects on the vessel, the type of accident (e.g. collision, explosion) and the risk and consequences of all these factors. The above

factors should be studied in combination. However, in addition to the above, the analysis and understanding of previous accidents, the determination of the cause of the accident and identification of the factors that led to the accident are also important. Through these two methods we achieve the complete identification of impending dangers.
In the second step we are confronted with understanding the nature of the possible factors that can fail while navigating a ship and the damage that can be caused in all areas. In this way we can properly assess the safe route that the ship must choose by rejecting all high-risk areas. Understanding the nature of the risks and the type of damage they can cause helps to make better decisions in order to deal with them.
The third step seeks to find all the ways-options through which a risk can be completely avoided or even significantly reduced. The security risk analysis is performed to determine which of all the available options can be selected for practical purposes.
The fourth step is to determine the amount that will cost to use a specific method to avoid risk. The cost of a particular method is a determining factor in whether it will be selected. In essence, the cost of the solution should be less than the extent of the damage that can be caused by this risk. In the last step, an attempt is made to choose the most appropriate method of avoiding an accident. This method must be characterized by reduced risk and consequences. A comparative study of all available options is essential. The main goal is to make sure that the method chosen will bring better results compared to other options in terms of cost and risk reduction.

3. METHODOLOGY

The calculation of maritime accident risk is characterized by high complexity. The main methods of analysis chosen to calculate this, so far, are decision trees, fuzzy logic, and Bayesian networks. In recent years, Bayesian networks have been increasingly used in the shipping industry, and fuzzy logic is one of the most useful non-conventional problem-solving control techniques characterized by complexity and uncertainty. [6] For the processing of the data collected in the research will be used supervised learning, through the use of Bayes networks but also the method of fuzzy logic as a complementary tool.In both models that will be built, the final risk is calculated, as defined in the current legislation and directives. Specifically, the risk (R) is defined by the probability of an accident (P) occurring on the severity of its consequences.

$$R = P \times S$$

Therefore the proposed model combines the results of the probability of an accident with the severity of the consequences it caused. In the last stage of the model the two factors (P) and (S) are integrated and produce the final environmental risk (R) as shown in Figure 1.

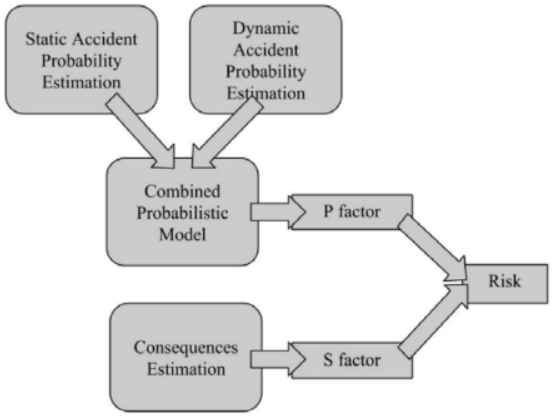

Figure 1: Illustration of the methodology for the developed model.

4. EXPECTED RESULTS

In the present paper a methodology is built capable of predicting a possible environmental risk of maritime accidents. The above will be achieved through the construction of Bayesian and fuzzy networks taking into account the main characteristics of the vessel, i.e. the type of vessel, tank size, age, etc., the dynamic characteristics of the accident such as traffic, weather conditions, location, etc. as well as the estimated environmental and economic consequences. Taking into account the parameters of location, statics, dynamics and navigation, the probability tables that will be defined for this model have been determined using historical data in combination with the knowledge of experts. The model that will be constructed essentially assesses the probability of an accident in a specific area and after taking into account the consequences (i.e. the cost of repairing a possible oil spill) estimates the final environmental risk. This will make it possible to identify areas and sea routes with high or low environmental and economic costs, taking an important step in reducing accidents with a high environmental risk.

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EARTH OBSERVATION FOR COASTAL EROSION MONITORING IN EUROPE: THE SPACE FOR SHORE PROJECT

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ABSTRACT
Coastal erosion is one of the biggest problems for the coastal regions of Europe. A big part of the European economy is based on the maritime economy, tourism, and yachting. Space for Shore is a European project fully funded by ESA that aims at setting up operational services for coastal erosion monitoring from space based on both optical and SAR Earth Observation data. The services, designed by and for end-users, will be applied to most coastal geomorphologies and produced over 9 distinct coastal regions within 5 European countries (France, Germany, Greece, Portugal, and Romania). The consortium is comprised of 10 remote sensing and coastal experts and it relies on a large community of end-users, which allow the service demonstration over a total of 1.000 Km long coastline. More specifically, the Harokopio University of Athens is one of the project's SAR experts and provides products based on SAR data regarding the waterline extraction in Greek coastal regions and for the cliff movement (PSI) in French coastal regions accordingly.

Keywords: Coastal erosion, Europe, Earth Observation, SAR data, coastline

1. INTRODUCTION – OBJECTIVE

Today, more than 200 million European citizens or 41 % of Europe's total population live in coastal regions while another 33% live within 50 Km from the sea [1]. Coastal regions account for about 40% of the European Union's Domestic Gross Product that mainly cames from the maritime economy, tourism, and yachting. Furthermore, the total value of the economic assets located within 500 m from the EU's coastline, in 2004 estimates, was about 500 - 1000 billion Euros with beaches, agricultural land, and industrial facilities included [2], [3]. Coastal erosion is a global worldwide threat for coasts. To put it differently, issues caused by coastal erosion, in the context of global warming and sea level rise they are going to be even more relevant in the future as both the frequency and strength of storm events are likely to increase causing billions of Euros of damages. Unfortunately, neither of the European directives covers this topic, and thus this problem is being dealt with at national levels that result in heterogeneous degrees of concern in the different EU Member States.
Dealing with coastal erosion implies to provide highly precise (sub-metric) geo-located information about shorelines on a yearly to decadal timescale. For this reason, the approach for coastal erosion assessment has been based on historical data sets that allow accurately determining the erosion hazard and projecting from such hazards at various time horizons that are compatible with safe coastal planning for people and goods. The utilization of new technologies in shoreline monitoring has significantly increased during the past 20 years (e.g. airborne lidar topographic surveys, photogrammetry, in situ laser scanning) but their definitive adoption relies on t their cost-effectiveness.
The Space for Shore is a European Project based on five European countries: France, Greece, Germany, Romania, and Portugal. The project focuses on the prototyping of coastal erosion products derived from past and current Earth Observation missions, including the Copernicus Sentinel-1/2 missions which offer bi-weekly revisit all over Europe.

The Coastal Erosion project is end-user driven. Coastal managers are central: (i) they have defined the required products; (ii) they have been sharing their ground truth datasets issued from their current monitoring program; and (iii) they will finally test the new products and give feedback about their relevance.
Rapid, up-to-date, and correct information is required in coastal management. Thus, coastal movements have primary importance for coastal managers. For the coastline change monitoring, remote sensing data play an important role in enabling the detection of any change by the extraction and comparison of coastlines of different time periods.

2. STUDY AREA

The test sites are located on the coastline (extended around 5 Km in both directions, inland, and sea) of northern Greece and a minor part of Turkey (Eastern of Evros Transboundary River). More specifically, it is extended from the City of Kavala, in the West, to the coastline of Sultaniçe in Turkey, in the East. The test site's coastline length is approximately 230 Km and the total area is 2.456 Km^2. The test site consists of two large urban areas; Kavala which is located on the west and Alexandroupoli on the east side of the area of interest.
The French test sites are located at the coastline of Normandy on the English Channel, because of its moderate exposure to waves and the macro to megatidal range of up to 14 m (Bay du Mont St Michel) and at the Nouvelle Aquitaine in the south-west of France, a highly dynamic coastal area exposed to Atlantic swells and having a mesotidal range (3-5m). There is a variety of coastal geomorphology, dominated by sandy sediments with well-developed coastal dunes, the quasi-linear coast is interrupted by estuary inlets and mixed-sediment lagoons. In the south of Aquitaine, close to the Spanish border, coastal cliffs can be found.

3. EXPERIMENTAL METHODS

It is possible to monitor coastal changes by extracting the coastline from satellite images. In the literature, most of the algorithms developed for optical images have been discussed in detail. In this study, two algorithms that extract coastlines automatically by processing SAR (Synthetic Aperture Radar) satellite images have been developed. The algorithms were developed in the open ESA's SNAP software based on a binary technique with the first one using one image per year and the second one using a set of four or five images for the same month of each year. Utilizing Sentinel-1 GRD data, at a resolution of 10 m, we expect to decrease the propagation of such approximations on topography interpolation from water lines while performances and limitations were carefully addressed. The first algorithm (single image), was applied on six images each for every year (2014-2015) from the same month (September). The second one (multi image), was applied on four images for the same month (September) for the year 2019. In order to test the accuracy of coastline detection, we organized a validation campaign with GPS in some of the test site areas. Based on the validation data, the second algorithm proved to provide more accurate results for the coastline detection.
Regarding the PSI algorithm, a large stack of SAR images acquired over the same area was used for a long deformation time series. These coherent methods exploit either permanently coherent Persistent Scatterers (PS) or temporally coherent Distributed Scatterers (DS). PSs are typically artificial objects that reflect radar energy well such as metal structures and buildings. The PS methods that have been developed include the Permanent or Persistent Scatterer Interferometry (PSI). PSI provides a parametric estimation of the 3D location and velocity of each PS along the line of sight (LOS) connecting it to the satellite [4], [5]. These measurements are combined using PSI to produce highly accurate terrain motion

maps. To monitor and analyze the ground deformation along with coastline sites, open and free Sentinel-1 A&B SLC images were used and in order to produce retrospective coastal deformation also, ERS-1/2 and ENVISAT satellites archive data from 1992-2010 were used which is available at medium resolution. Depending on the characteristics of each coastal area were used both PSI and DS methods. The PSI processing took place in commercial GAMMA RS software's IPTA module algorithm [6].

4. RESULTS – DISCUSSION

The waterline techniques detect the multi-temporal coastline vulnerability with the second algorithm providing more reliable results based on the validation data (Figure 1). The PSI technique is resulting to point interferograms with the final Persistent Scatterers showing the deformation rates for the French case studies (Figure 2). The points of ground deformation are detected mainly in the builder area. Partially the task was obtained but, in some areas, there was a lack of scatterers near the cliffs.

Figure 1. Single waterline method and validation data for Greece in Vistonis-Maroneia POC site

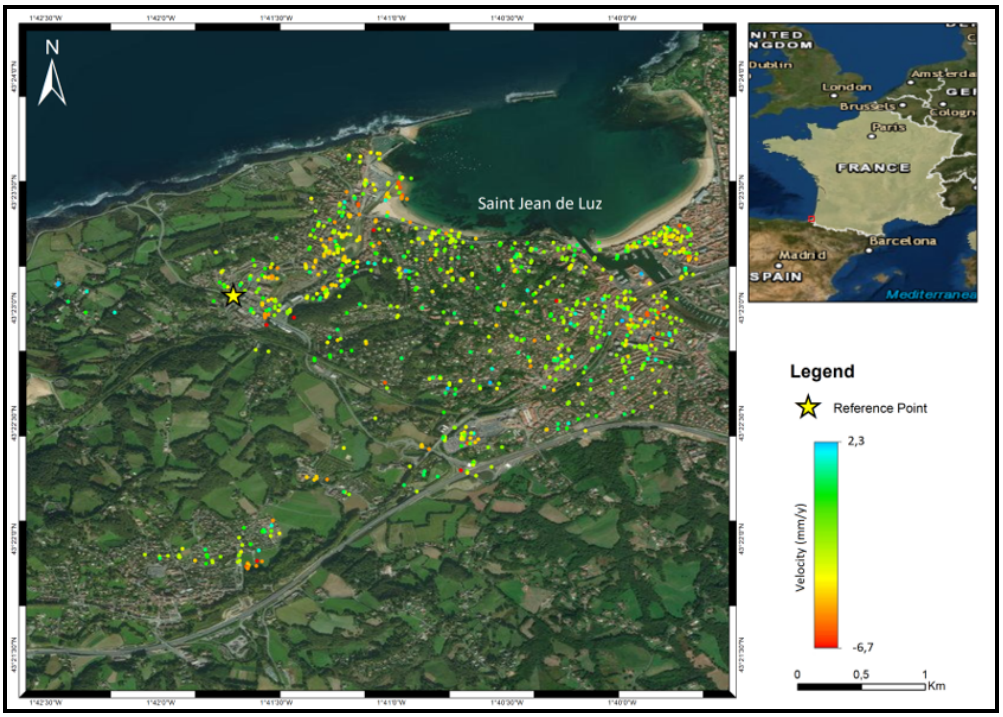

Figure 2. Top of the cliff movement with Sentinel 1 data for 2014-2019 Corniche Basque

5. CONCLUSION

In conclusion, the part of the Space for Shore project that we are carrying out:

- Is applying and developing further the interferometric techniques of PSI and the waterline detection techniques.
- Is providing a range of validated satellite products covering a part of European coastline types and patterns of coastal erosion.
- Is supporting end-user needs by the provision of knowledge about the coastline erosion.

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NATURAL DISASTERS AND TECHNOLOGICAL ACCIDENTS: EDUCATED TO PROTECT AND TO BE PROTECTED IN SENIOR HIGH SCHOOL

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ABSTRACT

Almost all European Union countries face natural disasters, which is why it is important to evaluate the potential hazard to these countries, and especially, to Greece. This was the main incentive for implementing in our school an educational, environmental project in collaboration with the elective subject of 'Natural Resources Management'. Apart from inspiring students, the program aimed at providing an incentive for students' promoting environmental protection, ways of sustaining the dangers, helping others to cope with them, as well as ensuring the dissemination of information to others. Overall, the program was based on the model of constructive approach and made use of students' misconceptions to build up knowledge.

Keywords: environmental project, students, earthquake, disasters, emergency plan, 112

1. INTRODUCTION

The environmental project implemented in our school was designed for first grade senior high school students, aged 15-16 years old, as part of their elective course "Natural Resource Management". It followed the constructive model teaching approach [4,5], and combined different school subjects, such as mathematics, geography, chemistry, information communications technology, and English, all enriched when included in an environmentaly program. Since our school is a member of the partnership program Teachers4Europe, the environmental program also tapped the European dimensions of the subject researched.

During the school year, students studied various natural disasters occurring in almost all European Union countries, such as earthquakes, fires and floods. Regarding earthquakes, they realized that although this natural phenomenon cannot be predicted, it is important for all European citizens to know how to protect themselves and others when found in such difficult situations. The European student, being tomorrow's European citizen, must be trained to collaborate with others and follow the state's instructions faithfully. By participating in our school's environmental project, students learned how to deal with earhquakes at school by implementing drills and therefore, became more responsible and able to disseminate the knowledge gained both to their families and the their immediate society.

At the same time, students got informed about technological accidents and realized how important this is for them as more than 20 industrial facilities located in our area implement the European directive SEVESO for the safety of workers and the environment. As part of their orientation, they visited the environmental observatory of Aspropyrgos, where they realized that human life is non-negotiable and defending it, is of outmost importance and cannot be debated. All measures taken should, therefore, be in accordance with the European directive SEVEZO for workers' safety, and for environmental safety. Students were also convinced that in an emergency situation, they should call the emergency European number 112, which can be dialed in all the countries-members of the European Union in order to facilitate the communication of citizens with the national emergency servic

2. DATA AND METHOD

Students' misconceptions [1,2,13] trigged our need for examining natural phenomena. By working on them in small groups, students initial cognitive conflict [5], can lead them to gaining the respective knowledge. Being aquainted with the basic of ICT is also prerequisite for students to be able to access this knowledge [3,5,17]. At the end of the project, students are expected:

- To have aquired some basic knowledge on natural phenomena, such as earthquakes, fires and floods.
- To be able to explain how an earthquake is created in relation to the movements of lithospheric plates [3,4,8,9,10].
- To be able to refer to some basic earthquake characteristics, such as earthquake magnitude, epicenter, focal depth, and seismic wave.
- To be able to identify seismic areas on the world map and navigate through seismic areas using GoogleEartth [8].
- To locate the position of Greece in relation to the position of the tectonic plates, using appropriate software [8].
- To realise that it is not possible to predict earthquakes.
- To understand that the effects of an earthquake on a residential area depend on the subsoil and the infrastructure of the buildings.
- To master the correct actions to be taken during and after the seismic vibration [6, 12,13].
- To be able to implement a specific emergency plan, organised by the school authorities.
- To collaborate in groups, respecting all members and partners.
- To understand the importance of acting responsibly when they follow a plan of action.
- To develop a positive attitude towards the scientific way of thinking and working [15].
- To be aware of volunteering offer and to develop a sense of responsibility.

3. RESULTS

Students eagerly participated in the weekly meetings during which they used simulation tools, such as Phet Interactive simulations, Google Earth, and Photodentro, to navigate through various earthquake zones [3,4,8,9,10,12] and find photos depicting real-life disasters. Through their search, their misconceptions were challenged, while at the same time, they realised the meaning of the term 'scientific facts'. Most importantly, they came to understand that natural disasters, such as earthquakes, cannot be predicted, but people need to be educated about them to protect themselves and their fellow human beings. To reach this end, each student group reported on the hazards that they identified in the respective sub-area, justifying the labeling with the criteria of OASP and then, proposed ways to remove or ovecome the respective hazard.

In addition, a group was appointed to disseminate the information aquired in relation to the manner, priority and time of evacuation of the classrooms, should an earthquake occurs during school time. They were also responsible for checking whether the instructions and a summary evacuation plan chart were placed in all classrooms for all students to see. Another group was responsible for removing large glass surfaces and any objects placed at a high point from the classrooms. They also posted fluorescent arrows to indicate building exits and posted the evaluation plans on the classrooms' bulletin boards. A third group was in charge of making sure all the necessary equipment and material (i.e. flashlights, whistles, firts aid kit, lists with the names and phone number of students' gaurdians, etc.) were kept at an appointed location and were regularly updated [6,12,18].

All the students were asked to participate in an earthquake drill so that they would be prepared to apply it, if necessary. In this way, the knowledge gained through the project would be tested and validated, increasing students' self-esteem at the same time. It is common practice that once a drill is over, a group of students hands out a questionnaire [11] to all the teachers and the students of the school to be completed and handed in as soon as possible [6,11,14].

This school year,however, for reasons of convenience the questionnaire was created through Google forms, and it was therefore,easy to complete, and process it statistically [11]. In particular, it was administered to 21 students and answered by 17.The results showed that 12% of the students did not stay in the classroom during the earthquake drill, but tended to run out of the classroom. 17% of the students answered that no lists of students' names and phones of guardians were kept. 18% of the students did not recognize what the "start" sound for the earthquake was. Moreover, 29% of them did not recognize the "end" sound, as well. Finally, 41% of the students had not even noticed the emergency exit marks posted in each classroom. All of them, however, were interested in repeating the drill and in practicing emergency plan imlementations more often. The complete questionnaire can be accessed electronically for further study [11].

Furthermore, it is a fact that not only natural disasters, but also technological ones have increased seriously during the last 50 years, which may have their direct or indirect impact on people, their economy, and their environment, affecting in the long run humanity as a whole. This is one of the reasons why industries need to estimate the potential dangers and take measures to reduce them, in accordance to the civil protection and European directive SEVESO. Civil Protection refers to all the activities aiming at the protection of human life and citizens' properties in cases of any natural, man-made, or environmental disaster by decreasing their effects at a European level in accordance to the national policies and on the basis of the principle of subsidiary.

Finally, a number of educational field trips were organised as part of the environmental program. In particular, during the first part of the project the students visited National Observatory of Athens and then, Goulandris Natural History Museum, where they attended the educational program 'Create an Earthquake'. They also visited the local fire brigade department. Given the fact that our area is still suffering at the aftermath of recent floods and fires, which cost human lives, the officials there informed students both of the department's role and the students' individual responsibility as European citizens when dealing with natural or man-made phenomena.Then, during the second part of the project, the students organized a one-day educational filed trip at the environmental observatory of Aspropyrgos, where air and water pollution are measured, and collaboration with the civil protection department is set up, following the European legislation and the European direction SEVESO on the implementation of an emergency plan. They also visited the Revithoussa Liquefied Natural Gas Terminal, where they were informed about its operation and the measures they undertake to conserve both air conditions and protect the aquatic environment, as well as the people working there.

4. CONCLUSIONS

During the project, reference to the European legislation regarding the measures industries should implement to avoid air and water pollution, as well as emergency management plans to be followed in case of any technological accident was made [15,18]. In general, all countries-members of the European Union have the common goal of preparing their citizens to cope with natural phenomena. In Greece, the General Secretariat for Civil Protection and the Earthquake Planning & Protection Organization ensure that today's students and tomorrow's citizens are informed and prepared to implement crisis management plans. Being European citizens, all students, regardeless of their country of origin, should be prepared to cooperate and follow state instructions on natural disasters. As for accidents, the

European Union and the General Secretariat for Civil Protection in Greece are currently drafting new, updated accident management plans. Tomorrow's Greek and European citizens must be informed and educated so that they can implement such a plan and protect human life and people's right to security.

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RISK COMMUNICATION AND DISASTER MANAGEMENT IN GREECE: THE PROSPECT OF AN ADULT EDUCATION PROGRAM

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ABSTRACT

The present study[1] addresses the issue of education in Risk Communication of disaster management/ Civil Protection professionals in Greece. To this end it seeks to validate the necessity and to determine the nature and basic characteristics of a relevant training program.

To do this, besides literature review, 11 professionals were interviewed on the importance of risk communication in the field and the necessity to be trained in it, as well as the educational needs and expectations that such a program should meet.

Interviewees confirmed that knowledge of risk communication is indispensable for all people involved in disaster management and deem a relevant program to be necessary -if not compulsory- in a form and content that should be adjusted each time to the needs of its perspective recipients (individuals and/or institutions). They practically demanded that it is taught by experienced and certified adult educators who will be knowledgeable not only in communication but also in disaster management. They prefer face-to-face training that focuses on practical knowledge and drills and wish for journalists to attend it as well, in order to improve cooperation and understanding between them.

Keywords: disaster management, civil protection, risk communication, adult education, needs assessment.

1. CRISIS AND EMERGENCY RISK COMMUNICATION

Risk Communication constitutes an integral part of disaster management and a means of support for civil protection. Its various forms, content, and extent depend on the phase of the management cycle in which they are carried out and as a result certain actions spread over the entire cycle, while others focus exclusively on selected phases [1].

In literature one may come across the terms “risk communication” and “crisis communication”, yet the present study utilizes their combination, known as the Crisis and Emergency Risk Communication (CERC) model, which incorporates the principles and practices of both [2]. CERC places emphasis on the dynamic characteristics of a crisis and the people’s varying communication needs as the situation evolves. As such, the model views crisis as a process that needs to be addressed at the pre-event stages before a risk is manifested, during its outbreak, and to continue into the recovery phase. It also acknowledges that effective communication regarding crises and emergencies must be carried on long after the immediate danger has passed, to facilitate new understandings of the risk and the necessary revision of procedures and policies to reduce it [3].

[1] The text draws on the author’s professional experience as Strategic Communication Advisor at the GSCP and is based on the postgraduate thesis she submitted, under the same title, for the “Adult Education” Postgraduate Course of the Hellenic Open University. Full text available at https://apothesis.eap.gr/handle/repo/46403.

2. THE GREEK REALITY IN RISK COMMUNICATION

In accordance with the country's overall civil protection system, risk communication in Greece is designed and delivered in three administration levels (state, regional and local) by various public services and entities, under the coordination of the General Secretariat for Civil Protection [4]. Yet in the case of an emergency, up to 20 different bodies may become involved in communicating the crisis, in addition to elected or appointed officials who have the legal duty to act as spokespeople [5]. What is more, the messages that originate from all these sources must be aligned and not contradicting in any way, as the people's safety or survival may depend on them [6].

This would be less of a challenge if the people responsible for risk communication had the right guidance or had received adequate training for it, but this is not the case in Greece. Most of the public servants involved with communication in disaster management receive no targeted training on the subject and are assigned the role regardless of their scientific or professional background.

Despite common hazards such as earthquakes that constantly threaten the country [7] and the fact that disasters globally will only worsen in the future [8,9], there exists no kind of educational program in risk communication and the subject is only taught as part of general courses in Disaster Management.

Similarly, the Greek scientific literature on risk communication is meager; some works can be found in conference proceedings [10,11] and postgraduate theses [12,13,14,15,16], though the latter focus only on the involvement of the mass media in civil protection.

On the contrary, international literature has long demonstrated the need for training in risk communication -equally to all other operations of disaster management- and highlights the consequences where such knowledge is missing [3,6,17,18,19].

3. OBJECTIVE AND METHOD OF THE STUDY

In view of the above and with the aim to support disaster managers in their complex role, the study proposes the design of a training program exclusively in risk communication for civil protection professionals and draws on their experience in order to determine (a) whether they indeed consider such knowledge and training necessary and (b) the target and essential characteristics of such a program, as well as the knowledge and skills they would expect to acquire from it.

Prior to the research, an extensive review of the literature on disaster management and risk communication was carried out, as well as a study of the Greek legislation on civil protection and the design of adult education programs. Also, an extensive search of available Greek bibliography and relevant courses. Based on those, a semi-structured questionnaire was developed on 3 axes: (1) experiences from risk communication, (2) views on its importance in the field of disaster management and the necessity for training in it, and (3) the basic outline of an educational program in risk communication. The questionnaire prompted the personal interviews of 11 civil protection professionals of different disciplines, from all three administration levels, who held various positions involving communication and had dealt with different phases of the disaster management cycle.

The informants were executives from policy-making services, first responders, officers from prefectures and municipalities and a researcher. Four of them had worked exclusively on communication (e.g. in a press office), while others had experience of other operations as well, having served in regional or local civil protection offices or relevant EU services. The majority had a long professional history in civil protection, not only in the field, but also in research, training, and drills. The defining criterion for their selection was their working experience on the subject, yet five of them were also adult educators, which added to their grasp of the subject and the thoroughness of their answers.

4. RESULTS

As far as risk communication is concerned, all interviewees agreed on its decisive role in efficiently managing disasters and rendered it almost as important as disaster management itself. They believe that such knowledge is essential for everybody in civil protection and sought on their own to acquire it, as none of them had such scientific background. When addressing the public, risk communication is deemed crucial not merely as regards information but also for better understanding their own place within the civil protection mechanism and the extent to which they can actually help in a crisis and in the long run. Risk communication was also considered fundamental for the development of appropriate and effective messages that alert but do not induce panic. Regarding interaction with the media, all interviewees described it as exceptionally demanding and deem that special knowledge is necessary for their handling. In addition, they highlighted the requirements of communication among civil protection services and personnel, without which they are unable to achieve interoperability and efficient collaboration.

They believe that a relevant educational program is absolutely necessary if not compulsory, at least for the people handling communication. Its form and duration should be adjusted each time to its prospect recipients and scope, and it is imperative that journalists attend it as well, to improve cooperation and understanding between the two communities of practice. The educational program should deliver mostly practical knowledge and be revisited on regular intervals. Although on-line training is always an option, interviewees agreed that face-to-face is significantly more effective, especially when it concerns communication. The program should be delivered free of cost, preferably by a public entity, and it is estimated that since its recipients will be public servants, they will prefer it to take place within working hours and lead to certification or allocate credits.

Interviewees were unanimous in their opinion that the program cannot be taught by educators of a single vocation but rather by a combination, namely a communication specialist, a journalist, and professionals with experience in disaster management and knowledge of the corresponding legal framework. They also agreed upon the need for certified adult educators or, at least, ones that have had relevant training. Lastly, besides risk communication - and among other topics - the program must definitely provide basic civil protection knowledge, along with common terminology for disaster management, the structure of the country's mechanism, utilization of ICT, and ways to address the public and the mass media.

5. CONCLUSION

Training in risk communication is considered a sine-qua-non for disaster management, however it has to be meticulously defined, targeted, and adjusted to its recipients' particular needs. There is no one solution for everyone, since its content is different for press officers, researchers, policy makers etc. and, as a result, the educational needs and required skills for those implementing it differ. Moreover, as the ever-changing context of disaster management practically shapes risk communication, the design of any relevant training program must be grounded on the particularities of both fields and knowledge on disaster management must invariably be delivered in tandem with that of risk communication. Furthermore, such training is instrumental to influencing people's risk perception and altering their mentality and habits, which is essential to rendering them "partners" in civil protection and better prepare for future risks in addition to the familiar ones.

As regards a potential course, one needs to consider that disaster managers are in considerable need for knowledge which will help them weather the challenges that arise not only during emergencies but in their day-to-day work as well. They insist on new educational forms and seek courses that will stimulate them because they regard the current, traditional ones tedious and outdated.

On the whole, along with answering our research questions, the present study provided a realistic portrayal of the current situation in risk communication and the predicaments that disaster managers most often find themselves in. This led to the conclusion that a broader change in mentality is necessary within the entire civil protection system and the State as well. Officials need to realize that proper and systematic risk communication will enhance the State's credibility and build citizen trust. But for that to take effect, the civil protection system must first comprehend the extent of the help it can derive from risk communication, in multiple levels, and reposition it so that professionals are made aware of its necessity, are systematically trained in it and are provided with ample space to implement it.

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EFFECTS OF EPPO'S SAFETY INITIATIVE FOR CHILD CARE CENTERS

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ABSTRACT

Earthquakes and other emergencies often strike quickly and without warning. Earthquakes have caused, and can cause in the future, loss of life and injury for kids, students, child care personnel and families. It is well known that by taking preventative measures before an earthquake and by improving preparedness and response through learning, a culture of safety can be fostered.

In Greece, a national policy is in place to support earthquake preparedness in the child care centers. Earthquake Planning and Protection Organization (EPPO) is a State Organization and the competent authority to develop and design the national policy on earthquake protection.

EPPO's Earthquake Safety Initiative for Child Care Centers invests in fostering preparedness by reducing vulnerabilities in order to mitigate the impact of seismic disastrous events on these settings. Building a preparedness program for kindergartens takes much effort and time. This study aims at assessing EPPO's Earthquake Safety Initiative for Child Care Centers and specifically the effect of training seminars and the development and use of a specific Handbook on Earthquake Planning for Child Care Centers, based on its contribution to the improvement of the level of preparedness of these workplaces during the last seven years.

To this end, a survey was performed based on a paper-and-pencil questionnaire. Personnel of kindergartens from 41 Municipalities of the country responded to this questionnare during 7 school periods (from 2013-2014 to 2019-2020). The results of the survey allowed analysis of how knowledge, experience and attitudes of the participants have been influenced by EPPO's Initiative as regards understanding disaster risk, strengthening disaster risk management, enhancing disaster preparedness for effective response and investing in disaster risk reduction for resilience. This research is part of the evaluation of EPPO's educational actions on seismic risk reduction.

Keywords: Earthquake, Child Care Centers, Emergency Planning, Seismic Risk Reducton, Drills

1. INTRODUCTION

Worldwide, children make up about 25 percent of the population and kindergartens are a place of learning, growing and support of children [1]. Since earthquakes may happen almost everywhere, earthquake safety should be practiced by everyone. Earthquake preparedness of Child Care Centers is an essential part of protection of any community in every country.

Greece is faced with natural hazards, such as earthquakes and fires. Some times these natural hazards turn into disasters, mainly earthquake disasters. Taking into account the unique needs and abilities of children, every kindergarten of the country should be at the heart of developing a culture of earthquake

safety, because children can effectively bring the message of preparedness home to their families and also, children who are prepared feel more confident during actual emergencies and disasters [2].
Earthquake Planning and Protection Organization (EPPO) is a State Organization and the competent authority in Greece to develop and design the national policy on earthquake protection. The last decade EPPO contributes substantially to build an earthquake safety culture at child care settings [3].

2. METHODOLOGY

This survey targets to assess the contribution of EPPO's Earthquake Safety Initiative to improve the level of kindergartens preparedness in Greece which runs the last seven years. It is important to mention that EPPO implements the specific Initiative in collaboration with the Municipalities.
A closed-form questionnaire was developed for the research, which contained 20 questions concerning protective earthquake measures at family and workplace level targeting kindergartens' personnel. Personnel from 41 Municipalities of 31 Prefectures of 12 Regions of the country took part in this survey. The questionnaires were administered to responders before each of EPPO's seminars entitled "Seismic Risk Reduction Actions at Kindergartens". A total of 3122 questionnaires were collected from September 2013 to February 2020, and analyzed by EPPO's Department of Education. It should be noticed that from March to July 2020 in line with the protective measures due to Coronavirus Disease 2019 (COVID-19) and in order to reduce contacts, there were no face-to-face seminars, so there are no data from questionnaires for this period.
More specifically, EPPO's Initiative includes the following:

a. Implementation of seminars at Municipality level, in order to appropriately educate and adequately train the kindergartens' staff. These EPPO's low-cost training actions with clearly set objectives and content should be implemented by every Municipality. More specifically, EPPO tries to provide ongoing education to the child care providers by utilizing a mix of brief information along with follow-up discussions, in an effort to expand their knowledge and to improve their skills on earthquake management to the specific environments.
b. Development of educational material (guidelines, brochures, posters, presentations etc.) specifically targeted to kindergartens' staff. In order to assist this staff to be safer during an emergency and to facilitate their preparedness before an earthquake occurs, EPPO published in 2017 a Handbook on Earthquake Emergency Planning for Child Care Centers [4]. It is well known that the key to minimizing the cost and impacts of emergencies is effective emergency planning and preparedness. The Handbook is a useful guide that is freely available both in print and on line and provides all the essential knowledge and practical instructions required for the kindergartens' staff. More specifically, it provides information so as to give an overview of the earthquake planning principles and process and to assist in the development and review of emergency management plans for kindergartens.

3. RESULTS OF SURVEY

Childcare providers have unique roles during earthquakes, and when they are well prepared for these, all citizens benefit. The data collected based on the responses of the staff of child care centers, were analyzed by EPPO's Department of Education with the purpose of gaining information regarding the level of earthquake readiness in these centers. Specifically, the researchers assessed if EPPO's Earthquake Safety Initiative contributed to an improvement of child care centers' preparedness level. The researchers identified differences in the results corresponding to three periods (2013 – 2014, 2014 - 2017 and 2017 - 2020). A possible explanation for this is that EPPO implements a lot of seminars for

kindergartens' staff from 2014 till today and developed the abovementioned Handbook at 2017 and that had a posiitive impact on the preparedness level in child care centers.
The following Figures present the results of the survey. To the question if they have ever faced an earthquake and if the phenomenon took place while they were at workplace, 2480 (79.46%) out of the 3122 participants answered that they have faced an earthquake and 973 (31.19%) answered that have had an earthquake experience at workplace (Figure 1).

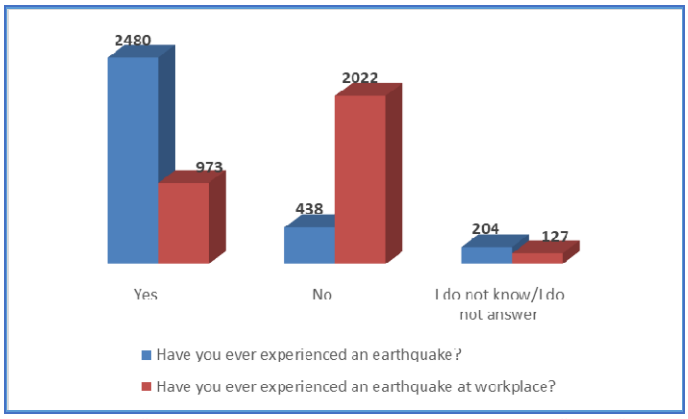

Figure 1. Responses to the questions: "Have you ever experienced an earthquake?" and "Have you ever experienced an earthquake at workplace" for the period 2013-2020

Figure 2 summarizes responses to the question "Is there an Earthquake Emergency Plan at your workplace?" for the abovementioned three periods of time. It should be mentioned that the number of samples of survey's participants is not the same for every period. More specifically, 51 participants responded at the period 2013-2014, 1213 responded at the period 2014-2017, and 1858 responded at the period 2017-2020. The analysis of the results shows a clear upward trend of the affirmative answers over the years. Substantially, this indicates that the primary gaps in the kindergartens' readiness were removed with the increase of EPPO's seminars and the adoption of EPPO's formalized Handbook on Earthquake Emergency Planning for Child Care Centers.

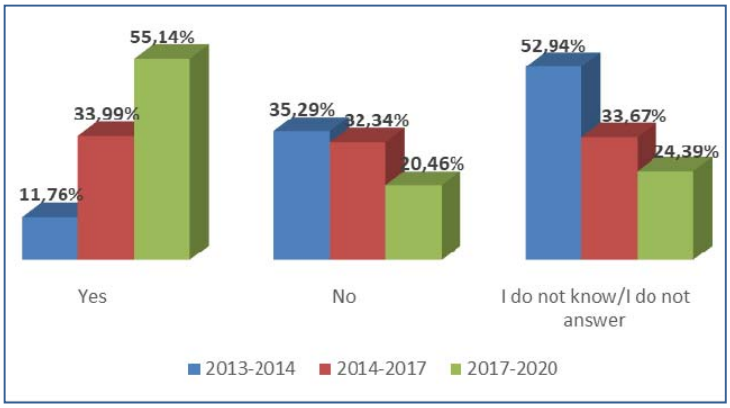

Figure 2. Answers to the question "Is there an Earthquake Emergency Plan at your Child Care Center?"

Figure 3 presents the findings of the survey conserning the earthquake drills that highlight the positive impact of the actions of OASP to conduct drills at the child care centers during the last seven years. It is well known that the preparation for earthquakes involves developing a well thought out disaster plan that is practiced through the conduction of drills. Child care centers are obliged by Hellenic legal

framework to hold drills regularly every year, as a comprehencive test of their emergency plan. The findings support that significant progress has been noted since 2013 but there is still room for improvement.

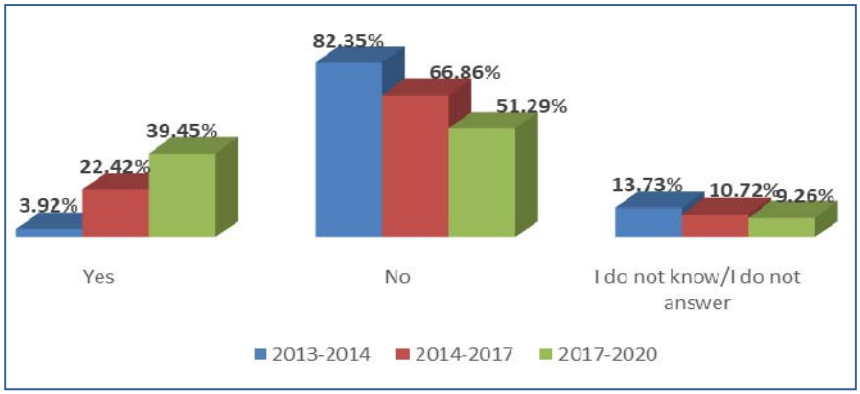

Figure 3. Answers to the question "Do you hold earthquake drills at your Child Care Center each year?"

4. CONCLUSIONS

Many children under the age of five spend their daytime hours away from their parents, in a child care center. Therefore, child care facilities should have a high level of earthquake preparedness since infants and children are physically and/or developmentally unable to protect themselves in case of earthquake. To this end, EPPO's Earthquake Safety Initiative for Child Care Centers is designed to provide child care personnel with the necessary tools to develop an effective earthquake preparedness plan. This research aims at assessing the contribution of EPPO's Initiative to the improvement of level of preparedness of Child Care Centers during the last seven years.

The analysis of the responses from kindergartens' staff from 41 Municipalities of 31 Prefectures of 12 Regions of the country, shows that the development of EPPO's Handbook on Earthquake Emergency Planning, as well as the implementation of training seminars for child care providers, have decisively contributed to improving earthquake preparedness and reducing the risk and the effects of a potential earthquake in child care center settings.

Building Child Care Centers' preparedness takes a lot of effort which EPPO intents to continue making along the way together with the personnel of Child Care Centers because children preparedness is important to the resilience of every community.

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I-REACT: IMPROVING RESILIENCE TO EMERGENCIES THROUGH ADVANCED CYBER TECHNOLOGIES

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ABSTRACT

Every year, thousands of disasters impact the world, generating substantial loss in terms of lives and public infrastructure. The recovery phase requires substantial money investment for governments, in order to rebuild the affected region. To minimize the effects of a disaster, applications supporting decision-making through real-time analytics must be fast and accurate. These tools may be supported by stream processing systems that enable the real-time processing of structure-less data; however, their use and configuration require expert programming knowledge and a setup phase that could lead to loss of relevant data. This work proposes a platform. I-REACT is the result of a three-year European Project that developed the first European-wide platform to integrate emergency management data coming from multiple sources, including that provided by citizens through social media and crowdsourcing. This way, we are able to produce information faster and allow citizens, civil protection services and policymakers to effectively prevent and/or react against disasters.

Keywords: Civil protection, Resilient societies, Novel technologies, Emergency management data

1. INTRODUCTION

Due to their potentially broad and grave impact, natural and man-made crises and disasters are typically jointly addressed by a number of governmental and non-governmental disaster relief organizations that are active during the entire disaster management cycle, i.e. mitigation, preparedness, response, and recovery. The mentioned phases thereby impose different sorts and requirements and processes upon inter-organizational information exchange. Whereas only sporadic information exchange is required in the mitigation phase, the subsequent phases of the cycle require a much more closely aligned operation of all parties involved in order to ensure fast allocation and optional distribution of personnel and other resources in the affected area.

Today, there is no emergency management platform that can face the increasingly more frequent and unpredictable disasters in the midst of climate change. However, at the same time, there is more data available than ever in history that can help us manage this changing reality: mobile phones, satellites, drones or social media are only some of the many technologies that are constantly generating information before, during and after emergencies. The challenge is now to collect all this information

and transform it into crucial knowledge that can help us prevent and respond to disasters. I-REACT is a collaborative project that aims to tackle this challenge through a big data system that will integrate information coming from multiple sources, including European early warning and mapping systems, earth observations, space assets, historical information, and weather forecasts, among others. Such sources will be combined and complemented with new data and models from novel technological developments created by I-REACT. These include a mobile app and a social media analysis tool to account for real-time crowdsourced information, drones to improve mapping, wearables to improve positioning, as well as augmented reality glasses to facilitate reporting and information visualization by first responders. With this approach, I-REACT will be able to empower stakeholders to prevent and manage disasters. Citizens will be involved in reporting first-hand information, authorities will be supported in the decision-making process, and first responders will be equipped with essential tools for early warning and response. Overall, I-REACT aims to be a European-wide solution to build more secure and resilient societies to disasters. [1,2].

2. BACKGROUND AND PROJECT INITIATiON

The H2020 I-REACT project, funded under “Secure societies - Protecting freedom and security of Europe and its citizens” Programme, resulted in the development of the first European-wide platform to integrate emergency management data coming from multiple sources, including data provided by citizens through social media and crowdsourcing .

I-REACT has developed a set of modules that integrate all the relevant data in one place, crossing over inputs from different sources: satellites, social media, incoming reports from responders using the I-REACT app, weather forecasts and much more. Altogether, the I-REACT solutions offer an improved assessment, planning and response to a disaster.

I-REACT solutions are now offered in three different core services:

a) I-REACT Social Media, built on a multi-language social media engine that allows monitoring and classification of Tweets related to natural hazard and event detection. It generates statistics for all posts related to the hazard, containing aggregated measures on the set of analysed messages. The information extraction/ analysis can be done in all phases of the emergency management in order to efficiently support not only the emergency managers but also the citizens in all phases of the hazardous event

b) I-REACT Reporting, leveraging mainly the I-REACT mobile apps: one for professionals and one devoted to citizens. Through this service, the user can perform and review reports, visualize map layers and use customised functionalities (e.g. mission management, coupling with the I-REACT wearable device) and is connected to the dashboard with the current status in terms of hazard and risk and latest content generated in the surroundings

c) I-REACT EMS(Emergency Management System) aims to deliver a holistic approach for emergency management by providing a decision support system that can support them when a hazard occurs. In detail it allows planning, launching and monitoring of missions, by integrating real-time map layers generated from Copernicus EMS service, receiving early warnings coming from the European systems EFAS and EFFIS respectively for floods and wildfires. Moreover, it allows reporting functionalities and it is able to receive and process information coming from different sources of information (e.g. professional/citizen mobile application and other devices when connected)

The platform also offers nine Added Value Services:

a) Seasonal and Climate Prediction service, providing long term forecast by delivering information of how average weather conditions are likely to evolve from 6 to 9 months. It allows the prediction of rare and high-impact weather events that could potentially produce significant damages, occurring in the tail

ends (<10% occurrence) of their climatological probability distributions. Allows to assess the long-term impact on floods and wildfires due to climate change

b) Weather Forecasts and Extreme Event Detection, based on the use of real time ensemble weather forecast data and real time observations. This service provides ensemble forecast and is set to provide statistically unbiased and most accurate probabilistic weather forecasts for chosen extreme weather events. The resulting weather information can be used for early warning purposes for the users of the system. Also, it integrates weather satellite and weather radar products to assure real time information for monitoring the prevailing weather conditions in Europe

c) Hazard and Risk Maps enable the user to request and visualise on-demand map-layers in a specific area and in a definite space-time interval. This service is a combination of two sub services:

(i) Hazard maps quantifies and classifies potential consequences of natural hazard events at the European scale for flood, wildfire and heat wave natural hazards.

(ii) Risk maps illustrate the impact or significance of risks (e.g. temperature, wind, wind gust, precipitation, and snowfall) together with the likelihood/ frequency.

In order to provide these services, I-REACT leverages data coming from the European Flood Awareness System (EFAS), the Fire Weather Index (FWI) and Earth Observation Imagery especially for the identification of potential wildfire hotspots. Finally, data related to heat waves, or extreme temperature monitoring, is based on long term weather forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF)

d) UAV data service . The data services are visual photo and video clips communications between UAVs and the Incident Room. These services allow the Incident Room to interact with the pilot while the UAV is in the air thanks to the software optimized for low bandwidth and the control of payloads (sensors and communications).

e) Smart Glasses application , designed to assist first responders in managing emergencies. The application allows a “hands-free” approach thanks to voice commands, on-eyes display and a simplified interaction. With those elements the first responder is able to write and register reports, get information and complete missions during a survey on areas hit by natural hazard.

f) Wearable , an enabling device for safer and more effective coordination of rescue teams. It allows location tracking, environmental and gas sensing thanks to combining advanced GNSS, Ultra-wide band radio (UWB), BLE and oxygen, temperature, humidity and pressure sensors. Also, thanks to use of motion sensors and custom developed recognition algorithms it allows detection of fall, steady and other on-demand activities

g) Nowcast, forecast, flood delineation, burned area service . This service allows the user, upon request, to visualise specific layers referred to a specific area of interest. In detail:

(i) Nowcast, delivers short-range forecasting that maps the current weather, estimating its speed and direction of movement. It uses local-based information therefore this feature is linked to the reports coming from the field through the I-REACT mobile app (esp. for floods)

(ii) Forecast provides a longer-range forecasting weather information, providing indication upon the direction and speed of weather

(iii) Flood delineation provides flood and flood frequency maps. The flood mapping/monitoring service is fully automatic and can be triggered over a defined location. This service was established to provide rapid post disaster flooding status and inundation extent maps, which can be used for post-disaster management and relief activities

(iv) The Burned Area Mapping (BAM) service enables the automatic identification of burned areas after a wildfire event. The BAM uses latest European satellite imagery provided through the Copernicus Sentinel satellites

All in all, the user triggers the service through a 'map request' and the mapping is automatically executed without further human interaction. This makes the service a smart, fast and economic operation

h) LEMS (Local Emergency Management Systems), allows the reception of alerts and warnings i.e. alert bulletins, related to meteorological and hydrogeological events, fires and raw measures from monitoring networks. By the end of I-REACT, the platform integrated alerting services from UK (EA), Finnish (FMI), Catalonian (GECAT), and the Civil Protection of the Piedmont Region. In detail, LEMS allows to take data from external services, select and normalize the content based on data and metadata structures, shared within I-REACT, and finally transfer them to the system in proper formats (i.e. xml Cap format, the world standard for the emergency alerting communication). [1,2,3].

3. CONCLUSIONS

After the completion of the I-REACT project (May 2019), the consortium partners have been in constant discussions in order to further assess the capabilities of the system, develop new functionalities and improve the usability for first responders. Building on technological advances made in several technological fields, such as unmanned vehicles, augmented reality, geolocation, sound devices, movement sensors on smartphones, artificial intelligence and many more the platform can now receive significant new features and upgrades, which will be:

a) tailored to the actual in-the-field needs of first responders,

b) developed by highly specialized technology providers and

c) scientifically validated by partnering research organizations.

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I-REACT RSRA: DEVELOPMENT OF A *R*APID *S*EISMIC *R*ISK *A*SSESSMENT TOOL THAT INTEGRATES INSTRUMENTAL, CROWDSOURCING, SOCIAL MEDIA DATA AND EMPIRICAL VULNERABILITY

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ABSTRACT

The problems of earthquake damage prevention and the effective seismic risk mitigation are critical issues that attract the interest of the seismological community and stakeholders globally. In particular, Rapid Seismic Risk Assessment (RSRA) methods gain increasing popularity and constitute the present state of the art regarding the earthquake threat. In this respect, an automatic RSRA system is currently under development by the Seismological Laboratory of the National and Kapodistrian University of Athens (SL-NKUA). Realtime recordings of permanent regional and local networks are employed and various modern scientific methodologies are applied to produce near-realtime shakemaps after an earthquake. Shakemaps are combined with detailed structural vulnerability indices to generate comprehensive maps of expected seismic damage, in terms of percentage of structural loss and its probability to occur at a building block level or residential division. The RSRA implementation will be fully automated and the procedure, enriched with crowdsourcing data, will be incorporated to I-REACT, a European platform that integrates data from pertinent agencies and social media, towards the facilitation of near-realtime field monitoring by first responders and end users. This concept has been submitted to H2020 SU-DRS02-2018-2019-2020 action call.

Keywords: I-REACT, Decision support systems, Shakemaps

1. INTRODUCTION

Urban seismic risk mitigation is the most optimum solution to reduce the cost and losses due to earthquake damage, as earthquake forecasting remains a strongly disputed issue while Earthquake Early Warning Systems (EEWS) are subjected to physical limitations. However, global and regional seismic

hazard assessments have been found to largely underestimate ground motions, especially in the case of near-field strong earthquakes [1]. This common ascertainment reveals the need for site-specific seismic risk assessments that incorporate comprehensive seismic source histories, appropriate attenuation laws of seismic energy, detailed properties of foundation soils, structural and social vulnerability [2]. The objective of this work is to develop a set of novel computing tools - services, in order to enhance resilience against seismic disasters. Specifically, our task is to incorporate seismic data from various sources into the I-REACT modern platform towards a Rapid Seismic Risk Assessment (RSRA) module to be a perceptive tool in the hands of first responders during and after seismic crises.

Our SL-NKUA research group has produced realistic seismic risk models for several urban areas in Greece during the last decade. The method was composed of stochastic simulation of strong ground motion generated from neighboring sources taking into account local site conditions and empirically estimated vulnerability of buildings [3, 4]. The gained expertise of our group has led to the implementation of **HELPOS-RISK**, a GIS tool for RSRA that incorporates the above methodology [5]. Specifically, the main computational task of HELPOS-RISK is the Deterministic Seismic Hazard Analysis (DSHA) for a given earthquake, taking into account site-effects and a combination of the derived Intensity Measures (IMs) with a predefined vulnerability model. Seismic source, i.e. its location, geometry, kinematics and its magnitude is the only variable in the workflow, employed as input to a DSHA based on stochastic ground motion simulation. The output includes maps of EMS-98 Damage Grades (DGs) [6] and their probability to occur. A key-point that the platform is stressed to, is the fast generation of output, reduction of error-prone conversions and adaptations between modules/systems and a fully automated workflow (Figure 1). HELPOS-RISK is currently modified to take into account near-realtime shakemaps produced by various types of data. Automatic triggering of the application will be based on alerts received through the SL-NKUA real-time SeisComP system. This will allow for rapid damage assessments and will support timely disaster management decisions and more accurate first responses. The application will be integrated into I-REACT (http://project.i-react.eu/project/) after being validated using damage data from previous earthquakes.

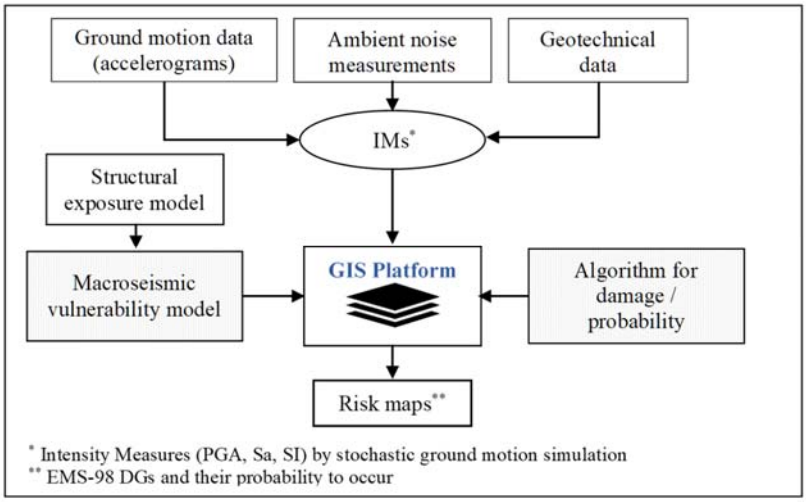

Figure 1. Basic design of the current HELPOS-Risk tool [5].

I-REACT is the product of a H2020 project. It is the first European-wide platform to integrate emergency management data coming from multiple sources, including data provided by citizens through social media and crowdsourcing. I-REACT includes a set of modules that integrate inputs from different sources, i.e. satellites, social media, incoming reports from responders, weather forecasts. Altogether, the I-REACT solutions offer improved assessment, planning and response to a disaster. The task of our effort is the development of an effective earthquake risk management and responsiveness module

within I-REACT that will be a handy tool towards resilience and will guide first responders' steps in the field after a destructive earthquake. In the following paragraph, we briefly outline the data and concept adopted for incorporating HELPOS-RISK into I-REACT.

2. DATA AND METHOD

The infrastructure utilized for the implementation of the I-REACT RSRA module consists of numerous permanent broadband earthquake recording networks maintained by SL-NKUA (ATHENET - 30 stations, RASMON – 12 stations, CORSSA - vertical accelerometric array composed of 15 borehole sensors installed at depths 0-178 m) and Institute de Physique du Globe de Paris (IPGP) (CRL - 24 stations). Services available by SL-NKUA, employed in the procedure, include realtime and continuously updated catalogues of automatic and manually revised earthquake locations and magnitudes, near-realtime earthquake focal mechanisms and shakemaps, hourly updated web traffic, realtime station information and state of health.

Shakemaps depict the distribution and severity of ground shaking, information that is critical for assessing the extent of the areas affected to determine which areas are potentially hit the hardest, allowing for a rapid estimation of losses. Near-realtime shakemaps produced by SL-NKUA will be employed in i-REACT RSRA. In addition to the typical method for creating shakemaps using a point source, we intend to apply an innovative procedure by applying finite sources [7, 8]. Based on the above-mentioned novel approach, SL-NKUA will produce near-realtime shakemaps in terms of various Intensity Measures (IMs). I-REACT RSRA will incorporate shakemaps through the SL-NKUA web-platform (http://www.geophysics.geol.uoa.gr). I-REACT RSRA will also incorporate synthetic shakemaps, produced by SL-NKUA in the case of lack of instrumental data. The k-square fractal model for extended, realistic stochastic source will be adopted [9]. This model produces broadband waveforms, including the low frequency and static terms of the near-field terms, which can largely affect strong ground motions. In addition, crowdsourcing and DAS data will be incorporated for the generation of comprehensive shakemaps. Shakemaps from the methods and sources described below will be implemented in I-REACT. These will then be automatically combined with structural vulnerability data following the method of [10]. The outcome consists of comprehensive maps of earthquake consequences assessment and their probability to occur.

Shakemaps from DAS data: Boosted by the oil and gas industry in the last decade, the Distributed Acoustic Sensing (DAS) technique has been developing very rapidly. DAS uses the Rayleigh backscattered light in standard fibers to record the fiber dynamic strain induced by seismic vibrations. This method has been successfully tested for monitoring natural earthquakes [11].

The Earthquake Network (EQN) platform (www.sismo.app): EQN implements a global earthquake early warning system based on smartphone networks [12]. EQN has proven that smartphones can detect earthquakes while they are happening and that the smartphone itself can be the device for receiving the early warning. Started in 2013, the EQN platform has helped to detect more than 3,300 events in 28 earthquake-prone countries and has involved more than 6 million participants who made their smartphone available for the application. Detections made by the smartphones will be sent to the EQN platform for analysis for the real-time detection in case of an earthquake and will then be transferred as input to I-REACT, in terms of localized IMs, in order to produce shakemaps.

LastQuake (https://m.emsc.eu/): It is a system at the intersection between seismology, citizen science and digital communication. Its aim is to offer timely, appropriate information in regions where an earthquake has been felt and to collect high numbers of eyewitnesses' direct and indirect observations about the degree of shaking being felt and possible damage incurred [13]. This improves rapid situation awareness and augments data at low cost. Through online reactions, eyewitnesses act as realtime

seismic sensors opening the way to explore a crowdsourced EEWS. In addition, through a Bayesian type of approach, it was recently demonstrated that the lack of crowdsourced data can reveal the existence of damage within few minutes of an earthquake occurrence and be exploited to offer a rapid heads-up to civil protection agencies [14]. The objective of LastQuake is to automatically integrate these threads in I-REACT, towards producing earthquake impact assessment, constituting a first heads-up within minutes of earthquake occurrence and, in case of significant damage, a time-varying situational map.

3. CONCLUSION

We present the novel I-REACT RSRA module that is currently under development. The objective of this effort is to enhance the capacity of first responders in the field after a seismic crisis. This concept has been submitted to the H2020/SU-DRS02-2018-2019-2020 action call, entitled “Technologies for first Responders”.

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APPLICATION FOR THE REAL-TIME ESTIMATION OF BUILDING'S SEISMIC DAMAGE IN CITY-SCALE ON THE BASIS OF ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

The real-time estimation of the seismic damage level of buildings in City-Scale can significantly contribute to the reduction of seismic losses. At the first critical moments after strong seismic events, the determination of the zones of the areas hit by the earthquake that require urgent response measures, allows the authorities to manage more effectively the available emergency resources. Therefore, the development of methods that could provide real-time estimation of seismic damage for large building stocks is considered necessary. The methods that have already been proposed for the solution of this problem are mainly based on the pre-seismic vulnerability assessment of buildings using specific, pre-selected structural characteristics or on the "remote-sensing" assessment of the buildings' seismic damage, using space-borne or air-borne data. In order to improve the effectiveness of the aforementioned methods, the Artificial Neural Networks (ANN) provide modern and strong computational abilities. In the present paper an ANN based software application which can be implemented for the rapid estimation of reinforced concrete (R/C) buildings' seismic damage level is described. This application is developed on the MATLAB software platform and its function requires seismic and structural data. Regarding the seismic data, the proposed software requires the introduction of earthquake accelerograms, whereas for the structural data it requires the introduction of the values of pre-selected structural parameters. Specialized modules calculate the seismic and the structural parameters consisting the inputs for the in-built trained ANNs. The application exports rapidly the estimation of the seismic damage level of R/C buildings. The proposed application is a first version of an in-progress software which can be connected to networks of accelerometers in order to receive in real-time the accelerograms of seismic events and will be capable to exports maps which illustrate the estimation of the damage level of the R/C buildings in regions that have been hit by earthquakes.

Keywords: Artificial Neural Networks, Real-time seismic damage assessment, Software Development

1. INTRODUCTION

The ability to estimate in real-time the seismic damage level of buildings in City-Scale is a definitive factor for the significant reduction of the losses caused by strong earthquakes. More specifically, this ability for real-time damage estimation can be a significant decision-making tool for the authorities in order to detect the zones of an area that has been hit by an earthquake which require urgent rescue/response measures. To this end, several methods have been developed. Some of them are based on the pre-seismic vulnerability assessment of buildings using specific pre-selected structural characteristics. Within this category lies the seismic vulnerability curves method, the damage probability matrices and the rapid visual screening of structures. Another category of methodologies is based on "remote-sensing" assessment of the buildings' seismic damage in the stricken area, using space-borne or air-borne data. The effectiveness of the aforementioned methods can be improved using Artificial Neural Networks (ANN) [1] which have been successfully utilized in many engineering applications and, more specifically, for the rapid estimation of the seismic damage of structures (e.g. [2, 3, 4]). In the current paper an ANN based application which can be used for the rapid estimation

of reinforced concrete (R/C) buildings' seismic damage is presented. This application is developed on the MATLAB software platform [5]. Its operation requires seismic and structural data (e.g. [2,4]). Regarding the seismic data, the software requires the introduction of seismic accelerograms, whereas for the structural data, the program requires the introduction of the values of pre-selected structural parameters. The application extracts rapidly the estimation of the damage level of R/C buildings solving the problem as a Function Approximation (FA) problem or as a Pattern Recognition (PR) problem (see e.g. [4]). The presented application is a first (testing) version of an in-progress application which can be connected to networks of accelerometers in order to receive in real-time the accelerograms of seismic events and will be capable to extract maps which illustrate the estimation of the damage level of the stricken regions' R/C buildings stock. The next steps of development include the insertion of the local soil conditions of the buildings as input parameters of ANNs, as well as the extension of the training data set in order to include buildings designed under the provisions of older seismic codes.

2. OUTLINE OF THE PROPOSED SOFTWARE APPLICATION

The presented software application is based on the implementation of optimum configured trained Multilayer Feedforward Perceptron Networks (MFPN) [1]. The optimum configuration and the training of the utilized MFPNs arise from a well-documented methodology which is briefly described in Figure 1 (for more details see [4]). In the same Figure the parameters selected for the problem's definition and solution are also illustrated. Following the procedure of Figure 1, two optimum configured trained MFPNs are exported: one for the optimum solution of the FA problem, and one for the optimum solution of the PR problem. In terms compatible to the ANNs' structure, a trained MFPN is stored in a file which contains the configuration parameters as well as the values of all synaptic weights and biases of the network after the training procedure. Two files (one for the solution of the FA problem, and one for the solution of the PR problem) are embedded to the application's subroutine which simulates the function of the corresponding trained MFPNs (calling the subroutines of the neural networks tool of MATLAB) in order to extract the prediction for the seismic damage state of buildings.

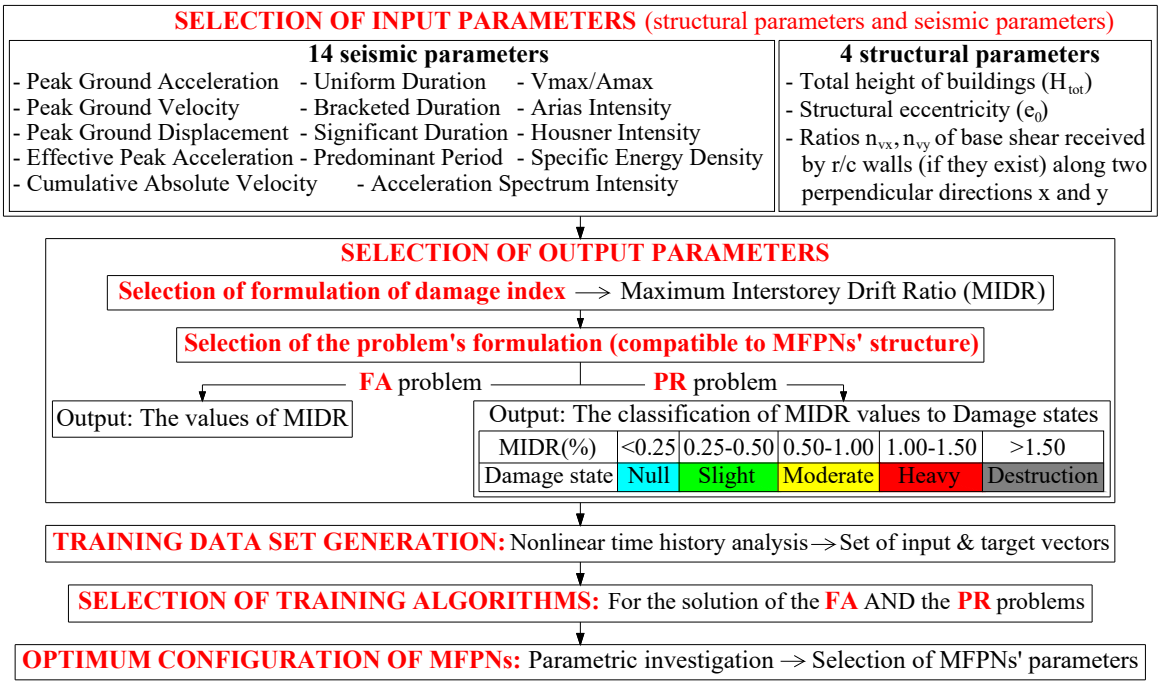


Figure 1. Procedure for the formulation of the problem in terms compatible to MFPNs

The presented application consists of five main components:
(a) The Graphic User Interface (GUI) for the insertion of the input data.

(b) Subroutines which calculate the seismic input parameters and the structural input parameters.
(c) Subroutines which form the user interface view components for the graphic presentation of the intermediate results (i.e. the spectra, the 14 seismic parameters and the 4 structural parameters) and the final results (i.e. the MIDR values and the classification of buildings' in damage states).
(d) The subroutine which formulates the input vector of the trained MFPNs.
(e) The subroutine which simulates the trained MFPNs and extracts the damage prediction.
In the following figures some of the basic screenshots of the application are presented. More specifically, Figure 2 illustrates the GUI for the insertion of the input data.

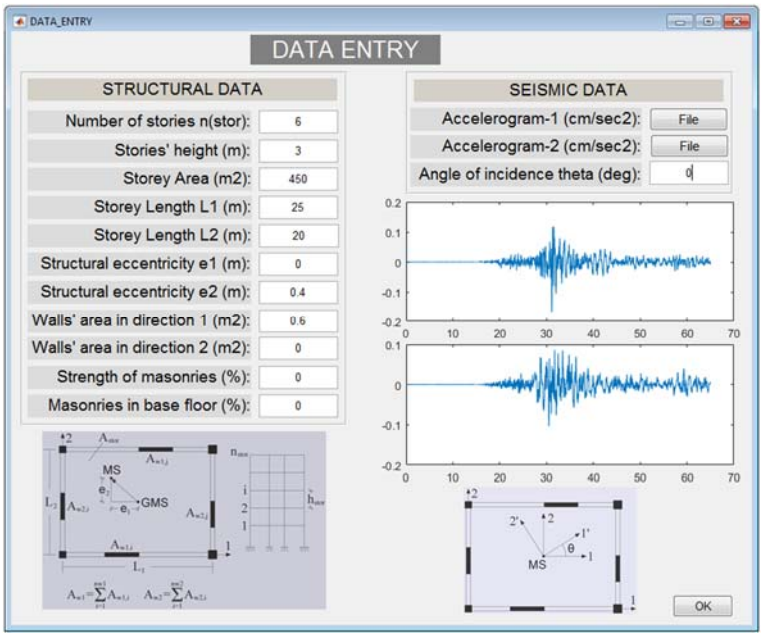


Figure 2. The GUI of the presented application for the insertion of data.

In Figure 3 one of the two user interface view components of the software presenting the intermediate results of application is illustrated.

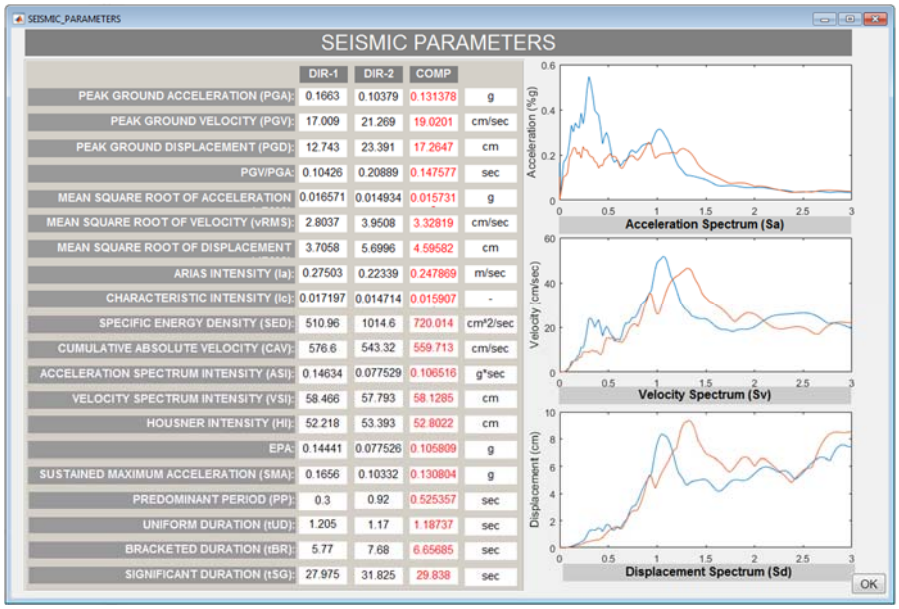


Figure 3. One of the user interface view components of the software which presents the intermediate results (the spectra and the 14 seismic parameters)

Finally, in Figure 4, the user interface view component presenting the prediction of the seismic damage state of the examined building extracted from the simulation of the in-built trained MFPN, is illustrated.

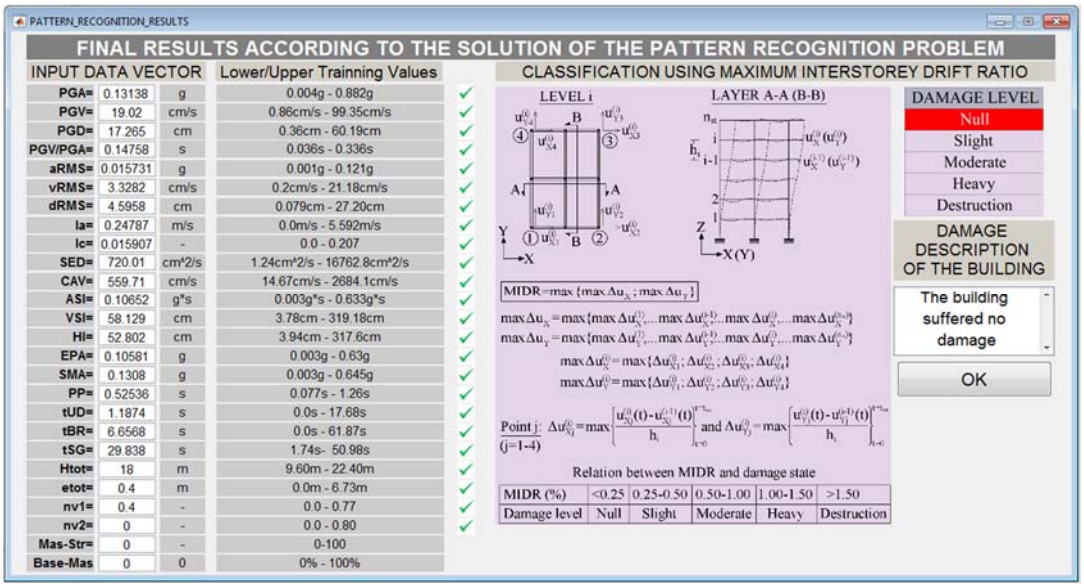
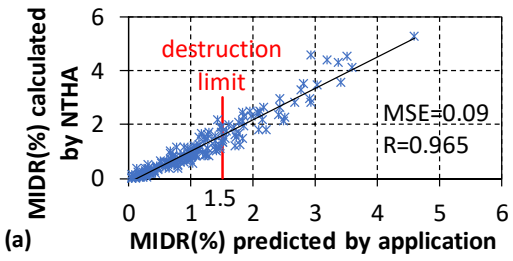


Figure 4. User interface view component which presents the final results of the application i.e. the seismic damage state.

3. RESULTS AND CONCLUSIONS

Herein, the software application in its current form is tested using a testing data-set which contains input vectors unknown to the utilized MFPNs. To this end, a testing data set compounded of 240 samples was generated using 3 different types of r/c buildings [4] subjected to 80 seismic excitations. For each one of the 240 samples the seismic damage state was also calculated by means of nonlinear time history analyses (NTHA). Thus, the predictions which were extracted using the presented application were compared with the reliable results of the NTHA. A batch file which executes multiple runs of the application for the 240 testing samples was developed. This batch file simulates the function of the application in its final form i.e. in the form which will lead to the generation of results for all buildings' types in a metropolitan area. In Figure 5a the predictions of the MIDR values extracted for the application versus the corresponding values exported from NTHA are illustrated. Furthermore, the predictions extracted from the application for the classification of the examined buildings in the 5 pre-defined damage classes (Figure 1) versus the corresponding classification exported from NTHA are depicted in Figure 5b. The test results highlight the ability of the developed code to extract reliable predictions of the seismic damage state of numerous r/c buildings.



Classification extracted from application

Target class	1	2	3	4	5	R
1	**32**	3	0	0	0	91.4%
2	3	**18**	3	0	0	75.0%
3	0	6	**36**	6	1	73.5%
4	0	0	13	**22**	12	46.8%
5	0	0	0	2	**38**	95.0%
P	91%	66.7%	69.2%	73.3%	74.5%	***74.9%***

(b)

Figure 5. Evaluation of the application's results (a) in case of FA problem (b) in case of PR problem

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A GEOSPATIAL INTELLIGENCE APPLICATION BASED ON SAR INTERFEROMETRY TO SUPPORT IMMEDIATE POST-SEISMIC INFRASTRUCTURE INSPECTIONS: THE CASES OF EARTHQUAKES IN THE BALKAN PENINSULA

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ABSTRACT

Despite substantial increases in our understanding of geophysical hazards, the rates of loss from them have increased over time, largely because of increased societal exposure. Specifically, earthquake risk is increasing globally more or less in direct proportion to exposure in terms of the population and the human built environment. Although some areas are heavily monitored due to high-tech monitoring capabilities, some others are often most poorly monitored. The current study explains how a geospatial intelligence application can turn into a useful operational tool in the immediate post-earthquake phase of infrastructure inspection that may have been affected by the co-seismic ground deformation due to very strong earthquake event. The objective of this study is to contribute to post-seismic impact immediate assessment on exposure including critical infrastructure based on SAR interferometric motion map production using Sentinel 1 data and ESA's SNAP software as well as local exposure data as a vector layer from open sources. The Durres (Albania) M=6.4 of 26/11/2019, Zagreb (Croatia) M=5.4 22/03/2020 and Parga-Kanalaki (Greece) M=5.6 23/03/2020 earthquakes in the Balkan Peninsula have been investigated as case studies. In order to achieve this goal, free SAR images of the Sentinel- 1 Copernicus satellite in both geometry of acquisition were used to create the differential interferograms and in the next step to convert them into deformation maps through phase unwrapping and convert phase to meters. Interferometric processing steps were carried out by the open and free ESA's SNAP software. Then, from open sources, data were used to identify and localize the exposure in the affected area. By combining (overlapping) the above two datasets of knowledge, a geospatial intelligence tool has been created in which for every element of the exposure that was identified, the ground deformation is also known.

Keywords: Geospatial Intelligence, SAR Interferometry, Sentinel-1, Exposure, Balkan Earthquakes

1. INTRODUCTION

Space-borne SAR interferometry is a technique that produces 3D topographic data of Earth's surface directly from two SAR images. An extension of the basic technique, called differential SAR interferometry, allows measurements of land deformation very precisely with millimetre resolution. It has various applications in the fields of seismology, volcanology, slope instabilities, crustal dynamics and land subsidence. Concerning geospatial intelligence (GEOINT), the basic principle of is to organize and

combine all available data around a geographical location on Earth and then exploit it in order to prepare products that can be easily used by planners, emergency responders and decision makers **[1]**. A co-seismic deformation map can be a useful tool for post-disaster infrastructure assessment. It can serve as a graphical reference providing crucial information to prioritize on-site inspections after an earthquake event. It is well known from previous years that Earth observation data contribute to natural disaster risk assessment and management especially the seismic hazard in all its phases **[2,3,4].** However, the largest number of research studies are related to the co-seismic phase **[5,6,7].** There is also a great number of research works on seismic hazard and exposure as well as studies on the effects of strong seismic events on anthropogenic and natural environment mainly based on field observations **[8,9,10,11].**The objective of this study is to contribute to post-seismic impact immediate assessment on exposure including critical infrastructure based on SAR interferometric motion map production using open and free data of Sentinel 1 and ESA's SNAP software as well as local exposure data as a vector layer from open sources. As mentioned before, the Durres (Albania) M=6.4 of 26/11/2019, Zagreb (Croatia) M=5.4 22/03/2020 and Parga-Kanalaki (Greece) M=5.6 23/03/2020 earthquakes in the Balkan Peninsula have been investigated as case studies.

2. DATA & METHODOLOGY

Regarding the interferometric processing the SNAP software has been used including the SNAPHU offering unwrapping capabilities. ESA SNAP is as free software distributed under GNU license. The CORINE Land Cover (CLC) inventory, open and free access, was used to map the main urban centers boundaries in the affected areas. As another main source concerning mapping and geo-location of linear infrastructure the OpenStreetMap has been used. For the rest, specifically for critical infrastructure like hospitals, bridges, cultural heritage sites, dams, schools and road-tunnels certified sources have been used and, in some cases, have been validated with Google Earth very high-resolution satellite imagery. In order to carry out interferometric processing a RUS Copernicus Virtual Machine, offering high performance computing in Linux environment, has been used after registration **[12]**. Processing could be distinguished in three phases which are summarized below. We process the Sentinel-1 images (SAR), using both geometries of acquisition to create the differential interferograms and then convert them into deformation maps in meters (Figure 1). Then we identify and localize the exposure in the affected area and by combining (overlapping) the above two datasets of knowledge, as a result a geospatial intelligence tool has been created in which for every element of the exposure, the ground deformation that the area had suffered due to the strong earthquake is known (Figure 2). The final result is the displacement map with the digitized exposure which has been overlapped in order to calculate the deformation that occurred at every exposure (in form of polygon, line or point).

3. RESULTS

The obtained wrapped interferograms are of good quality and contain the phase difference, between master and slave images, produced by the main seismic event. In order to obtain the absolute value of displacement, wrapped interferograms (deformation in radians) have been unwrapped and transformed from phase radians into motion (meters) (Figure 1). In these products (unwrapped interferograms) phase fringes have disappeared and absolute motion in Line of sight (LOS) is recovered. Over the displacement maps the digitized exposure (urban boundaries, airports, dams, schools, bridges, cultural Heritage sites and monuments etc) has been overlapped in order to calculate the deformation that occurred at every exposure (in form of polygon, line or point) (Figure 1 and 2). This way it was possible to estimate the extent of the ground deformation for which particular exposure data are displayed. To be more specific, the city of Durres shows a ground deformation 5 to 6 cm, in comparison with the City of Tirana 4.5 to 5.5

cm (Figure 1). Furthermore, along the Durres-Tirana main road track the measured ground deformation has maximum values near Durres (7 cm) while near Tirana relatively low values (4 cm) (Figure 1). The railway shows displacement rates that drop from Durres (6.5 cm) to Tirana city (4.5 cm) with the maximum rate of displacement being about 5 kilometers outside of Durres city (7.5 cm) (Figure 1).

3.1 Tables, Images and Figures

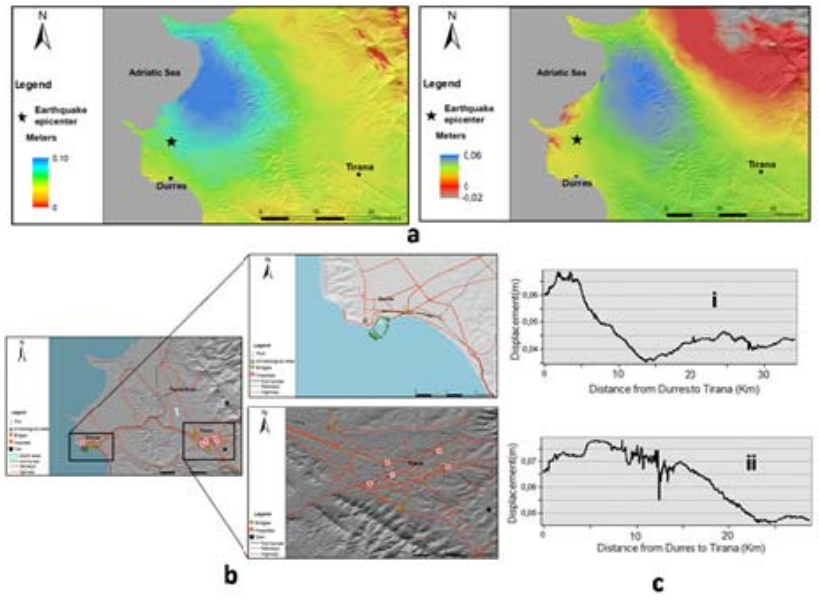

Figure 1. (a) Co-seismic deformation maps in meters, in ascending (left) and descending (right) geometry, **(b)** Local exposure data for the area extending from Tirana to Durres, **(c)** Histogram showing the deformation along linear transportation, **i)** national road and **ii)** railway road network between Durres (0 Km) and Tirana city.

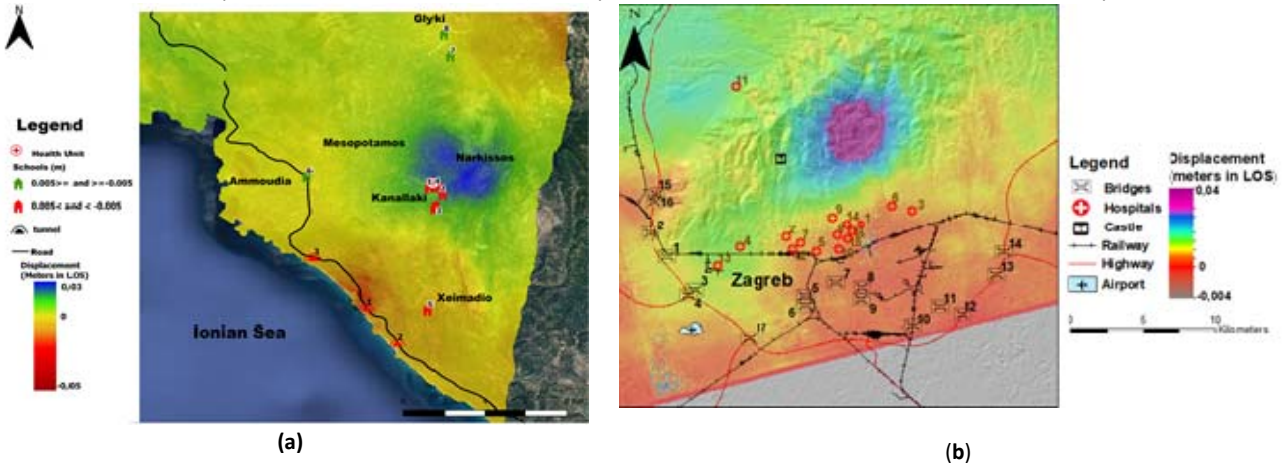

Figure 2. Local exposure data for **(a)** Parga-Kanallaki and **(b)** Zagreb overlapped the co-seismic deformation maps.

4. CONCLUSIONS-DISCUSSION

The present study deals with a geospatial intelligence application that can be used for post-disaster assessment process based on local exposure information and co-seismic DınSAR results. The immediate future task is to transfer this geospatial intelligence application to devices (smartphones, tablets or pads). It could thus, in synergy with integrated GPS capabilities, be an operational tool to guide teams performing infrastructure integrity assessments after strong seismic events. The first attempt was made in the case of the Durres (Albania) earthquake in Albania, the use and control was carried out by a team of scientists (engineers and geologists) who visited the affected area a few days after the earthquake. The system worked and the team of scientists demanded more interactivity between the system and the team's members.

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GEOSPATIAL FEATURES AND MAPPING OF FLOOD EVENTS IN TRANSBOUNDARY BASINS IN THE SOUTHERN BALKANS USING EARTH OBSERVATION SATELLITE DATA

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ABSTRACT

The current research conducts a study regarding the mapping of flood incidents inside of transboundary basins in the North Balkan area with the use of open, satellite earth observation data from the Copernicus programme, a branch of the European Space Agency. This research's goal is twofold, at first it demarcates the transboundary basins found in Northen Balkan area, as well as investigate and map the flooded areas of these basins due to recent flood events with the use of open, remote sensing data.

After the demarcation of the basins is concluded, data were retrieved regarding the physical, geographical, and anthropogeographical aspects of Aoos, Axios, Strymonas, Evros basins. Moreover, open satellite data were retrieved SAR/optical images from Sentinel-2 and Sentinel-1 satellites. For every flood event 2 optical and 2 SAR images were retrieved, one that overlaps the time of the flood and one during summer were no water masses are present or identifiable.

Moreover, with the use of SNAP application provided by ESA, the pre-processing and the final processing was conducted only on the SAR data, given to the fact that the optical data had a significant amount of cloud coverage. During the pre-processing, the SAR images received Terrain Correction, Calibration, Speckle Noise Removal and Subset (adjust their size using the Area of Interest polygon) techniques. At the final processing stage, the binarization of the image's pixels took place, from that point forward the water covered areas took the value 255, while all other, non-water pixels were given a null value, afterwards the conversion of the final images to KML protocol took place in order to overlay them in a Google Earth environment.

At last, the final synthesis of the thematical maps regarding the flood extend of the flood events inside the four transboundary basins took place. The flood extent layer was overlaid onto a high-resolution optical satellite imagery in a Google Earth environment and the results, were compared to the results of the Emergency Mapping Service (EMS), a service provided by the Copernicus programme.

All the results coincide with the results of the EMS system. Any inaccuracies were accredited to the fact the EMS service used higher resolution data than ours. In the case of Evros, the EMS service did not map the Turkish side (not an EU member), but our research has produced outcomes regardless of the administrative boundaries of Greece and Turkey.

Keywords: Satellite Earth Observation Systems, Transboundary Basins, Flood Mapping, SAR, South Balkans

1. INTRODUCTION

Greece faces one of the most important problems in the world, the management of transboundary waters and in particular the floods that occur in transboundary basins. More specifically, important rivers for the South Balkans are located at Northern Greece, such as Evros, Aoos, Axios etc., rivers that are "shared" with all the countries bordering Greece, including Turkey. These transboundary rivers, and consequently their basins, are a major management issue, not only for reasons of economic exploitation or political pressure but also for reasons of the protection of human life, for reasons of Civil Protection.

Based on the above, we understand that management of the flood risk, requires upgraded know-how based on United Nations decisions (SENDAI, https://www.undrr.org). To this end, the present research will attempt to demonstrate that there can be a holistic flood management program within these basins and between the countries involved, by mapping flood phenomena that occurred inside these basins, at the region of the Southern Balkans, with use of Earth observation space data.
So, its purpose is twofold, on the one hand the identification of transboundary basins in the Southern Balkans and on the other hand the mapping of flood phenomena in the basins identified using the Copernicus Earth Observation Data. In more detail, the first part will list the "cross-border basin" discussions and decisions of countries and organizations such as the UN, as well as will define the basins to be studied such as that of Evros, which in the Balkan Peninsula is crucial for Bulgaria, Turkey and Greece, the countries that run within their border. The second part will include the practical technological analysis of flood phenomena and flood extends in Evros, Aoos, Axios and Strymonas basins, in order to prove that even remotely, through satellite data we can have accurate data and results helping the cooperation and consensus of management bodies and countries without their physical presence.

2. AREA & BASINS OF INTEREST

Greece is located in the Southern Balkans and most of its rivers on the northern border are transboundary. Greece is located upstream of Aoos and downstream of four rivers which it shares with neighboring countries: Axios, Strymonas, Nestos and Evros. Also, Prespes and Lake Doirani are subject to a transboundary management regime. Finally, the Delta of Axios, Nestos and Evros as well as Lake Kerkini are areas of global ecological interest and are protected by the Ramsar Convention and Natura 2000. From the above, the rivers Strymonas, Evros, Aoos and Axios were selected to be studied.

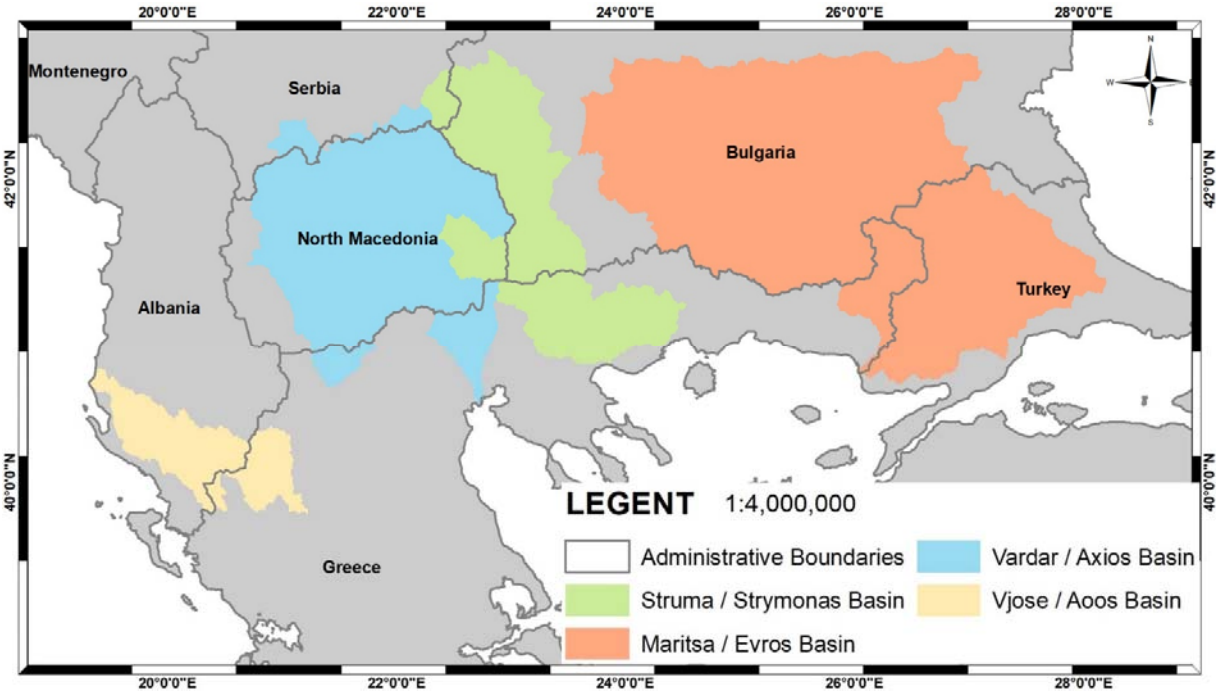


Figure 1: Area and Basins of Interest.

3. DATA & METHODOLOGY

The data used were acquired from the ESA Copernicus Hub, they consist of 2 Sentinel-1 GRD images and 2 Sentinel-2 Optical images, one that overlaps the time of the flood and one during summer were no water masses are present or identifiable, see table 1.

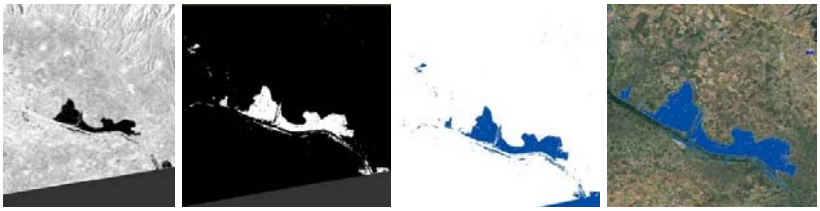
Table 1: Number and Sensing Date of satellite images used.

AREA / BASIN	SENTINEL-1 Number of Images	Sensing Date	SENTINEL-2 Number of Images	Sensing Date
Aoos Transboundary Basin	2	05/12/2017 & 02/08/2018	2	05/12/2017 & 24/01/2018
Axios Transboundary Basin	2	07/08/2016 –& 08/06/2016	2	09/08/2016 & 29/08/2016
Strymonas Transboundary Basin	2	29/03/2015 & 20/08/2015	-	-
Evros Transboundary Basin	4	27/03/2018 & 05/08/2018	4	30/03/2018 & 06/04/2018

The methodology steps followed in order to produce the final results are the following

1. RESEARCH AND SELECTION, BASINS OF INTEREST (Evros, Aoos, Axios and Strymonas Basins)
2. COLLECTION OF BASIN DESCRIPTION DATA (Physical / Geographical /Anthropogeographical)
3. SEARCH AND RECOVERY OF RECENT FLOOD EVENTS (Via Emergency Management Service - Mapping, A Copernicus Programme Platform)
4. RETRIVAL OF SATELLITE IMAGES (SAR / OPTICAL, Via Copernicus Open Access Hub)
5. PRE-PROCESSING / PROCESSING / QUOTATION & INTERPRETATION OF RESULTS (Presentation of the processing steps and the final results in the form of flood maps)
6. Evaluation of the contribution of Earth Observation Data to the monitoring and recording of flood phenomena within transboundary basins in the Southern Balkan Peninsula

The Sentinel-1 SAR images were processed according to the steps mentioned down at Figure 2 using ESA's "SNAP" application which is available for free.

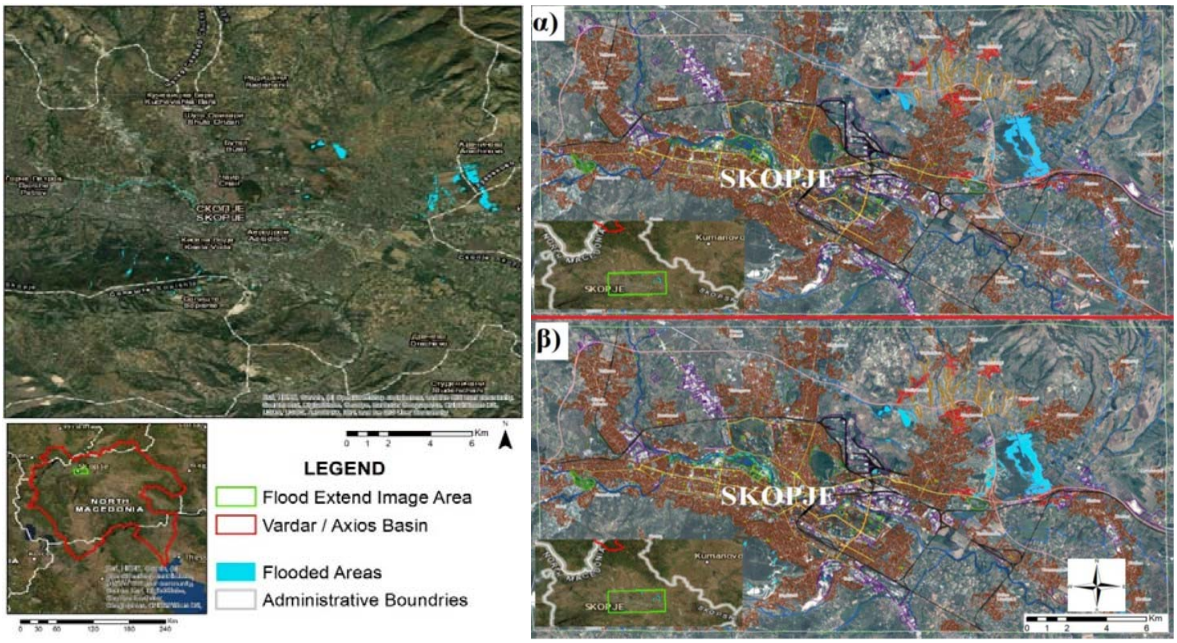


(a) (b) (c) (d)

Figure 2: Images state during the Main Processing. (a) Non – Binary, (b) Binarization (Water Masses 255, All other NaN), (c) GIS Adjusted, (d) Google Earth Loaded

4. RESULTS

Based on the methodology presented, the flood extent in the 4 transboundary basins was produced. More specifically, flood maps were produced which contain the areas covered by water compared to the boundaries of river basins and the rectangle of the Area of Interest. The above were also compared with the results of the EMS – Mapping of the Copernicus Programme as show down at Figure 3.



(a) (b)

Figure 3: Result Overview – Vardar / Axios Basin (NORTH MACEDONIA-GREECE). (a) Thematical Flood Extend Map for Axios / Vardar Basin flood event with a high-resolution optical imagery as a basemap, (b) Result comparison between those of the Emergency Mapping Service and ours. a) EMS Flood Extent Map b) Flood extent map from current flood project. EMS Flooded Area: 2.5 Km^2 Current Flood Project: 2 Km

5. CONCLUTIONS

1. Flooded areas within transboundary basins found by processing SAR images of Copernicus Sentinel-1 satellite are a) Aoos-01/12/2017: 46Km^2 b) Axios – 06/08/2016: 2Km^2 Strymonas – 30/03/2015: 45Km^2 Evros - 27/03/2018: 318Km^2.
2. Sentinel-1 SAR satellite imagery was considered the most valuable for the present study because Sentinel-2 optical imagery was characterized by high cloud cover and could not be used.
3. Matching results with those of the automated EMS system.
4. The important contribution of the free satellite earth observation data of the Copernicus program of the European Space Agency to the elaboration of research studies like the present one.
5. The contribution of this data that enables us to monitor and capture phenomena regardless of administrative boundaries

7. REFERENCES

8.

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A LOW COST SEISMOGRAPH: FIRST RESULTS

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ABSTRACT
Current work demonstrates the test investigation of our developed low cost seismograph, which was designed for local to regional seismicity and micro seismicity monitoring. Reducing the seismograph cost enables the creation of a dense seismic network. In this work acquisition data from conventional high cost seismograph and the proposed low-cost were compared. As a consequence, the low-cost seismograph was installed along with a high resolution 24 bits digitizer (equipped with a broad band seismometer) in an area of high seismic activity (Lefkada Island – Evgiros region). A testing list of 10 local events with different epicenters and magnitudes has been created, giving the opportunity to compare these recordings in the same test site. Initial results are presented, showing a satisfactory outcome in the performance of the proposed low cost seismograph. The underlying goal is to develop reliable low-cost acquisition devices costing at least one order of magnitude less than ordinary seismological stations while having on the same time the necessary acceptable precision for effective seismicity monitoring.

Keywords: Data acquisition, low-cost seismograph, seismicity

1. INTRODUCTION

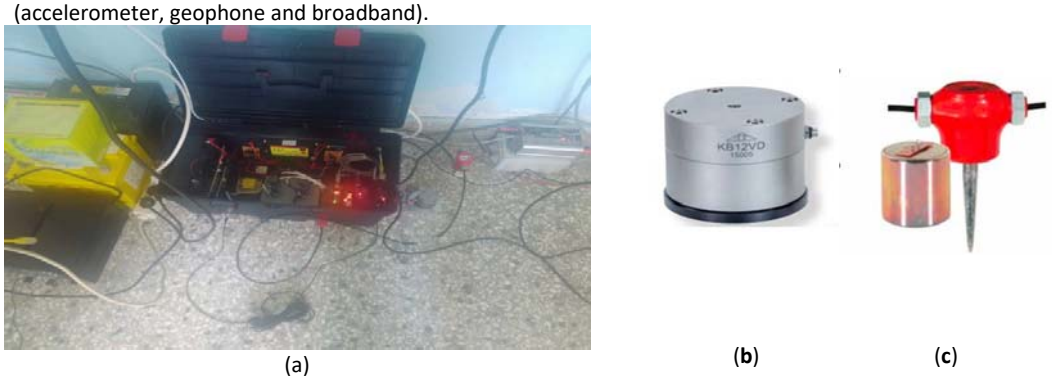
To begin with, a new sensing unit (fig.1a) was proposed (Vlachos, Avlonitis, & Karakostas, 2019) so as to measure ground vibrations generated by earthquakes, with development cost around 1.000 euros. A ceramic accelerometer (Weber, n.d.) with cutoff frequency fc=0.15Hz (KB12VD – fig.1b) combined with a moving coil geophone (Geospace , n.d.) with cutoff frequency fc=4.5Hz (GS11D – fig.1c) and both based on a single microcontroller board (Arduino Uno R3) and a microprocessor board (Raspberry Pi 3 B+) were used. Current sampling frequency is 345 Hz while broadbands' is 100 Hz. As far as data is concerned, locally storage as well as remote transfer through internet connection to the Ionian University database every five (5) minutes has been achieved. For each event the recording signals have been analyzed in terms of arrival time estimation of both P and S waves (Allen, 1978; Leonard and Kennett, 1999), in order to evaluate the performance of the low-cost seismograph in terms of certain seismic parameters.

2. EXPERIMENTAL METHOD

The main objective of this work has been to design and analyze a set of 10 earthquakes (table 1) with magnitudes between 1.7 to 2.7. Both recording systems are located in the same place (Evgiros, Lefkada Island, Greece). Having successfully chosen each event independently, all seismic waveforms were retrieved and signals were analyzed in terms of estimation of arrival times of both P and S waves (as seen on table 1).

Nr	*Date*	*Time*	*Coordinates*	*Depth*	*Magnitude*	Sensor	Dt (seconds)
1	2019_07_01	15:58:32.30	38.4347, 20.4900	7.5	1. 9	*accelerometer* *geophone* *broadband*	3.985 3.997 4
2	2019_07_02	03:27:32.50	38.4353, 20.4817	7.3	2.1	*accelerometer* *geophone* *broadband*	4.008 3.977 4
3	2019_07_02	06:05:22.40	38.4335, 20.4922	7.5	1.9	*accelerometer* *geophone* *broadband*	4.012 4 3.99
4	2019_07_02	12:16:53.50	38.4342, 20.4818	6.7	2.4	*accelerometer* *geophone* *broadband*	4.044 4.023 3.98
5	2019_07_02	12:40:37.50	38.4338, 20.4833	8.7	2.6	*accelerometer* *geophone* *broadband*	4.038 4.043 4
6	2019_07_02	12:48:19.30	38.4345, 20.4778	8.7	2.6	*accelerometer* *geophone* *broadband*	4.029 3.945 3.9
7	2019_07_03	02:08:08.20	38.4075, 20.5518	18.5	1.8	*accelerometer* *geophone* *broadband*	4.267 4.267 4.42
8	2019_07_03	03:12:32.40	38.4338, 20.5082	12	2.4	*accelerometer* *geophone* *broadband*	3.968 3.939 3.74
9	2019_07_03	06:38:55.20	38.4302, 20.5010	8.2	2.7	*accelerometer* *geophone* *broadband*	4.0288 4.0261 4.05
10	2019_07_03	13:51:41.60	38.4215, 20.4937	9.8	1.7	*accelerometer* *geophone* *broadband*	3.985 3.997 4

Table 1. Complete event listing along with Dt duration (S-P calculation/Lag time) for each sensor (accelerometer, geophone and broadband).



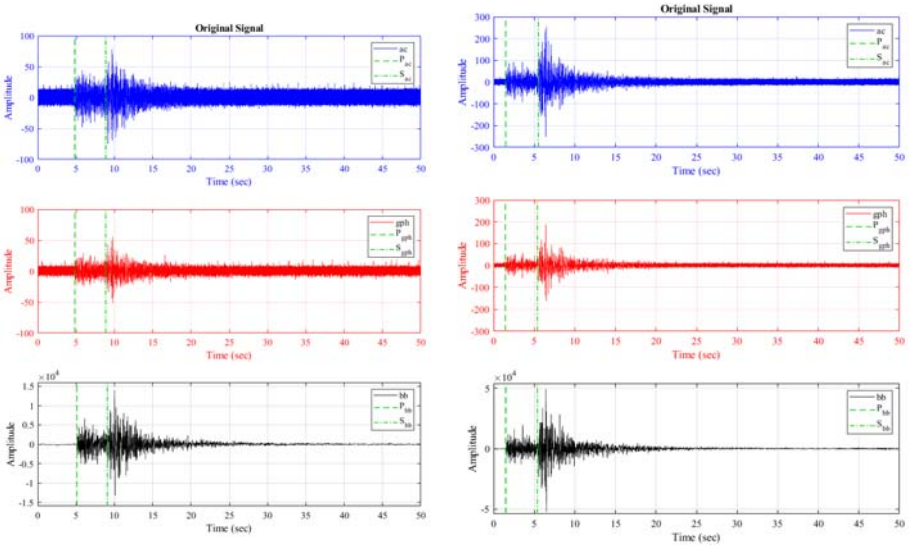
(a) (**b**) (**c**)

Figure 1. (**a**) Proposed low cost seismograph (hosted at the black suitcase) placed indoors at Eygiros Village in Leykada Island near the high cost seismograph. (**b**) Acceleration sensor used (Accelerometer KB12VD (**c**) Velocity sensor used (Geophone GS11D – 4.5 Hz)

3. RESULTS AND DISCUSSION

Figure 2 illustrates accelerometer (blue waveforms) and geophone (red waveforms) records originating from proposed low-cost seismograph while the black one depicts the waveform which came from the conventional high cost seismograph (broadband). Despite the noise presence in blue and red waveforms, P and S waves' arrival time estimation was effectively achieved. An overall agreement is

found between conventional classic seismograph and proposed low cost seismograph estimations, as seen on figure 3.



(**a**) (**b**)

Figure 2. (**a**) Arrival time validation for event 4. (**b**) Arrival time validation for event 6.

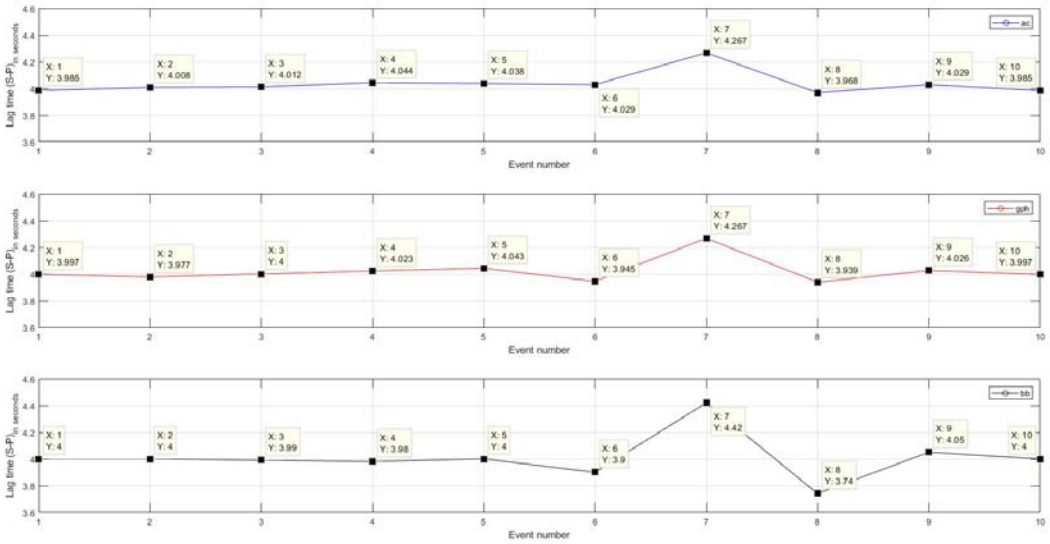


Figure 3. *Accelerometer (blue line-up) and Geophone (red line-middle) lag time representation acquired from the proposed seismograph, Broadband lag time representation (black line-bottom) acquired from the conventional seismograph for all the 10 selected earthquake events.*

4. CONCLUSION

These abovementioned results are very promising for as much as they indicate satisfactory sensitivity tolerance for local events with magnitude larger than 1.7. Next research stages in addition to hardware improvements (high resolution digitizer based on high precision analog to digital converter) are the incorporation of more earthquakes (with magnitude equal to 1 and up) to create a larger testing list, as

well as further processing with amplitude estimation (maximum, minimum, peak-to-peak) and spectral analysis investigation.

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NOVEL SOLUTIONS FOR COMMAND AND CONTROL NETWORK FOR DISASTER MANAGEMENT

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ABSTRACT
A manmade and natural disaster is a sudden incident that disturbs the normal conditions both intensively and extensively by threatening human life and property where resources required for combating the scenario substantially exceeds what is locally available. In this paper, we make an endeavor to analyze a comprehensive Command & Control solution for managing the entire communications ecosystem and an advanced tactical communications solution to generate an effective response necessary to meet the constraint of the hour in case of an incident.

Keywords: Command and Control Network, mitigation, Communication systems, incident, administration, disaster

1. INTRODUCTION

During the last years, we have witnessed several unfavorable and devastating incidents like floods, earthquakes, and tsunami, etc, which do have a considerable detrimental effect on the global economy and society at large. Since such adverse incidents are seldom predicted beforehand and chances of prevention are very rare, it is mandatory to have an efficient system to mitigate the aftermath. It has been observed for several decades that lack of timely and right information from the incident area leads to an undesirable delay in the procedure of mitigation resulting in an increase of death toll and loss of property. Moreover, the lack of efficient management makes the total disaster scenario worst which is irreversible. Thus, an efficient communication channel is the need of time to handle disaster scenario in a better way. We have many systems that are deployed at the time of any catastrophe to mitigate the disaster situation. In this paper, we present the systems mACS (Modular Audio Control Solution): Communications Interoperability & Consolidation and the CellBOX: Complete LTE Network in a BOX which are helping in decision making with its analytical tools or templates as well as storing data for future use. [1,2&3].

2. ANALYSIS OF MACS (MODULAR AUDIO CONTROL SOLUTION): COMMUNICATIONS INTEROPERABILITY & CONSOLIDATION

mACS is a comprehensive Command & Control solution for managing the entire communications ecosystem. By consolidating all communication assets, including radio, telephony, cellular, LTE, intercoms, conference services and any other relevant channel, mACS enables seamless connectivity and interoperability between the various forces and delivers far-reaching operational benefits. (Figure 1).

2.1. mACS at a Glance

- Network centric, comprehensive communications suite for Smart City/Campus Command & Control Centers
- Seamless interoperability between all communication sources
- Secure audio groups and conference sessions
- Fully customizable to changing operational scenarios
- Modular and scalable architecture
- Intuitive user interface
- Remote control and extension of radio coverage
- Complete redundancy
- Industrial grade, 19" rack-mounted chassis
- Recording and playback

Figure 1. Presents the different type of communication technologies and solutions that can be interconnected and interoperated through mACS.

2.2 Extending Radio Operations Beyond Line of Sight

Through simple network architecture, mACS unifies and optimizes the various communications channels and provides full interoperability between the different networks. At the heart of the solution, the Radio Gateway uses unique network bridging technologies to unify all RF channels by converting them to a common Radio over IP. Non-radio channels (landlines, cellphones, satellite phones and intercoms) are converted into Voice over IP, creating an instant IP centric network and providing access to any channel from any endpoint.

The Audio Control Box is an intuitive, touch-screen dispatcher console that displays all communications assets and provides complete monitoring and control of all related networks. It allows operators to transfer any channel to any operator and enable interoperability between various radio and non-radio devices through standard IP connectivity.

An essential part of any Command & Control or dispatch center for smart cities and campuses, emergency response and first responder forces, fire and emergency medical services, defense C4I and command post; mACS is a flexible and expandable solution that can operate on any scale, from a single-

site to a cross-agency, and even nationwide multi-site network, providing complete interoperability with no geographical limitations. [4].

3. ANALYSIS OF CELLBOX : COMPLETE LTE NETWORK IN A BOX

CellBOX is a compact LTE Network-in-a-Box (NIB) that provides fully-independent, high-speed broadband communications. Designed as an advanced tactical communications solution, CellBOX is lightweight and easily deployable, creating a secured network within seconds.

Enables First Responders and Security Forces to quickly and simply establish an independent Ad-Hoc 4G/LTE network where network coverage is unavailable. [4].

CellBOX can work either:

(i) as a Standalone LTE Bubble (External video sources such as the compound's CCTV system or a drone can be connected to the personnel's smartphones for a bird's-eye view) (Figure 2).

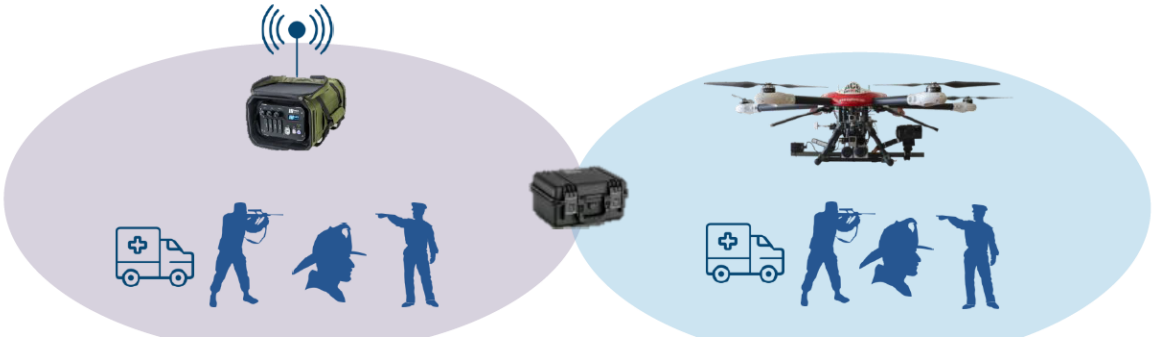

Figure 2. Presents the different type of the beneficiaries on the field and indicative usage of capabilities of the CELLBOX.

or

(ii) to provide LTE Connectivity Through Satellite and create Bridge between two LTE groups (Figure 3)

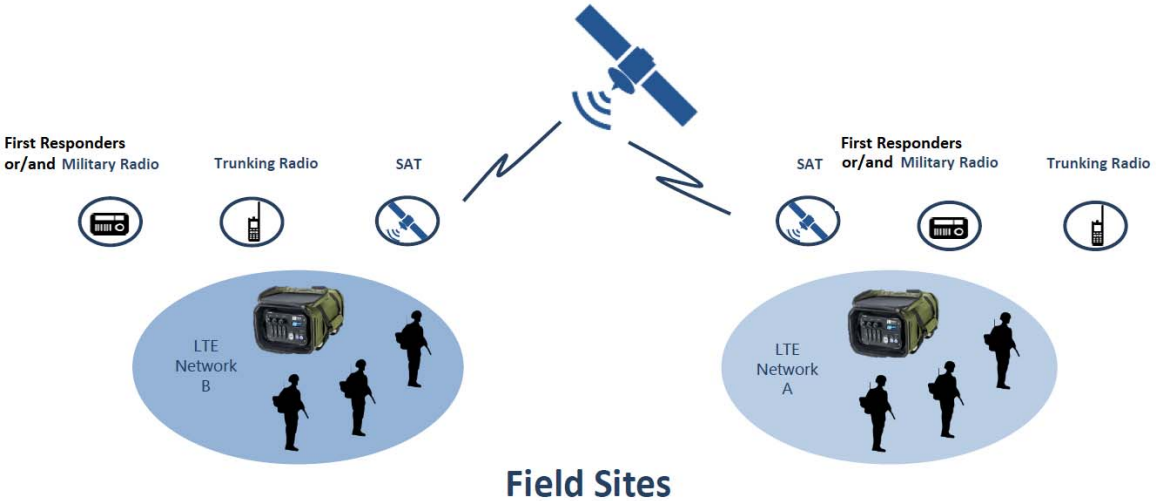

Figure 3. Presents Field Sites and additional usage type for the CELLBOX.

3.1 CellBox at a Glance

- Complete, independent LTE network
- Lightweight, single-button operation
- Advanced communications and situation awareness applications

- Secure and encrypted communications
- Supports up to 256 active users
- Supports various standard LTE bands
- Ruggedized packaging
- Compatible with standard smartphones, tablets and dongles
- 3G/4G or SAT backhauling options
- Built-in interoperability with legacy radio systems

3.2 Advanced tactıcal communıcatıons

CellBOX is part of an advanced, field-proven product line. Operated through a simple and intuitive user interface and compatible with any endpoint device (smartphones, tablets and dongles), CellBOX provides a wide range of applications, including PTT (Push-to-Talk), file and image sharing, Bi-directional, HD video sharing, chat and GPS positioning. Customizable and available in various configurations, the network also supports secure and encrypted interoperability with other communications platforms, situational awareness, connectivity to various sensors (CCTVs, drones, environmental sensors and more), and includes various backhauling capabilities; enabling personnel to focus on their mission, improves operational efficiency and saves lives.[4].

Figure 4. CELLBOX Enables: PTT Communications, HD Video Sharing, Situation Awareness, Chat and File Sharing.

CONCLUSION

In this paper, we present a novel Command and Control System and a communication network to fit into it, so that it gives rise to a very efficient communication channel to handle the disaster scenario in the best possible manner. The end-users are equipped to use this Command and Control System for handling the incident in a well-regimented way and with smart connectivity capacity.

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4. https://mer-group.com

MULTIMODAL WILDFIRE EVACUATION AT THE MICROSCOPIC LEVEL

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ABSTRACT
When conducting large scale evacuations, the safety and risk to the community needs to be considered with respect to the severity of the hazard, the use of escape routes, and the employed evacuation mode. Evacuation simulation models can reduce the apparent complexity of these aspects by providing a platform to assess the likely evacuation performance, aiding in the planning of large-scale evacuations. Typically, the evacuation may entail a multimodal approach with agents walking to designated shelters, to transport hubs or to use their private vehicles. Thus, the evacuation strategy may include pedestrian and vehicle evacuees. Often the two evacuation modes interact and influence each other. Both may also be affected by the progressing wildfire. It is thus beneficial to represent all three components within a unified tool. To date, there is no software model that has successfully integrated these components into a single tool that works at the microscopic level, capable of representing the interactions between pedestrian and vehicle evacuees. A tool is presented here that can represent pedestrians and vehicles at the individual level including the interactions that may occur when their respective routes intersect. The evacuation results allow the user to assess the evacuation performance and determine key evacuation parameters including, evacuation times, congestion levels, distances travelled, number of trapped pedestrians or vehicles, and fatalities, caused by the wildfire. A case study, loosely based on a real incident in Marysville, Australia, is presented to demonstrate the capabilities of the tool for evaluating set evacuation strategies.

Keywords: multimodal evacuation, pedestrian and vehicle interactions, preparedness, human behaviour modelling, wildfire

1. INTRODUCTION
In recent years, the increased expanse of the Wildland Urban Interface (WUI) has led to large, planned, and unplanned, evacuations to take place due to wildfires. These events increase in frequency and intensity due to global warming and extreme weather conditions [1]. Large scale evacuations often involve people evacuating both on foot and by vehicles [2]. In recent examples of wildfire evacuations such as in California, USA, [3] and at Mati, Greece [4], people attempted to evacuate both by foot and by vehicles. The apparent complexities of wildfire induced evacuations can be reduced by modelling tools that can aid incident managers in planning and training for future evacuations for a variety of *what-if* scenarios [5]. Given the dynamic nature of wildfire evacuations the employed strategy is dependent on the interactions between three main components, i.e. those between pedestrian and vehicle evacuees, and the effects that the wildfire has on both. To date, there is no software tool that has successfully integrated these three key components into a single tool that works at the microscopic level of detail and can represent the impact of their interaction.

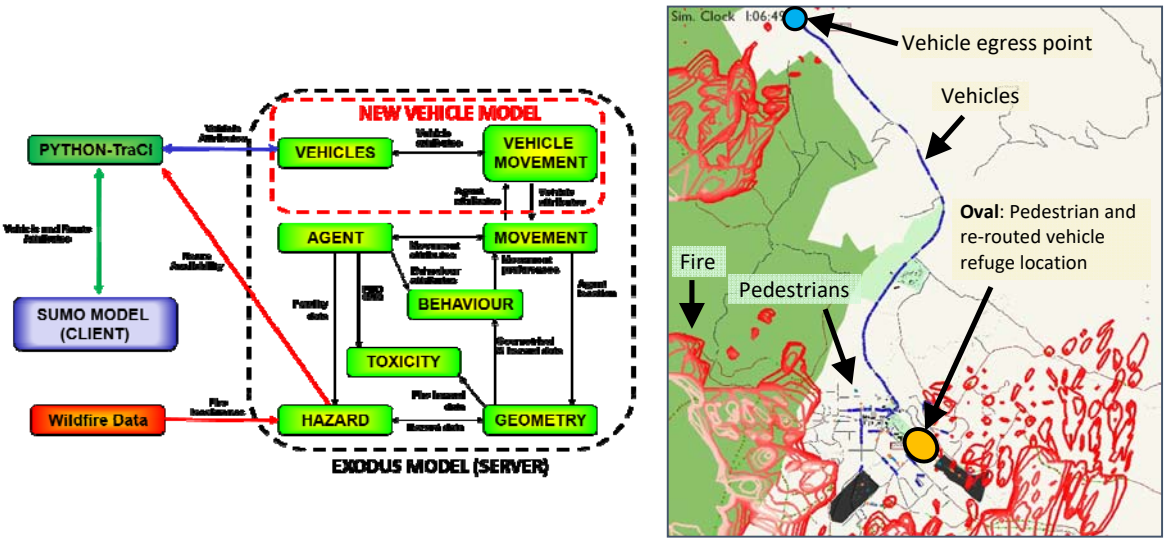
1.1. Background
Three types of computer models can aid incident managers in planning and preparing for wildfire evacuations, i.e., pedestrian evacuation models [5], traffic models [6,7] and wildfire spread models

[8,9,10,11,12]. Pedestrian evacuation models are used to represent the movement and behaviour of pedestrians as they seek refuge locations or leave the area. Traffic models are used to represent the movement of vehicles identifying possible bottlenecks and congestion. Wildfire models predict the location of moving fire perimeters, smoke fronts, fire embers, flame length and heat to identify areas at risk. Used independently, these models, cannot provide insights on the complexities that develop when these three key factors interact and affect the overall evacuation strategy. The vehicle evacuation is not taking place in isolation of the pedestrian evacuation and the evolution of the fire. The pedestrians' routes will intersect the vehicles' routes generating points of conflict where vehicles or pedestrians will need to yield to allow progress. Previous research has been carried out looking at developing a framework for integrating fire, pedestrian, and vehicle models for the WUI [6,7]. This paper, describes the actual coupling and integration of the state of the art urbanEXODUS pedestrian evacuation model [13], the SUMO [6] traffic model and fire models [8,9,10,11,12] demonstrating the working of a unified system. While coarse models, that treat pedestrian and traffic movement as flows [7] attempt to represent these types of models within a single tool, in this work, pedestrian and vehicle models act at the microscopic level of detail, i.e. representing pedestrians and vehicles individually each having their own attributes and capabilities.

1.2. Methodology

The tool presented here couples two well established engineering simulation tools, the pedestrian Agent Based Model (ABM) urbanEXODUS [13] and the open source SUMO traffic model [6]. It can also import wildfire propagation data [8,9] and determine the overall evacuation performance within a unified system. The heart of the unified tool is urbanEXODUS (Figure 1a). The SUMO traffic model is linked to urbanEXODUS via SUMO's TracCI interface [6]. SUMO models the movement and routing of the vehicles in the road network and the interactions between vehicles, whereas urbanEXODUS controls all interactions of the pedestrians with the vehicles [14] and vehicles with pedestrians. With regards to the wildfire data the fire perimeter output dataset generated by widely used fire models [8,9,10,11,12] is used to determine the effects that wildfire may have on the evacuees. The fire dataset represents the burnt or propagating burning area. It is used to calculate the effect of the fire on the road network and evacuees within urbanEXODUS, which may result in the generation of blocked routes or fatalities (both pedestrian and vehicle). In the case of blocked routes urbanEXODUS signals SUMO whether a vehicle needs to be re-routed or is assumed to be destroyed by the fire, together with which roads are blocked.

A key advantage of using microscopic level models to represent pedestrians and vehicles is that it is possible to determine pedestrian-vehicle interactions at the individual level, as well as determine how fire products may impact the evacuation. The interaction between pedestrians and vehicles is especially important as the multimodal nature of the evacuation may have a significant impact on the evacuation process. The model takes into account the suggestions identified by Schroeder [15] and Wang [16] in relation to pedestrian crossing behaviours and urgency [14] as well as data collected from an online pedestrian crossing behaviour survey [17] to build a unique set of behaviours for representing how people are likely to interact with moving vehicles in an emergency situation. The cognitive processes of pedestrian road crossing, included in this research, cover decisions on whether to cross a road or not (gap acceptance model) and where to cross the road. The way that the agents exhibit these behaviours depends on their urgency and risk-taking characteristics. When crossing the road, the model resolves any possible interactions with vehicles moving on that road. This unified tool allows the user to obtain insights regarding the evacuation process that are difficult, if not impossible, to obtain in any other practical way. Examples of insights include assembly and evacuation times, identification of optimal routes, time when conditions on routes become untenable, and determine possible fatalities [5].



(a) (b)

Figure 1. (a) Integration of urbanEXODUS, SUMO and wildfire models (b) pedestrian and vehicle evacuation underway as the wildfire engulfs the town of Marysville.

2. CASE STUDY

The coupling of the pedestrian and traffic models with wildfire propagation data is demonstrated by modelling the evacuation of the town of Marysville. The population of the town is assumed to be 3633 people, 10% of those will evacuate by foot towards the Oval (Figure 1b) while 90% will use their vehicles to evacuate towards the North vehicle egress route. The command to evacuate the area is given at 3h 30min after fire ignition. Two key scenarios are briefly presented here, each was run 10 times. Scenario A represents a case where the pedestrian-vehicle interactions are not enabled. The evacuation models are thus completely independent from each other. Conversely, scenario B represents a case where the pedestrian-vehicle interactions have been enabled. The summary results are presented in Table 1.

Table 1. Summary average evacuation performance results. Values in brackets represent the standard deviation.

Scenario	TET (hh:mm)	F_{Tot}	F_{Veh}	V_{Trap}	V_{Red}	F_{Period} (hh:mm)
A	01:55 (1.3 min)	1452 (1.8)	1341 (0)	435 (0)	217 (0)	01:01 – 01:30
B	01:56 (1.4 min)	1461 (6.9)	1350 (7.04)	437 (1.52)	212 (5.25)	01:01 – 01:30

The average, total evacuation time (TET) in both cases is similar (1h55' and 1h56'). In scenario B however, the interactions between pedestrians and vehicles generate, slightly greater variation in the total number of fatalities (F_{Tot}), agent fatalities in vehicles (F_{Veh}), vehicles that get trapped (V_{Trap}) and vehicles that redirect towards the Oval due to the wildfire (V_{Red}). The period that fatalities are generated (F_{Period}) is fixed in both scenarios as this is driven by the deterministic nature of the wildfire data. Also, there is zero deviation for F_{Veh}, V_{Trap} and V_{Red} in scenario A due to the deterministic nature of SUMO. However, urbanEXODUS is stochastic in nature, this fact in conjunction with the pedestrian-vehicle interactions, generates variation in the evacuation performance results. In this case, given the size of the town and the relatively low rural population density there are only a few opportunities for pedestrians to interact with vehicles. This is evident from the similarity between the scenario results. It is anticipated that when modelling a densely populated urbanised area, the pedestrian-vehicle interactions will have a more profound impact. However, what this demonstration case accomplishes is that the unified tool can reveal the impact that the interactions have on the evacuation process and that they constitute a factor that needs to be considered when conducting a large-scale evacuation study.

3. CONCLUSIONS

The coupling of pedestrian and vehicle models with wildfire data attempts to provide answers to crucial questions that incident managers are called to address when planning and preparing for future wildfire incidents. The resultant unified tool can reveal the complexities and the combined effect that the pedestrian-vehicle interactions and impact of wildfire have on the evacuation performance. The ability to derive evacuation performance data based on engineering tools proves invaluable, as currently there is no other practical method for addressing these questions beyond computer simulation. These insights aim in augmenting an incident manager's knowledge and experience allowing them to take informed decisions that can improve preparedness levels, allow for better use of resources, potentially saving time, lives, and property.

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A PRIORITIZATION SCHEME FOR SEISMIC INTERVENTION IN SCHOOL BUILDINGS. THE CASE OF THESSALONIKI, GREECE

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ABSTRACT
Seismic risk assessment of critical buildings stock, like the school buildings, pdrovides the authorities and the community with the necessary information for decision- making regarding the mitigation of the adverse effects of a catastrophic earthquake on the built environment and the population. Especially in the case of school buildings, the requirements for a reliable seismic vulnerability and risk assessment are particularly high. Seismic risk assessment involves many uncertainties, as it depends on several steps, starting from the identification of the exposure of the elements at risk (school buildings, student population, employees etc.), the evaluation of site-specific seismic hazard, concluding to the calculation of the expected damages and losses for each seismic scenario. As a general remark, most of the existing methodologies allowing the assessment of seismic risk cannot be easily applied, as they require highly specialized users together with a significant amount of data not always available or accessible. Therefore, there is a need to develop an integrated and relatively simple easy-to-use methodology, which should be specially adapted to school buildings. To this end, the present work outlines the essentials of a unified methodology for assessing the vulnerability and seismic risk of schools, adapted to the Greek data, which will be suitable for use by both non-specialized and experienced users. The proposed approach is suitable for the development of a realistic mitigation and prioritization scheme of retrofitting and structural strengthening actions for the different school building typologies.

Keywords: natural hazards, vulnerability assessment, risk, hazard, exposure model

1. INTRODUCTION
School buildings, which house a vulnerable population, are often hit by catastrophic earthquakes and the losses in many cases are significant. Protecting school buildings from earthquakes should be a priority in all countries. In the last decades, thousands of students lost their lives when the buildings of the school units in which they attended collapsed (e.g. Armenia earthquake in 1988, Venezuela earthquake in 1997, China earthquake in 2008). In Greece, despite the low damage and fatality rate related the seismic response of the school building stock, it is necessary to develop a coherent approach to evaluate the seismic vulnerability of the schools using state-of-the-art techniques. The seismic vulnerability of a school depends on many factors such as construction year, construction characteristics and details including materials and the quality of construction, geometry of the building, the connections of the structural elements, foundation system, quality of maintenance etc. Significant subsequent modifications (e.g. addition of floors), as well as any past damages or material degradation with time, for example due to corrosion and aging effects, can increase the seismic vulnerability of school buildings. Most schools in large cities such as Athens and Thessaloniki were built in between 1960s and 1980s with no/low code seismic regulations and therefore with low safety factors. Thus, even a moderate earthquake can cause significant losses in the school building stock. Consequently, hierarchical identification of the most vulnerable schools in order to proceed to their retrofitting and strengthening is certainly an urgent priority. To this end, the

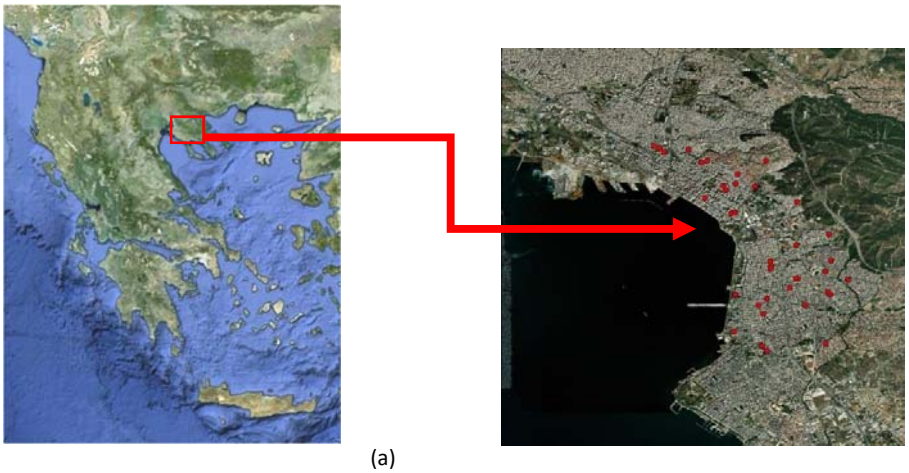
present work proposes a prioritization scheme for seismic intervention in school buildings in Greece, which is based on a seismic risk assessment methodology of school buildings using the open-source earthquake hazard and risk software OpenQuake Engine (Pagani et al., 2014). The methodology is applied in the schools of Thessaloniki municipality.

2. DESCRIPTION OF THE METHODOLOGY AND APPLICATION IN THE SCHOOLS OF THESSALONIKI MUNICIPALITY, GREECE

The proposed methodology for the prioritization for seismic intervention in school buildings in large scale (here in city scale), consists of the following steps:

Step 1: Mapping and classification of the school buildings.

The primary step of the methodological chain is to develop an appropriate exposure model of the school buildings at risk. For this purpose, one can may use the general inventory of buildings of ELSTAT, which include for all buildings in Greece detailed data concerning the construction material, the number of floors, existence of pilotis, construction period etc. These data openly available are used to classify the schools, using adequate taxonomy scheme, in appropriate typologies based on their geometric and dynamic characteristics. Figure 1b shows the location of the 62 studied school building (132 structural independent components). Their classification according to the GEM Building Taxonomy (Brzev et al., 2013) is shown in Figure 2.



(a) (b)

Figure 1. (a) Study area on the map of Greece, (b) Mapping of the studied school buildings (in red)

Step 2: Seismic hazard model.

For the application at the school buildings of Thessaloniki municipality we performed an Event-Based Probabilistic Seismic Hazard Analysis in OpenQuake, using the ESHM13 seismic hazard logic tree (Woessner et al., 2015). Figure 3 shows the resulting spatial distribution of peak ground acceleration PGA across the city of Thessaloniki for a mean return period of 475 years using the $V_{s,30}$ model from the microzonation study of Thessaloniki (Anastasiadis et al., 2001).

Step 3: Assessment of seismic damages

The first step of the risk assessment, i.e. estimation of losses, consist of the selection of appropriate fragility curves according to the building typologies defined in Step 1. For that we adopted herein the fragility model proposed by Martins and Silva (2020). Then, combining the results of the exposure (step 1), the hazard (step 2) and the selected fragility models (step 3), we estimated the expected seismic damages to the school buildings (Figure 4a) for a return period of 475 years. According to this analysis, the main conclusion is that on average the school buildings in the municipality of Thessaloniki will exhibit slight damages independently of their typology. The higher damages are estimated, as expected, for the masonry buildings (MUR+CL99).

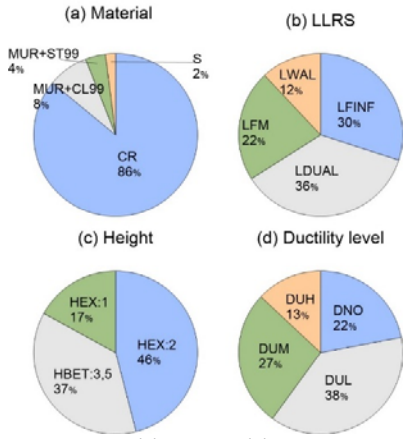


Figure 2. Classification of the studied school buildings based on (a) Material, (b) Lateral Load-Resisting System (LLRS), (c) Height and (d) Ductility level according to the GEM Building Taxonomy (Brzev et al., 2013). (CR: CONCRETE, MUR+CL99: CLAY BRICK UNREINFORCED MASONRY; LFINF – INFILLED FRAME, LDUAL – DUAL FRAME-WALL, LFM– MOMENT FRAME, LWAL– WALL; DUH – HIGH DUCTILITY, DUM – MEDIUM DUCTILITY, DUL – LOW DUCTILITY, DNO– NO DUCTILITY; HEX:1– ONE-STOREY BUILDING, HEX:2 – TWO STOREY BUILDING, HBET:3,5 – THREE TO FIVE-STOREY BUILDING)

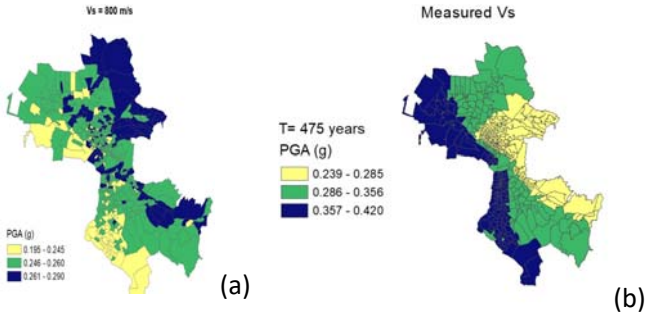


Figure 3. Spatial distribution of peak ground acceleration PGA in the city of Thessaloniki for a mean return period equal to 475 years a) for rock site conditions, considering $V_{s,30}$=800 m/s and (b) using the $V_{s,30}$ model from the microzonation study of Thessaloniki (Anastasiadis et al., 2001).

In order to evaluate the reliability and usefulness of this proposed approach it has been decided to compare the results with a more simplified methodology applying a rapid visual screening (RVS) procedure quite familiar to engineers for a first order vulnerability assessment. For that, we adopted herein the method proposed by FEMAR-154 (2015), which is also adopted by the Organization for Earthquake Planning and Protection (OASP) in Greece. A relevant tool for this purpose has been developed recently in the framework of an ongoing project entitled SAFESCHOOLS (https://sites.google.com/view/safeschools-project). The RVS procedures use a methodology based on a Data Collection Form, completed on site by the person conducting the survey; it is based on visual screening of the building. Based on the data collected during the survey, a score is calculated that provides an indication of the expected seismic vulnerability of the building irrespectively the seismic hazard. In this study, in order to see the differences of the two procedures in terms of the estimated vulnerability, we applied the RVS procedure proposed in 2014 by the Ministry of Environment (FEK 405/B'/20-2-2014, §40), which classifies the school buildings in three categories, i.e. red, yellow and green for the high, medium and low prioritization for seismic intervention, respectively (Figure 4b).

The main conclusion of the comparison is that the simple RVS procedure (visual screening), which is certainly associated with important uncertainties, results in higher vulnerability and hence damages' estimations for almost all school building typologies, compared to the herein proposed methodology. Consequently, any mitigation strategy based on the results of RSV might give a misleading picture of the actual needs for retrofitting.

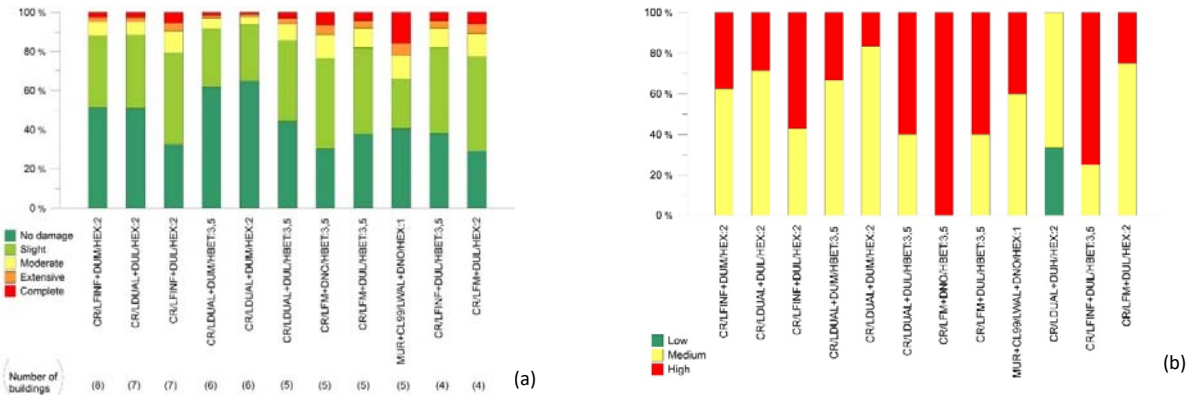


Figure 4. (a) Summary of the estimated level of damages (low, medium, high) according to the different school building typologies. (b) Application of the RVS procedure to the 62 school buildings in Thessaloniki municipality and classification of their vulnerability level. (CR: CONCRETE, MUR+CL99: CLAY BRICK UNREINFORCED MASONRY; LFINF – INFILLED FRAME, LDUAL – DUAL FRAME-WALL, LFM– MOMENT FRAME, LWAL– WALL; DUH – HIGH DUCTILITY, DUM – MEDIUM DUCTILITY, DUL – LOW DUCTILITY, DNO– NO DUCTILITY; HEX:1– ONE-STOREY BUILDING, HEX:2 – TWO STOREY BUILDING, HBET:3,5 – THREE TO FIVE-STOREY BUILDING)

3. CONCLUSIONS

We present a methodology for the assessment of seismic vulnerability of school buildings which might lead to a more accurate and realistic prioritization scheme and strategy for retrofitting and strengthening needs. The methodology is applied to 64 school buildings located in the municipality of Thessaloniki. For the seismic hazard we perform an event- based seismic hazard analysis. For the vulnerability model, we apply the fragility curves by Martins and Silva (2020). Estimated damages are compared to the resulting vulnerability from a RVS procedure for the same school buildings. The herein proposed methodology proved to give more realistic results in order to make a prioritization strategy for strengthening and retrofitting actions for school buildings.

ACKNOWLEDGMENT

This research is co-financed by Greece and the European Union (European Social Fund- ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning» in the context of the project “Reinforcement of Postdoctoral Researchers - 2nd Cycle” (MIS-5033021), implemented by the State Scholarships Foundation (IKY).

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EMERGENCY EVACUATION IN CASE OF AN IMMINENT OR AN ONGOING DISASTER IN GREECE: A COMMENT

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ABSTRACT

Various evacuation strategies have been tried in different countries around the world employing among others compulsory or directed evacuation, recommended evacuation, self-evacuation and 'shelter in place'. In Greece, no matter the objerved practices and experiences, the overarching notion of "organised preventive displacement of the population" is promoted by the General Civil Protection Plans for all situations calling for population evacuation, with little reference to other evacuation approaches. Based on a review of literature and of the legal framework, the paper discusses the legislation, the guidelines and practices concerning emergency evacuation in Greece and attempts to provide some insight on better planning and implementing the evacuation and displacement of people in case of an anticipated or ongoing disaster.

Keywords: emergency evacuation, organised preventive population displacement, Greece

1. INTRODUCTION

Emergency evacuation applies to a range of situtions involving danger in a place (due to natural hazards, technological accidents or intentional threats such as terrorist attacks and bombing) and refers to various spatiotemporal scales, from short building evacuation in case of a bomb threat to the permenent displacement of the population e.g. due to risk of coastal erosion or landslide risk. In general, it signifies a movement of people from a place that is considered to be in imminent danger to a place that is considered safer.

In disaster management, emergency evacuation commonly takes place under urgency although some types of situations, such as fluvial floods or volcanic eruptions generally allow for more warning time. Moreover, uncertainty is typically present as regards both the manifestation of the hazard and the evolution of the situation in space and time. Last but not least, emergency evacuation relates with risk perception and acceptability, trust to authorities, social capital and the copying strategies of the population, hence has strong cultural and socioeconomic dimensions.

Given the complexity of the undertaking, it is not surprising that experiences from emergency evacuation in crises and disasters bring up many challenges for planning and implementation of population displacement or/and emergency evacuation. On the other hand, there is significant experience and knowledge gained in this field [1].

Various evacuation strategies have been tried in different countries around the world. Evacuation can be either compulsory or directed, when a government entity has such a mandate, or recommended, when an evacuation warning has been issued but people have the option to remain. In some cases, movement of people to safer places is self-initiated in the absence of official warnings or in contrary to official recommendations (self-evacuation). 'Shelter in place' is also an option in which people in danger may take protective shelter inside structures. In evacuation, the movement of people may be either horizontal (e.g. inland away from coastal areas) or vertical (e.g. movement of people to higher storeys in case of a tsunami). All the above types of evacuation, even self-evacuation, must rely on detailed planning and exercising and involve a range of stakeholders from civil protection

authotities to enterprises in charge of transport infrastructure to civil society and the general public. Evacuation typically evolves in stages and these set the basis of evacuation plannning and management. In any case evacuation plans should be developed, although adjustments to the situation at hand are typically required and no single evacuation plan can be applied to all situations.
Based on literature review and the study of the legal framework and past experiences, the paper discusses strategies and practices for emergency evacuation in Greece and attempts to provide some insight on better planning and executing emergency evacuation in case of an anticipated or ongoing disaster.

2. LEGAL FRAMEWORK, PLANNING AND EXPERIENCES IN GREECE

Emergency self-evacuation in case of an earthquake has been a longstanding practice in Greece as self protection behavior in earthquakes assumes the evacuation of buildings and taking refugee in open spaces. Earthquake Planning and Protection Organisation (EPPO) since its establishment in 1983, has been busy in issuing evacuation guidelines and relevant training material for different target groups [2], [3]. Furthermore, of notice are the early efforts of the Ministry of Physical Planning and Environment in 1984 to issue requirements for ensuring adequate open public space for emergency evacuation and shelter in case of a flood or earthquake in all urban areas planned under the Urban Reorganisation Program[1].
Emergency evacuation in earthquakes is now a mature matter in Greece; drills at schools are regular and are not uncommon at public buildings and businesses. Moreover, under the guidance of EPPO, many Municipalities have mapped appropriate open spaces to be used for emergency evacuation. After decades of efforts, noticeable advancement is achieved as regards earthquakes however evacuation in other emergencies is still more of a challenge.
A turning point in evacuation in case of forest fires were the 2007 mega-forest fires that revealed major gaps and weaknesses [4]. A few months later, the General Secretariat of Civil Protection (GSCP) institutionalised emergency evacuation in case of a forest fire; bL.3613/2007, article 18, assigned responsibilities in decision-making for emergency evacuation. The term “organised preventive displacement of the population” (from now on “OPDP” in this paper) appeared for the first time and is since used to convey evacuation of population in case of an imminent or ongoing disaster. Following this Law, guidelines were issued in 2008 and undated in 2011. Few years later, L. 4249/2014 (article 108, par. 5f) regulates “organised preventive displacement of the population” for all types of disaster. Guidelines under this Law were issued by GSCP in 2015.
An early attempt for OPDP took place in Evros during the fluvial floods of February 2010, when the villages Lavara, Prague, Mandra and Poros were evacuated [5], [6]. Since then, numerous cases of organised displacement have been announced, mainly in cases of forest fires and floods, however little information is publically available about them. Seemingly not enough progress has been made in this field, given that during the fatal forest fire at Mati, Attica, in 2018, no decision for an organised preventive displacement of the population was taken and even worse no warning to the population in danger was issued. Justified or unjustified criticism from different viewpoints was strong and scientists stated openly that a timely evacuation was a realistic option [6]. In the case of the forest fires in Attica on September 9, 2020 warnings to the population to evacuate were issued by the GSCP and were communicated through the emergency number 112; anyhow the official procedures for OPDP according to the General Plan were not followed.
The recent L.4662/2020 on civil protection system which was published on February 7th, 2020, includes a whole part on OPDP seen mostly as in the previous legal framework.

[1] Urban Reorganisation Program (EPA) (1982-1984) aimed at urban planning of all settlements with population more than 2.000 people in Greece (about 453 settelements).

Justified by the COVID-19 crisis, implementation of the new Law is now for the most part put on a halt. Nonetheless, the latest General Civil Protection Plans concerning floods, forest fires, earthquakes, major industrial accidents and transport of dangerous goods were issued by GSCP under L.3013/2002 in the very end of 2019 till the beginning of 2020 and they all contain a Part on "organised preventive displacement of the population". Based on previous regulation, they all focus on responsibilities and decision-making procedures concerning OPDR and outline an Action Plan comprising 7 steps. Municipalities and Regions are instructed to draft memoranda of actions for OPDR and agencies responsible for spaces of specific use such as summer camps are directed towards evacuation planning and preparedness. Planning and monitoring the implementation of population displacement which is usually very challenging is roughly outlined. Moreover, all plans are strikingly similar (even in wording) as regards OPDR. How these plans are adjusted to the specificities of the hazard and the situation as regards OPDP is summarised in Table 1.

Table 1. Other evacuation solutions besides Organised Preventive Population Displacement, mentioned in the recent General Civil Protection Plans

Plan Code Name	Reference to other solutions besides OPDP	Comments by the author
"Dardanos" (on floods)	In case of flash floods when there is a call for assistance by trapped people in danger or when the presence of people in an area poses an imminent danger for their lives, their urgent displacement is seen as a rescue operation.	Different types of differ in characteristics influencing evacuation i.e. speed of flood manifestation, secondary risks, potential impacts, means/ tools/procedures for flood control and management. In the Plan, guidance on population displacement is adapted to cases in which there is enough warning time and also, there is little uncertainty as regards secondary and hidden / creeping risks. In short, the Plan falls short in tackling the range of types of floods and their implications for evacuation.
"Iolaos" (on forest fires)	In terms of health and safety , selection of refugee spaces is seen principally in the same way as in the case of other hazards (i.e. earthquakes); yet, risks from air pollution due to the fire (smoke, particles etc.) are to be considered.	Selection of appropriate refugee space in forest fires can become difficult especially in cases of changing strong winds or pollution risk. This can challenge significantly "just-in-case" planning of refugee space that the Plan dictates now. Shelter in place and self-evacuation which are not uncommon practices in case of a forest fires are ignored by the Plan although these imply significant challenges for evacuation planning and implementation.
"Egelados" (on earthquakes)	Population displacement in case of earthquakes refers only to secondary hazards such as urban fires, landslides, release of hazardous materials and danger from building collapse. Self-evacuation is ignored in the Plan although it is the common practice in Greece.	OPDP even due to secondary hazards involves high uncertainty which affects safety and efficiency in all steps of the endeavor. Even if not centrally organized, self-evacuation calls for arrangements in emergency planning and management (i.e. monitoring open refuge spaces, public information). The Plan sees refuge space and space for emergency shelter as the same although they are very different in terms of emergency needs, emergency planning procedures, requirements and responsibilities.
"Heraklitos" (on major technological accidents	The Plan acknowledges shelter in place and OPDP, with the Fire Chief on the spot directing the choice of solution. Info in App. 4 helps in this choice.	Organized population displacement is seen as no different from the one in any other case of a disaster. Nonetheless, the Plan briefly touches upon the shelter-in-place solution but it does not provide guidance on the many challenges this solution implies for emergency management.
Plan on accidents during the transport of dangerous goods	The Plan acknowledges both shelter-in-place and OPDP, with the Fire Chief on the spot directing the choice of solution. The Appendix presents protection measures, however none of those refers to population displacement.	OPDP is seen as in any other case of a disaster. Nonetheless, the Plan briefly touches upon the shelter-in-place solution but does not provide guidance on the many challenges this solution implies for emergency management. Since accidents in transport of dangerous goods can happen anywhere along transport lines, a lack of population risk awareness is expected. Therefore there are even more challenges in population warning and information for the plan to deal with.

4. CONCLUSIONS AND RECCOMENDATIONS

In Greece, the overarching notion of "organised preventive displacement of the population" generally applies. All General Civil Protection Plans promote this approach no matter the type of emergency or the specificities of the situation at hand, with little reference to other types of evacuation. All Plans perceive "organised preventive displacement of the population" as a 7 steps operation and emphasise on regulating decision making procedures. None of the Plans delineates self-evacuation and only some mention other evacuation approaches which might correspond better to the specific circumstances and the combination of urgency and uncertainty.

The Plan on earthquakes mentions that OPDP applies mainly in case of secondary risks such as landslides, NaTechs or collapses of buildings in densely populated areas due to aftershocks. Yet it fails to acknowledge emergency self evacuation and the many challenges it poses for civil protection planning (i.e. management of appropriate open spaces, population information, security of refugee spaces, training of special target groups, pet evacuation etc.). Plans on technological accidents mention also the "shelter in place solution" however they hardly touch upon this solution and they mainly reproduce the known text on "organised preventive displacement of the population" from the other Plans.

In conclusion what is called "organised preventive organised population displacement" seems to prevail in civil protection nowadays and other solutions are overlooked. This one-size-fits-all approach to emergency evacuation has already been demonstrated weak in recent cases of sudden unexpected / low probability disasters when the foreseen by the plan formal decision-making procedures were proven complicated and impossible to follow under urgency; also, implementation of organised population displacement on the ground was impossible under the circumstances and within the available time frame. As a result, spontaneous self-evacuation took place and in some cases led to casualties.

"Organised preventive population displacement" implies a top-down well planned and organised operation following evidence-based decision making. One could argue that in an effort to promote the concept of a neat operation, the General Civil Protection Plans overlook solutions that have already been observed on the ground and practiced internationally. Obviously, not acknowledging other solutions does not eliminate or even discourage other practices in real life. Consequently, what is missing is that different evacuation approaches are regulated, planned and efficiently implemented so that there is a room for choice of the solution that better suits the specificities of the situation at hand.

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LONG-DISTANCE VOICE MESSAGING SYSTEMS (CLEAR VOICE) DURING THE TIME OF NATURAL AND MANMADE DISASTER ACCORDING TO HEALTH AND SAFETY REGULATIONS.

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ABSTRACT
This paper present the Clear Voice a family of planar speakers that developed in response to the global demand for an acoustic hailing device that has the ability to effectively communicate with large crowds over great distances. The planar transducer, Clear Voice, is able to achieve distance and clarity levels that are unmatched by any conventional speaker and horn.
The Clear Voice systems are the ideal solution for Police and fire officials communicating to large crowds, Public safety & rescue personnel responding in emergency situations, Maritime hailing, warning, and safety commands and temporary command and control centers and security checkpoints.

Keywords: Messaging systems, Communication, large crowds, emergency situations, Planar Technology

1. INTRODUCTION

In the event of a disaster, it is very important to quickly evacuate to evacuation sites in order to minimize the number of victims of the disaster. Governmental authorities only present their citizens with information about the locations of evacuation sites and anticipated damages in the event of disasters such as Urban and forest Fires, tsunami and earthquakes. [1]. Thus, in the event of a disaster, people present at various places will not be sure about the evacuation routes that they should take individually. Accordingly, there is a need for a Long-Distance Voice Messaging System in order to offer voice message guidance to the potential victims such as quickly determining evacuation routes and guiding people in accordance with the status of the traffic network, the locations of evacuation sites, and the number of victims.
A newly developed planar transducer that is matched in performance and quality, which is based on Planar technology, is disclosed. Various long-Distance voice messaging systems for use in poor communication environments, as in the event of a disaster, have been proposed, including planar technology. According to existing planar systems, first responders weren't satisfied with the status quo and a new need to develop a better planar device is born. A team of engineers and physicists developed a new planar transducer that is unmatched in performance and quality. This paper introduces the development of the technology and system features including some test results of the system function also.

2. ANALYSIS OF CLEAR VOICE SYSTEMS

Planar technology has been around since the early 1930's and has always been known for its ability to deliver clear and crisp sound. Over the years users of planar have been satisfied

with the technology available and have incorporated planar devices into a variety of commercial and home audio products.
Clear Voice planar transducer reaching distances in excess of 2000' and able to broadcast an intelligible message 10 decibels below the ambient noise level, the Clear Voice transducer was tested by an independent laboratory recording a perfect score on the CIS intelligibility test. In a separate test using STIPA testing equipment, the Clear Voice transducer registered an "Average High Background Noise STI improvement" of 12.4% over a high-fidelity line array reference speaker.
Due to their functional design, conventional speakers and horns create multiple sound waves of the desired frequencies in addition to generating multiple waves of unwanted frequencies. As the wanted and unwanted frequency waves travel away from the source they collide and multiply resulting in distortion and cancellation of the sound wave.
In other words, conventional speakers and horns use a cone shape to project sound toward its intended target. When sound is generated from a conical device, multiple signal waves are generated from reflection and multiple phase emission which results in distortion. The farther the sound travels, the more distortion occurs, resulting in a less intelligible message over long distances. (Fig. 1).

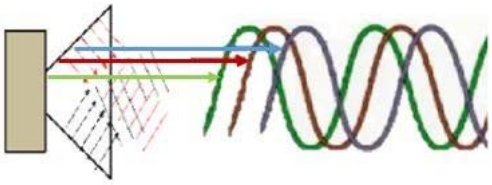

Figure 1. Distortion Degrades Intelligibility of Message as it Travels Forward

Clear Voice is a Magnetic Audio Device (MAD) that uses Planar Technology to generate the audio signal. The Clear Voice “transducer” generates a single, perfectly shaped sound wave that can travel long distances while delivering superior intelligibility. The advanced technology also provides the ability to generate an intelligible signal at a volume level that is up to 10db lower than the ambient noise level of the operating environment, reducing the risk of hearing damage to the operator and those in close proximity (Fig 2) .

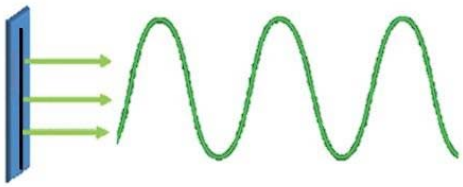

Figure 2. Single Sound Wave Travels Long Distances with Superior Intelligibility

The affect of the multiple signal collision, distortion, and cancellation is known as Speaker Chaos. When sound waves collide and multiply, the resulting distortion reduces the intelligibility of the sound wave and decreases the distance the sound wave can travel.
Scientists have long known the dramatic effects that temperature, humidity, and wind have on sound as it travels long distances through air. In most of our day-to-day activities we’re not aware of these changes. However, if you could listen and compare the sound of someone talking at various distances (100’, 500’, and 1000’), you would begin to hear changes to the sound as it traveled over the long distances.
One of the changes you might perceive is the loss of vocal clarity or intelligibility as you moved farther from the source. This happens as a result of high frequency absorption caused in part

from changes to air temperature (known as temperature gradients), humidity levels, and the terrain of the ground surface. Scientific studies have calculated that sound pressure levels (SPL) can be reduced by as much as 20-50 dB in conditions when temperature and humidity are fluctuating. This amount of attenuation can obviously reduce the intelligibility of a message as distance increases. To overcome this phenomenon, Clear Voice invented a new digital signal processing (DSP) technology, dubbed 'TURBO", that counteracts the reduction in voice clarity caused by atmospheric conditions. When this DSP circuit is activated, it retunes the audio signal to cut through the atmosphere resulting in higher intelligibility at greater distances, even during severe weather events.[2].

2.1 First Responders uses of clear voice systems

Clear Voice through a variety of solutions, offers the right technological tools to the First Responders to achieve that. Examples [2]:

(a) Mobile Solutions for the field (Handheld, on tripod, on a vehicle, on a helicopter etc) : During a fire there could be people trapped behind it and do not know what to do and where to go in order to get saved, while the First Responders cannot communicate with them because there could be far way or it is windy , or it is dangerous to try getting closer etc. By using Clear Voice Systems, the First Responders can offer guidance from a safe distance in a safe way and lead people to safety without putting themselves in danger.

(b) Fixed Solutions: Authorities could create wired or wireless networks and provide direct Voice Information and guidance to the citizens of the municipalities in case of danger. Furthermore, Authorities could create fixed points with Clear Voice Systems in areas of high risk (ex: Dams, Bridges, Intersections, Roads, Government Buildings, Lakes, Rivers, Borders etc) in order to urgently inform the people when it is needed.

(c) Wearable Solutions: During a time of crisis, First Responders need to be able to guide the crowd inside and outside of buildings. Based on Clear Voice Solutions, Customized Vests can be provided with Built-in speaker, while keeping their hands free. Alternatively, wearable solution without the vest can be provided and be wear on top of any Vest.

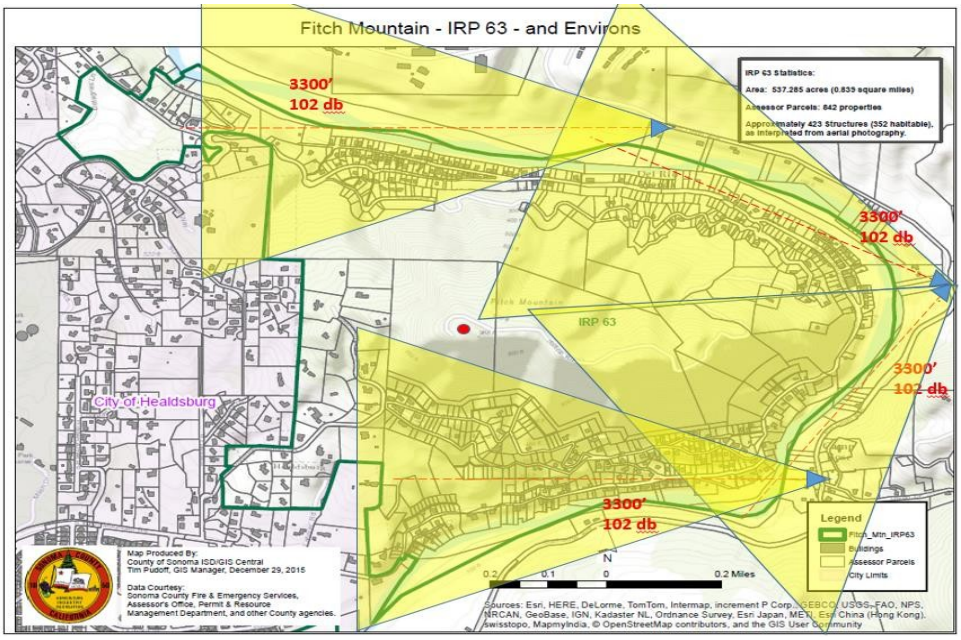

Figure 3. Emergency Alert System to Provide Critical Announcements to Residents Along River

2.2 Use case of fixed-point Cear Voice installation

This use case entails a warning system for a heavily populated area around a river. The constraints are as follows – a. very high background noise levels due to road traffic and general merchant activity and b. a general lack of infrastructure to support a distributed system using a 70V or 100V horn speakers which would have to rely on hundreds of horns. The picture (Fig. 3) provides an overview of the geography as well as the system designed to cover said area. The system is designed to use as few mounting locations as possible providing acceptable dB ratings over the range required. One of the advantages of this solution are evident in the design – only 3 mounting locations with 4 speaker arrays in each creates a very low infrastructure demand and a much lower installation cost. However, two additional benefits are also reaped using Clearvoice technology. First, the intelligibility of the audio will be infinitely better – i.e. it will be much easier to understand what is being announced than a conventional system where information will come from numerous horn speakers at the same time. The fewer points of audio, the better the intelligibility. Second, at no point will the dB exceed a level that could cause hearing loss, and, in fact, the level will be perceived as very uniform over the area covered.

3. CONCLUSIONS

During the time of crisis, it is important that the First Responders can be heard on the field, even in long distances (or even to tall buildings) in order to offer voice message guidance to the potential victims. First Responders can use Clear Voice transducers in order to inform people during the time of a crisis as well as to guide them from a long distance

Clear Voice transducers are more appropriate due to:

(i) intelligible messages are delivered at 10 decibels below the ambient noise level. Conventional speakers need to be 10 dB above the ambient noise level

(ii) clear voice speakers deliver sound without creating distortion waves that reduce intelligibility

(iii) clear voice technology allows you to use fewer devices to cover a bigger/louder area

(iv) clear voice signal characteristics allow a design to have crossing sound waves without creating distortion or signal cancellation. Cannot do this with conventional speakers

Moreover, Clear Voice transducers do not create "Chaos" because they generate a single sound wave from a single source without any distortion. The properties of this pure sound wave are what allows it to travel greater distances and arrive at the listener with greater clarity. In environments where the ambient noise level is very high or in situations where a large area needs to be covered, the Clear Voice transducer is superior to all conventional speakers, horns, and even other planar devices.

Finally, Clear Voice systems can be uses by First Responders as well as for security purposes by the Police and the Army. Police and Army can use them for warning purposes (for example in the borders for the illegal immigrants or even on military vehicles or even Coast Guard Boats and Navy boats).

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UAVs TO ENHANCE WATERSHED MANAGEMENT. EXAMPLES FROM NORTH GREECE.

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ABSTRACT

Unmanned Aerial Vehicles (UAVs) are powerful tools that have been deployed in many scientific research fields including water resources management. Examples of watershed management applications include: a) identification of pollutants, b) mapping of erosion and deposition areas, c) landscape assessment, d) land cover changes within watershed, e) ecosystem and invasive species monitoring, f) inspections on water resources infrastructure, g) hydrometric measurements and h) recording of flood events. The specific manuscript is a presentation of recent applications of UAVs in two different cross sections of Aggitis River located in Serres Prefecture of Northern Greece. The applications implemented were divided into two pillars: I) hydrometric measurements in order to record the streamflow and II) photogrammetric measurements to map the geomorphology and stream bank changes. The hydrometric measurements included an image-based method known as Large Scale Particle Image Velocimetry (LSPIV), while photogrammetric applications include the creation of orthomosaics in order to visualize geomorphological characteristics. The application of the UAV in this river of Northern Greece revealed many difficulties in the implementation due to high vegetation cover that can prevent accessibility or interfere in the satellite position signal. In contrast, there are many advantages such as measurements in places where human access is difficult or even impossible and thus UAVs are probably the main and only option in specific streams.

Keywords: drone, hydrometry, particle image velocimetry, photogrammetry, geomorphology

1. INTRODUCTION

Particle image velocimetry (PIV) is a non-intrusive image-based method that calculates the fluid velocity based on the motion of seeding particles [1]. Large-scale PIV (LSPIV), as the name entails, is a modified version characterized by larger dimensions than PIV. LSPIV was developed by Fujita and Komura in 1994 and named by Fujita Muste and Kruger in 1998 [2]. LSPIV use either natural (e.g. leaves and branches from trees or natural patterns such as bubbles and waves) or artificial seeding particles (e.g. ecofoam) in order to capture their movement on the water surface from continuous captured images and thus calculate the surface velocity from one point to another in a specific time period [3]. The main advantage of the image-based methods, in contrast to the traditional hydrometric measurements, is the remote position of the instrumentation without being in contact with the water and far from potential dangers [4]. The PIVlab software is a free tool developed by Thielicke and Stamhuis for PIV analysis in MATLAB [5]. It can be also used for LSPIV applications by comparing simultaneously captured images and providing a reference distance for calibration and transformation from pixels to meters [6]. The PIVlab is able to produce several results such as vectors of surface velocity, streamlines, velocity magnitude, vorticity, divergence, etc. İn an understandable and easy on the eyes visualization way [7].

Photogrammetry, among other various uses, is also applicable for landform representation and detecting morphological changes by using Ground Control Points (GCP) and expert software in order to combine overlapping images and create digital surface models [8, 9]. The GCP are points of known position that allow adequate scaling and positioning for the surface models [10]. Software-based photogrammetry has risen its applications since 1990s, but still the software was expensive, the hardware was huge in dimensions and it required a lot of GCPs in order to produce topographic maps [11]. A new approach to photogrammetry called Structure from Motion (SfM) has greatly facilitated and increased the applications during the last decade. SfM requires very few ground control points and it is an extremely flexible technique applied at extremely detailed resolutions [12]. In addition, the "drone revolution" because of their decrease in cost but also exploitation of capabilities and usefulness has extended the use of photogrammetry from airborne images [13]. Currently, many commercial and open source tools and software are available and able to generate point clouds, orthophotomaps, digital surface models (DSMs) and 3D models [14]. In this current study, Agisoft Photoscan Pro (now known as Agisoft Metashape) was selected as an easy, established and efficient tool for photogrammetry.

2. EXPERIMENTAL METHODS

The experiments that were selected to be presented were conducted in two different cross sections of Aggitis River. The first experiment was conducted in a section between the villages Simvoli and Fotolivos. There is a low-water crossing (also known as an Irish bridge) with culverts constructed by 2 concrete pipes. The DJI Spark was able to capture a video of 17 sec. for the PIV analysis in the PIVlab software. Cross sections measurements of the river width for calibration scopes were achieved by using a typical tape measure. The second experiment was done in a different cross section of Aggitis River near Draviskos Village. UAV's flights (DJI Spark) in two different days (September 21th and December 15th 2019) were able to produce two orthomosaics in Agisoft software. The GCP were measured by using a GPS-GNSS JAVAD TRIUMPH-1 receiver in order to georeference the two orthophotomaps.

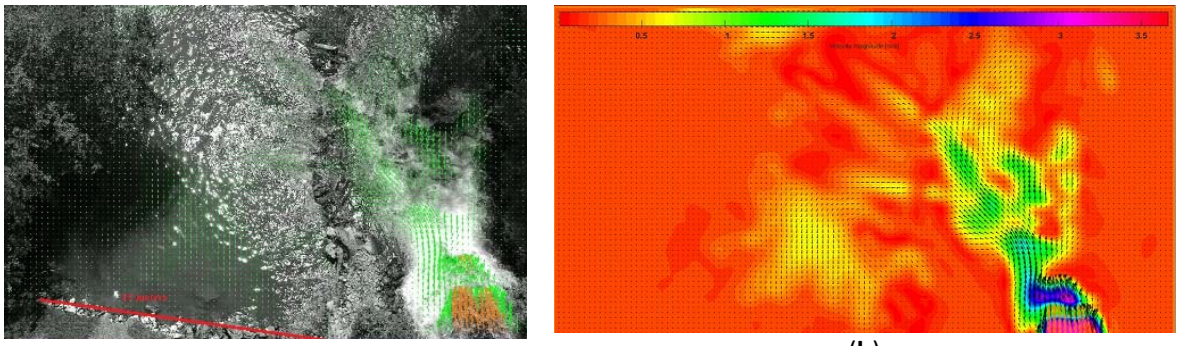
3. RESULTS & DISCUSSION

3.1. LSPIV analysis

The PIVlab software produced the vectors of the surface velocity by analyzing the continuous frames of the captured study area (Figure 1.a). The vectors are depicted as colored arrows and also the referenced distance is illustrated (red line). Flow direction occurs from the bottom to the top of the depicted image. The velocity magnitude can be visualized based on a colored scale bar (Figure 1.b). The surface velocity magnitude is greater in the bottom and right part of the captured image because there is the output of the water (culvert) below the road. The red colored image represents no velocity, yellow is very low velocity (0.5 m/s) while blue and purple corresponds to higher velocity magnitude (2-3.5 m/s). Further measurements on the cross-sectional area can provide accurate estimations on water discharge.

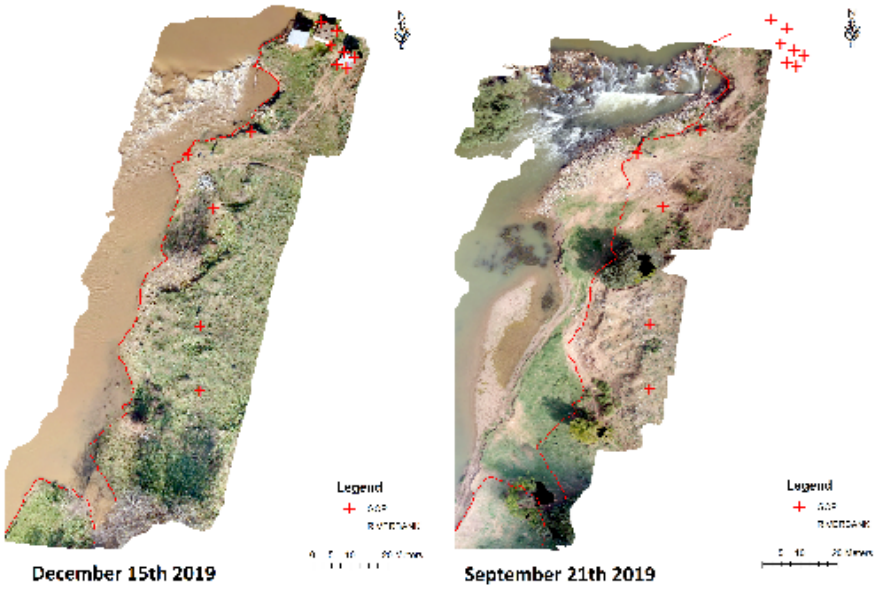
3.2. Photogrammetric analysis

The Agisoft software was able to able to combine the images of these two different date flights, create the point clouds and georeferenced orthomosaics of the study area based on the GCPs (Figure 2). The comparison in ArcGIS between these two captured orthomosaics revealed different flow and water level conditions as well as changes in geomorphological characteristics (e.g. islands in braided rivers, river bank changes, flood plains etc.) that are obvious due to their spatial extent and distance (e.g. river bank change more than 5 m). These geomorphological characteristics can be mapped and monitored continuously or in specific periods (wet vs dry) or even after major rainfall-drought events.



(a) (b)

Figure 1. This is the study area of the first experiment in Aggitis River. Results produced in the PIVlab software: (**a**) the surface velocity depicted as vectors (green and red arrows) and (**b**) the surface water velocity (m/s) depicted as a colored bar.



(a) **(b)**

Figure 2. Orthomosaics of the study area produced in Agisoft software for **(a)** December 15th 2019 and **(b)** September 21th 2019. The riverbank boundary is depicted in a red yellow line and the GCP in red crosses.

4. CONCLUSION

An image-based method, known as LSPIV, was utilized to produce the surface velocity magnitude field of a real river cross section in Aggitis River. Images, captured remotely by the low cost but very capable DJI Spark, were analyzed with the free software PIVlab. LSPIV method can be used for providing velocity and discharge data even in conditions when conventional techniques fail or are very difficult to deploy them. Furthermore, another experiment was conducted for photogrammetric scopes. UAV images were combined and analyzed in order to create a representable point cloud and thus the orthomosaic of a second natural cross section of Aggitis River. Two orthomosaics based on two different dates of flight were created in Agisoft software and the geomorphologic changes were mapped in ArcGIS. This is very useful for geomorphologic scopes to monitor and detect the riverbank changes. These two cross

sections were selected because of their following characteristics that made them good examples of a successive implementation for both LSPIV and photogrammetric analysis. Both of these study areas are easily accessible either by car and foot, there is no high vegetation or other obstacles such as human constructions to face and no flight limitations. In addition, the satellite signal required for both UAV and GPS-GNSS antenna was strong. A disadvantage was that it was difficult to perform regular flow measurements to validate the results (e.g. by using a current flow meter) because of the dangerous conditions (high water level and flow). Furthermore, it must be noted that flights are heavily dependent on weather conditions. Generally, there are many places and different streams and cross-sections where both methods were applied. These streams vary in characteristics, e.g. low-high flow, low order stream Vs rivers or different size bed material, thus different illustration from the UAV images can be captured. In addition, vegetation (forested vs shrub vs herbaceous vegetation) can play a vital role in capturing the optimal images since vegetation can lead to undesirable shades to no satellite signal. Finally, their morphology is different and includes applications in streams, canyon and mountain waters to river reaches in flat areas.

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SCIENCE PROJECT: SPACEBORNE SAR INTERFEROMETRY AS A NONIVASIVE TOOL TO ASSESS THE VULNERABILITY OVER CULTURAL HERITAGE SITES

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ABSTRACT

Cultural heritage is a key element of history; the ancient monuments and archaeological sites enrich today's societies and help connect us to our cultural origins. Protection and conservation of our cultural assets for future generations in the face of various natural or anthropogenic hazards is a major concern nowadays. Heritage sites and monuments need to be protected and promoted, as they are vulnerable to ground movement. Reducing the impact of natural/man-made disasters on the human cultural heritage sites is a fundamental research goal. The SpaCeborne SAR Interferometry as a Nonivasive tool to assess the vulnerability over Cultural hEritage sites (SCIENCE) project is developing the state-of-the-art techniques of Persistent Scatterers Interferometry (PSI) and Tomography-based Persistent Scatterers Interferometry (Tomo-PSInSAR) aiming to detect structural and ground motions of the four under investigation cultural heritage sites (Ming Dynasty City Walls in Nanjing, Great Wall in Zhangjiakou, Acropolis complex of Athens and Heraklion walls (Crete Island)). During the SCIENCE project several radar datasets are processed (ERS-1 & 2, ENVISAT, TerraSAR-X, COSMO-SkyMed and Sentinel 1A & B). The resulting products are exported in various formats for the identification of the persistent scatterers, using high resolution optical images and fusing them with high accuracy Digital Surface Models (DSM). In-situ measurements and data for the cultural heritage sites conditions are used as a validation of the final Permanent Scatterers products. Concluding, SCIENCE project's final goal is the risk assessment analysis of the cultural heritage monuments and their surrounding areas aiming to benefit institutions, organizations, stakeholders and private agencies in the cultural heritage domain through the creation of a validated pre-operation non-invasive system and service based on earth observation data, supporting end-user needs by the provision of knowledge about cultural heritage protection.

Keywords: SAR interferometry, vulnerability assesment, cultural heritage sites, Greece, China

1. INTRODUCTION – OBJECTIVE

The ultimate objective of the SCIENCE PROJECT is to predict the vulnerability of the archaeological sites to ground deformation in time and space and protect them against damage. The SCIENCE project aims to develop, demonstrate, and validate, in terms of geotechnical local conditions and monuments' structural health, SAR interferometric techniques to monitor potential ground deformation affecting the archaeological sites and monuments of great importance.

During the last few years, spaceborne Synthetic Aperture Radar (SAR) interferometry has proven to be a powerful remote sensing tool for detecting and measuring ground deformation and studying the deformation's impact on man-made structures [1,2]. It provides centimeter to millimeter resolution and even single buildings/monuments can be mapped from space. Considering the limitations of conventional MT-InSAR techniques, such as Persistent Scatterers Interferometry (PSI), in this project a two-step Tomography-based Persistent Scatterers (PS) Interferometry (Tomo-PSInSAR) approach is proposed for monitoring ground deformation and structural instabilities over the Ancient City Walls

(Ming Dynasty) in Nanjing city, China [1] and in the Great Wall in Zhangjiakou, China. The Tomo-PSInSAR can separate overlaid PS in the same location, minimizing the unfavorable layover effects of slant-range imaging in SAR data [1].
Moreover, the demonstrations are performed on well-known test sites in China and in Greece, such as: a) Ming Dynasty City Walls in Nanjing, b) Great Wall in Zhangjiakou, c) Acropolis complex of Athens and d) Heraklion walls (Crete Island), respectively.

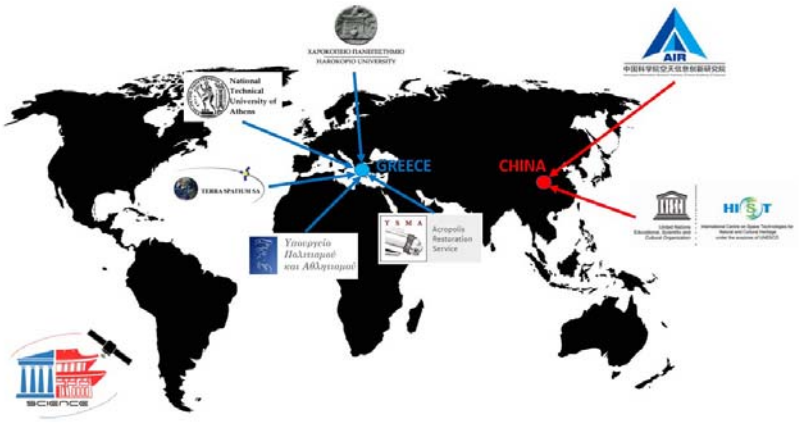

Figure 1 The bilateral consortium (Greece-China) in the framework of the SCIENCE project.

In the framework of the SCIENCE project the bilateral consortium is composed **(Fig.1)** by the Greek delegation of Harokopio University of Athens, the National Technical University of Athens, the Terraspatium S.A., the Ephorate of Antiquities of Heraklion (Crete), the Acropolis Restoration Service (YSMA) and by the Chinese delegation of Science Academy of China (Institute of Remote Sensing and Digital Earth) and the International Centre on Space Technologies for Natural and Cultural Heritage (HIST) under the auspices of UNESCO (HIST-UNESCO).

2. EXPERIMENTAL METHODS

Two main interferometric techniques are used through the SCIENCE project **(Fig.2)** for the detection of structural and ground motions affecting the cultural heritage monuments are: a) Persistent Scatterers Interferometry (PSI) and b) Tomography-based Persistent Scatterers Interferometry (Tomo-PSInSAR).
PSI technique (Interferometric Point Target Analysis - IPTA algorithm) is applied to the two Greek case studies of Acropolis complex of Athens and the Heraklion walls in Crete island. The main characteristic of the IPTA algorithm [3] is that the interferometric analysis is possible for chosen point targets with a particular range and azimuth. Specifically, PSI assumes the presence of a single temporally coherent scatterer in a range-azimuth pixel with multiple scatterers interfering in the same pixel, as for the case of a layover to be typically rejected [2]. This is one of the main limitations of PSI that SAR tomography has the potential to overcome and retrieve the elevation and deformation parameters for multiple scatterers in the same resolution cell [2]. Aiming to overcome the limitations of conventional MT-InSAR techniques, the Tomo-PSInSAR technique [1] is applied to the two Chinese case studies of Great Wall in Zhangjiakou and Ming Dynasty City Walls in Nanjing. Tomo-PSInSAR is an integrating technique merits from PSInSAR [4] and SAR tomography [5,6]. Specifically, the implemented Tomo-PSInSAR processing scheme applied in two steps: 1) calculation of a linear motion model and selection of single PS candidates using the amplitude dispersion criterion for the surface deformation monitoring and 2)

extension of the Tomo-PSInSAR model with a two-tier network for the estimation of linear rates, thermal amplitudes and for retrieving deformation time series of PS points [1].
The second step of SCIENCE project scheme **(Fig.2)** is the identification of the permanent scatterers that have occurred from the two abovementioned techniques. This is possible by overlaying the resulted permanent scatterers on high resolution optical images or/and by the fusion with a high accuracy Digital Surface Model (DSM).

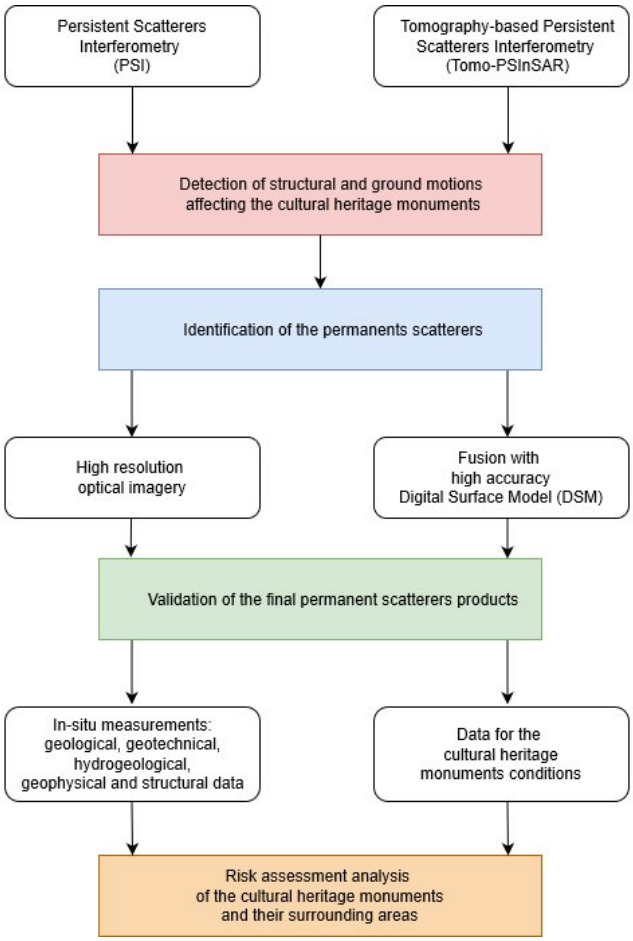

Figure 2 Flowchart of the applied methods through SCIENCE project.

Subsequently, the next step is the validation of the final permament scatterers products for the case studies using all the available in-situ geological, geotechnical, hydrogeological,geophysical and structural data and data associated to the cultural heritage monuments conditions.
The final step of the SCIENCE project scheme is the risk assesment analysis of the under investigation cultural heritage monuments with their surrounding areas in order to demonstrate the vulnerability of them and help the authorities in charge to prioritize restoration activities when required.

RESULTS – DISCUSSION

The PS-InSAR technique [3] is resulting to point interferograms with the final persistent scatterers showing the deformation rates for the two Greek case studies. In addition, the application of Tomo-PSInSAR technique [1] is resulting to accumulated deformation time series that were derived on a monument-scale using as a reference the first SAR acquisition, allowing the monitoring and analysis of potential structural risks for the two Chinese case studies. This is an on-going work and the preliminary results are expected during the next months.

3. CONCLUSION

In conclusion, the bilateral SCIENCE project:

- is applying and developing further the interferometric techniques of PSI and Tomo-PSInSAR for cultural heritage monitoring giving an added-value to research aspects.
- is proposing a state-of-the-art validated pre-operation non-invasive system and service based on earth observation data (radar data, optical data and DSMs) for risk assessment analysis.
- is supporting end-user needs by the provision of knowledge about the protection of the four under investigation cultural heritage monuments.

ACKNOWLEDGEMENTS

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EXPLORING AN EARLY HEAT WAVE EVENT IN AN INDUSTRIALIZED AREA OF EASTERN MEDITERRANEAN (THRIASIO PLAIN – GREECE)

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ABSTRACT
Heat wave events are often associated with poor air quality inducing ambient conditions considered to be a serious environmental health threat. The aim of this study is to examine the impact of an early heat wave episode on human thermal discomfort and urban air environment, in an industrialized plain of eastern Mediterranean, Thriasio Plain, Greece. The heat wave occurred in mid-May 2020 shortly after the first stage of the lift of restriction measurements taken to halt the spread of COVID-19 pandemic in Greece (4th May). Discomfort Index (DI) and Daily Quality Index (DAQI) were calculated on hourly basis throughout spring 2020 (March, April, May) using data from two measuring meteorological and air pollution stations in the Thriasio Plain. The analysis showed an unusual and rapid rise of air temperature indicating the early heat wave event, with the values found to be on the order of about 10 K above the monthly normal climatic average. The results showed a high level of thermal discomfort and increased air pollution levels, while significant correlations between air temperature, DI and AQSI values were identified.

Keywords: heat wave; air quality index; thermal discomfort.

1. INTRODUCTION

Impacts of extreme temperatures influence every sector of human activity. This is true especially if events happen on not expected time. Between 15 – 20th of May 2020 Greece experienced the earliest heat wave ever recorded, validated according to Metaxas and Kallos (1980) criteria [1, 2]. In the present study, we explore heat stress and air pollution stress via two wide used indices. The first is the Discomfort Index (DI) which was first proposed from Thom (1959) as was modified for Greece by Paliatsos and Nastos, (1999) [3]. The index is calculated using the air temperature and relative humidity values to estimate human thermal comfort. The second index is the Daily Air Quality (stress) Index (DAQI), which is calculated comparing hourly or daily air pollutants values with threshold, if they exist.

2. DATA AND METHOD

The data used in this study are hourly values of meteorological parameters and air pollutants concentrations for the time periods 1 March to 31 May 2020. Adopted meteorological data referred to hourly values of air temperature (°C) and relative humidity (%). The air quality data included hourly concentrations of nitrogen dioxide (NO2), sulphur dioxide (SO2), ozone (O3) and Particulate Matter (PM10), measured at two different stations within the Thriasio Plain. Herein a description of stations used and data provided: Elefsis meteorological station, is operated by Hellenic National Meteorological Service (HNMS) (World Meteorological Organization – WMO code LGEL – 167180). Station EL-1 is in the

centre of Elefsis city (1000m from the sea shore), away from large constructions and is operated by the Bureau of Pollution – Municipality of Elefsis, and provides only air quality data. Station Alonistra (AL), is operated by the Bureau of Environment, Municipality of Aspropyrgos (BEMA) and provides air quality and meteorological data. The station is located 500m south of the centre of the city of Aspropyrgos and 1000m from the sea shore. The thermal discomfort was assessed using the modified for Greece Discomfort Index (DI) which is calculated by the following equation [3]: $DI = Ta - 0.55 \cdot (1 - 0.01 \cdot RH) \cdot (Ta - 14.5)$ where Ta is the dry bulb temperature (°C) and RH is relative humidity (%). Index was calculated by using hourly values of the parameters and daily values are sown in Fig 1a. The Daily Air Quality Index (DAQI) (or Air Quality Stress Index 24 – AQSI24 as first named) was used in order to assess the air pollution stress of the ambient environment. The equation of DAQI derived from the average daily concentrations of air pollutants [4, 5], is presented below: $AQSI_{24} = \sum_{i=1}^{4} \frac{average \cdot daily \cdot value}{MI - 24hvalue}$ indicates the air pollutants (NO2, SO2 O3 and PM10) and MI-24hvalue indicates the threshold values of air pollutants according to the European Community standards (hourly SO2: 350 μg/m3; Hourly NO2: 200 μg/m3; 8 hour moving average value for O3: 180 μg/m3; daily PM10: 50 μg/m3). DAQI or AQSI24 categories were sugested by Matzarakis and Mayer (1991) [4].

3. RESULTS

The area of Thriasio Plain is particularly vulnerable to high temperature values [2, 6]. In Thriasio Plain high hourly values of air temperature were recorded during the studied period, exceeding the value of 36 °C. Maximum values of air temperature observed were recorded 17 and 19 May 2020, when the air temperature exceeded the threshold of 36 °C for more than an hour during each day. Maximum values of air temperature recorded at 38 °C were observed at LGEL station for 4 consecutive hours, while minimum values were recorded 18 °C, prodiced a 20 °C temperature range. The values analysis showed an unusual and rapid increase of air temperature indicating the early heat wave event, with the values found to be on the order of more than 10 K above the monthly normal climatic average of 20.5 °C. Relative Humidity (RH) data demonstrated a great variation from 15% to 37% in day hours while during the night ranged from 38% to 83%. Absolutely calm conditions were recorded in both meteorological stations with no existence of records for wind speed. The thermal discomfort estimated by DI index was significantly high especially during midday. Maximum DI values were calculated at LGEL and AL stations. The daily variation of DI values for the two stations were calculated above 23 °C for 6 consecutive days in both stations. The maximum hourly values of DI were calculated on 19th May at LGEL (26.7 °C for 5 consecutive hours). In AL station 26.1 °C for 2 consecutive hours and more than 25 oC for 4 consecutive hours during on May 19th and more than 7 consecutive hours on May 18th. Pearson correlation showed a significant positive correlation between air temperature and DI, with estimated correlation coefficients ranging from 0.75 to 1.0 for air temperature values. The opposite was estimated for relative humidity (RH) with a negative correlation ranging between -0.49 and -0.55. The results for DAQI demonstrate very poor air quality conditions with the values of index exceeding the threshold of 0.8 (which identify poor air quality). The mean daily DAQI value was significantly high, ranging from 0.81 to 1.31 at ELE and from 0.81 to 1.18 at AL station. The DAQI values ranged over the threshold of 0.8 in both stations during the whole period (May 15th to May 20th), during all days and night hours. The peak values were observed on May 17th. The values indicated 'heavily stressed' air quality conditions.

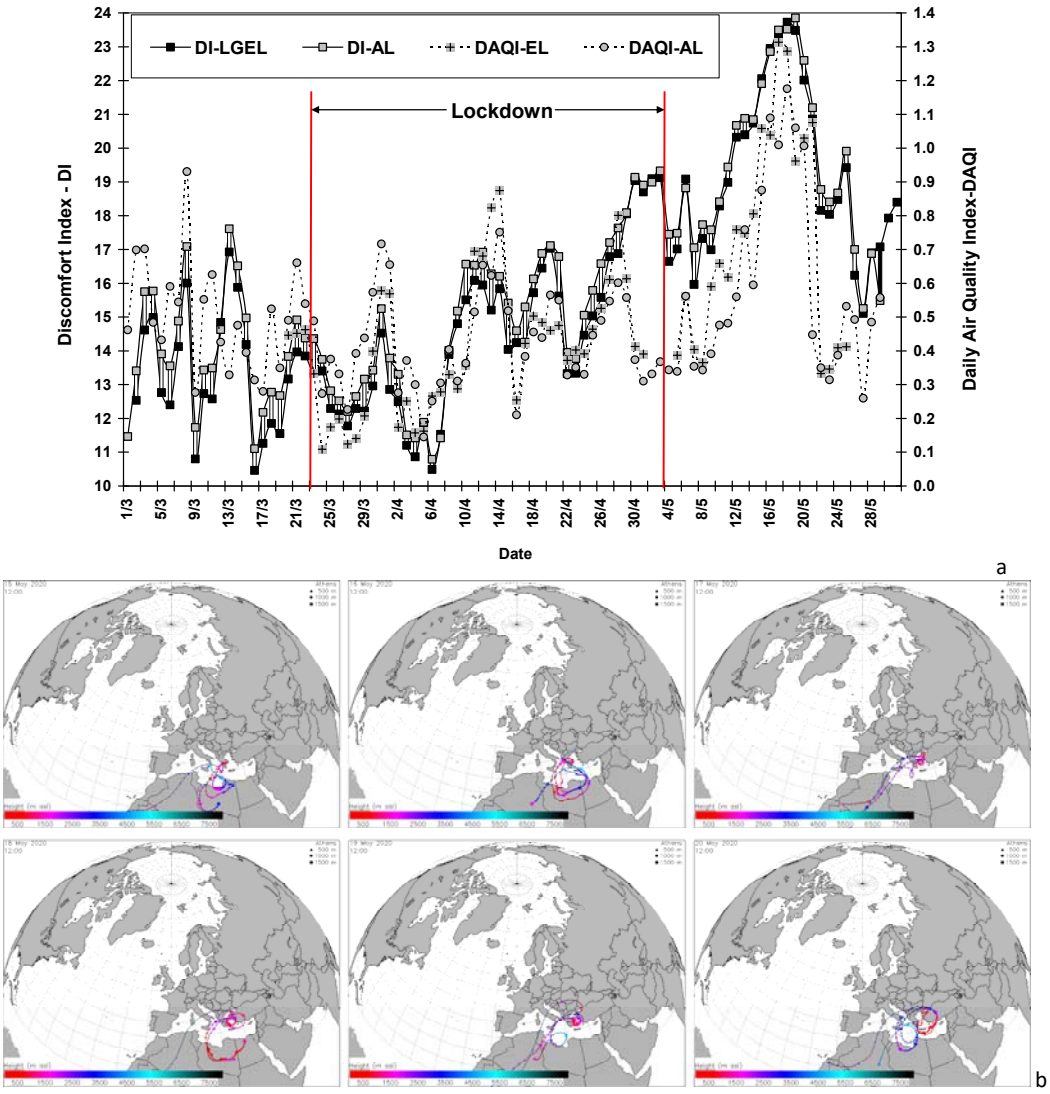

Figure 1. (**a**) Daily variation of Discomfort Index and Daily Air Quality Index (DAQI); (**b**) Air masses back trajectories for 15th to 20th May 2020, at 12 UTC.

Table 1. Pearson correlation for Air Temperature, Relative Humidity, air pollutants, DI and DAQI values.

	Temp-LGEL	*RH-LGEL*	*DI-LGEL*	*Temp-AL*	*RH-AL*	*DI-AL*	*SO2-AL*	*NO2-AL*	*O3-AL*	*PM10-AL*	*DAQI-AL*	*NO2-EL*	*O3-EL*	*PM10-EL*	*DAQI-EL*
Temp-LGEL	1														
RH-LGEL	-0.58	1													
DI-LGEL	**1.00**	-0.57	1												
Temp-AL	**0.99**	-0.59	**0.99**	1											
RH-AL	-0.50	**0.91**	-0.50	-0.49	1										
DI-AL	**0.99**	**-0.57**	**0.99**	1.00	-0.49	1									
SO2-AL	0.45	-0.18	0.42	0.45	-0.23	0.43	1								
NO2-AL	0.45	-0.08	0.42	0.45	-0.13	0.43	**0.68**	1							
O3-AL	0.27	**-0.57**	0.28	0.29	-0.45	0.29	-0.19	-0.53	1						
PM10-AL	**0.56**	-0.10	0.54	**0.56**	-0.14	**0.56**	**0.69**	**0.72**	-0.17	1					
DAQI-AL	**0.59**	-0.15	**0.57**	**0.60**	-0.18	**0.59**	**0.70**	**0.72**	-0.12	**1.00**	1				
NO2-EL	**0.63**	-0.22	**0.60**	**0.61**	-0.18	**0.59**	**0.66**	**0.86**	-0.43	**0.74**	**0.75**	1			
O3-EL	0.44	-0.62	0.46	0.45	-0.58	0.47	0.02	-0.11	**0.70**	-0.03	0.01	-0.68	1		
PM10-EL	**0.67**	-0.29	**0.66**	**0.68**	-0.30	**0.67**	0.50	**0.63**	0.05	**0.85**	**0.86**	**0.55**	0.08	1	
DAQI-EL	**0.82**	-0.46	**0.81**	**0.82**	-0.45	**0.82**	0.59	**0.69**	0.16	**0.84**	**0.86**	**0.75**	0.30	**0.92**	1

A significant correlation was observed when Pearson's correlation was performed to examine the possible relation between the DI index with the air quality index DAQI. Pearson linear correlation was applied to data from stations where meteorological and air pollution data were available. The estimated

correlation coefficients varied between 0.60 and 1.0. The strongest positive correlation was found between DI and DAQI values. All pollutants have strong positive correlation, but PM10 pollutant has shown the strongest correlation with DAQI among all others.

In Fig 1b, back trajectories generated using FLEXTRA trajectories (www.nilu.no/trajectories) [8] shown air masses transportation from Sahara desert and their circulation above central Mediterranean Sea and Greece for the aforementioned time period. The circulations of air masses above Mediterranean Sea enrich hot dry air with humidity [2, 7]. Also according to Table 1 PM10 values are absolutely correlated with DAQI values. This is an indication that PM10 values may be due to a Sahara dust transport episode.

This abrupt increase in indice values came after an almost two month lockdown due to COVID-19 pandemic (Fig 1a). The lockdown was set from March 23 to May 4, 2020, despite the strict criticism in such measures [9]. During this time of period values of both DI and DAQI were in relatively low levels, according to all criteria previously mentioned. The early spring heat wave, led to an abrupt increase of Discomfort Index and at the same time an increase of DAQI values (poor air quality). This abrupt increase had the shape of a shock wave for the two indices representing effects on human comfortable sensation. The combination in the specific area could become lethal as it is indicated in previous studies, because of general population thermal shock and poor air quality [2, 7].

Persistence of such episodes is not expected in this time of year, so we must alert authorities in order to be ready to plan and take any precaution measures for future events.

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HEAT WAVES, LAND SURFACE TEMPERATURE AND SPATIAL DISTRIBUTION OF PUBLIC HOSPITALS IN ATTICA – GREECE

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ABSTRACT
Heat waves are a major and lethal threat for population in Greece, especially for those who live in urban areas. One of the characteristics which increase the effects of heat waves are high values of Land Surface Temperatures (LST). Urban areas suffer from the permanent precence of high values of LST. In this paper we explore EM-DAT database records conserning heat waves with satellite data for LST and we refer to spatial distribution of public hospitals. First results indicate that this distribution does not favour the patients need for cooler environment during heat waves.

Keywords: Land Surface Temperature (LST), MODIS sensor, urban heat island

1. SCOPE OF THE PAPER

Heat waves are a major and lethal threat for population in Greece, especially for those who live in urban areas [1, 2]. One of the characteristics which increase the effects of heat waves are high values of Land Surface Temperatures (LST). Land surface temperature (LST) is a fundamental variable in the physics of the earth's surface processes both regionally and globally. The importance of LST is increasingly recognized and there is a strong interest in developing methodologies for measuring it from space. Knowledge of LST provides information on the temporal and spatial changes of the surface equilibrium state and it is fundamental in many applications. It is widely used in various fields such as evapotranspiration, climate study, hydrological cycle, vegetation monitoring, urban climate and environmental studies [3].
Land Surface Temperature (LST) is a fundamental aspect of climate and biology, affecting organisms and ecosystems from local to global scales. Its retrieval from remotely sensed thermal-infrared (TIR) data provides spatially continuous LST measurements with global coverage to examine the thermal heterogeneity of the Earth's surface, and the impact on surface temperatures resulting from natural and human-induced changes. The LST in the Moderate Resolution Imaging Spectroradiometer (MODIS) LST product is the radiometric (kinetic) temperature derived from the thermal infrared (TIR) radiation emitted by the land surface, and measured instantaneously. Satellite – derived LST measures the canopy temperature in vegetated areas, a unique and useful ecological parameter because critical temperature – dependent physiological processes and associated energy fluxes occur in the vegetated canopy. Daytime LST is coupled with the radiative and thermodynamic characteristics of the Earth's surface than standard air temperature measurements. LST is also more sensitive to changes in vegetation density and captures additional information on the biophysical controls on surface temperature, such as surface roughness and transpirational coolin. Although correlated with Tair, LST differs from Tair in its physical meaning, magnitude, and measurement techniques. LST can be estimated from measurements of

thermal radiance coming from the land surface, retrieved from satellite, and mapped globally. This quality makes LST a good indicator of energy partitioning at the land surface-atmosphere boundary and sensitive to changing surface conditions [3].
Urban areas suffer from the permanent precence of high values of LST. In this paper we explore EM-DAT database records conserning heat waves with satellite data for LST and we refer to spatial distribution of public hospitals. Publıc hospitals were usually located taking into consideration population, environmental and transportation criteria. But the lack of sprawl planning of urban areas remain under question.

2. METHOD USED

Data used were LST values through the MODIS sensor, which is mounted on the TERRA satellite throughout the product MOD11A2. Parameters used, were: LST Day 1km, LST Day 1km Land Cover Mask, LST Night 1km, LST Night 1km Land Cover Mask. Data adopted from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNLDAAC) at *https://daac.ornl.gov* were used for the period 2000-2017 for the area of Megara (1) in the range 3x5km, of the Thriasio Plain (2) in the area of 11x5km, the wider area of Athens divided into northern (3), central (4) and southern (5) part with a width of 3x5km each and the area of the Mesogeia (6) with a width of 3x5km. Data set's are available every 8 days.

3. RESULTS

Results are shown in Fig 1a. They have a bell shape and there is a lag of 8days between maximum values during day and minimum values during night. The six areas have the same diurnal shape with differences in high and low values.
According to the day-night data the three peri urban plains Thriasio, Megara and Mesogeia presents the maximum LST values. The area that presents the maximum LST values is the Thriasio Plain. It was observed during the night that the area that presents the maximum LST values based on the day-night data is that of the southern part of Athens where it is warmer in relation to Thriasio up to 4.5 °C with this difference observed in December. According to day-night LST data, the area of the central part of Athens is warmer than north and south areas. The area with the lowest LST values is the southern part of Athens. At night, based on the day-night data, the southern part of Athens is the area with the highest values, while Thriasio has the lowest, with the exception of July, when the Mesogeia plain shows the lowest LST with a difference of 0.1 °C. It was observed that while some areas show low LST values during the day, LST values appear higher at night and correspondingly areas with high values during the day show lower LST values. This is due to lack of cooling during the night, indicating Urban Heat Ishland (UHI) effect. The lower values of UHI are observed for South area of Athens, while Central and North area precense a constant high value.
Heat waves occur very often in Greece and in some case cause heat stress, fatalities and damages [1, 2, 4, 5]. Patients from heat stress ussually ask for medical help one or two days after the pic of heat wave [6]. Table 1, shows heat wave data adopted from EM-DAT database. Those heat waves had serious consequences to population and Attiki prefecture among others show a high vulnerability.

Table 1. Heat waves in Greece according EM-DAT database

Year	Location	Dis Mag Value	Total Deaths	No Injured
1985	Countrywide		20	
1987	Countrywide	41°C	1000	
1988	Countrywide	°C	56	
2000	Part of the country – Attiki included	44 °C	27	176
2007	Part of the country – Attiki included	46 °C	16	

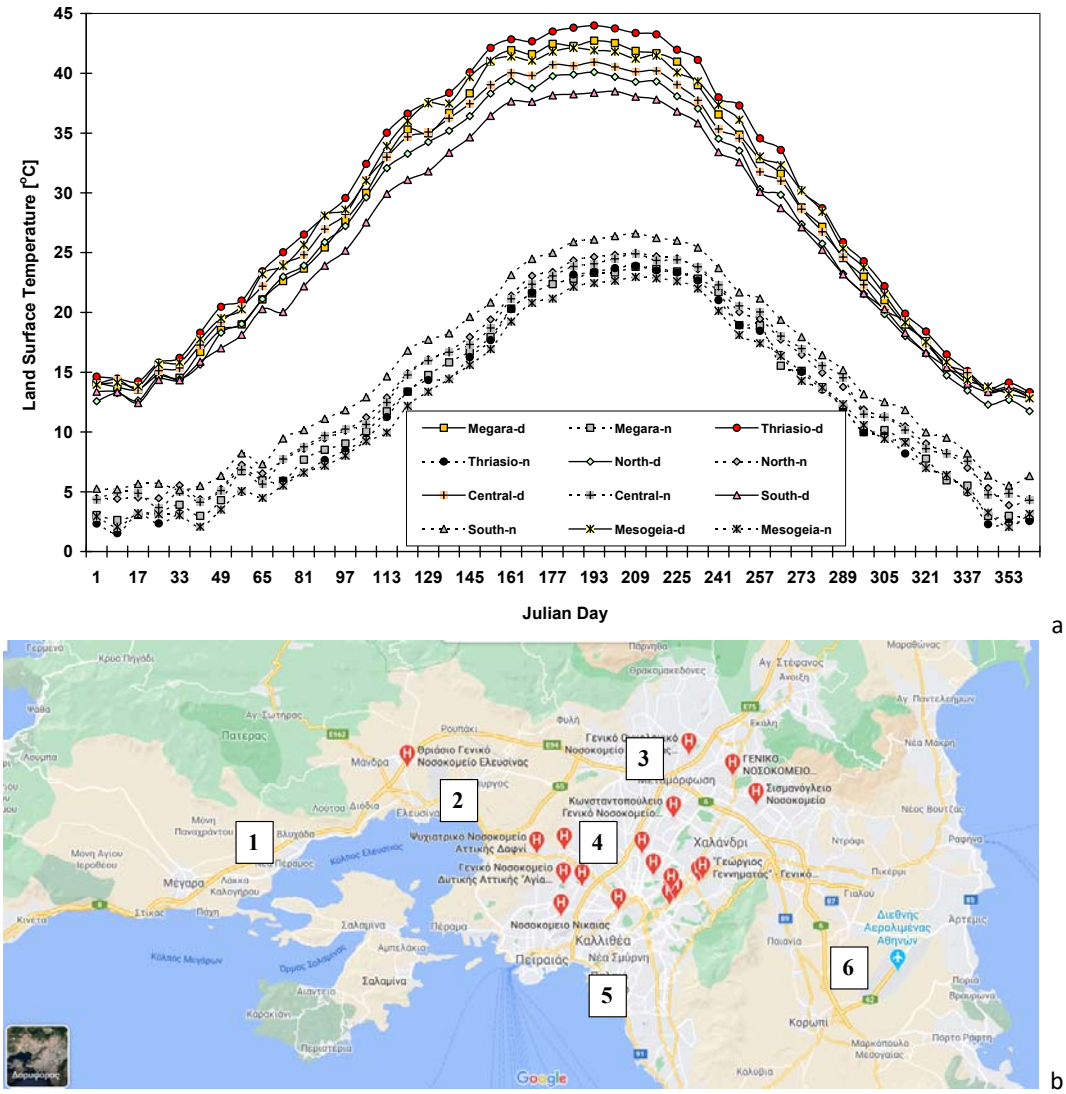

Figure 1. (**a**) Intra-annual variation of Land Surface Temperature (LST) – maximum LST during day and minimum LST during night, for the 6 locations in Attica Prefecture, averaged during the period 2000-2017 (b) Spatial distribution of public hospitals in Attica.

As for public hospitals in the following image adopted from google maps, we can notice that their spatial distribution is not homogenous. Maybe in the past locations of hospitals there were meeting criteria, but taking into consideration the continuous change in urban areas, now they are not.

Most of public hospitals are located in the central area of Athens (area 4 in Fig 1b), which is vulnerable to high LST during day and night (UHI phenomenon). So, when a heat wave apear, the area where public hospitals are located does not offer a cool environment for heat stroke victims.

4. CONCLUSIONS

At the local level, as far as urban centers are concerned, the balance of radiation, heat flows and other climatic phenomena have been strongly influenced by anthropogenic structures and human activities. One of the results is the enhancement of the urban heat island phenomenon (Urban Heat Island, UHI) which is captured through the LST. LST monitoring and study is valuable for evaluating and assessing the intensity and extent of this phenomenon.

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THE USE OF URBAN PLANNING AS A TOOL FOR STRENGTHENING CIVIL PROTECTION AND INCREASİNG OF INCLUSIVE COMMUNITY RESILIENCE

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ABSTRACT
Climate change has been correlated with the exponential increase and intensity of natural disasters that are recorded the latest years, e.g. mega-fires, flashfloods, tornedos, etc. in a global basis, with devastating consequences for the affected residential areas. Moreover, man-made disasters may also threat the urban environment with catastrophic results, like the recent huge explosion in the Beirut port. The rapid urbanization and the inadequate urban planning make cities even more vulnerable to disasters, e.g. a significant number of catastrophic wildland urban interface (WUI) fires have been recorded in a global level the latest years with many casualties and property losses. In the above concept, urban planning seems a crucial element for building effective urban resilience strategies; prepare upon disaster risks; build safer cities towards emerging hazards; consider the "design for all concept" for coping with emergencies; mitigate the possible disaster impacts. This paper strives to explain how the urban planning could generally contribute to the disaster risk reduction of the urban environment; highlight interconnection with civil protection aspects and communities' resilience, focusing on the vulnerable groups of population; present the universal urban planning concept.

Keywords: urban planning, accessibility, disaster management, civil protection, resilience

1. INTRODUCTION
The last decades a significant increase of disasters has been recorded in a global basis, according to the International Disaster Database EM-DAT [1]; this observation can be correlated with climate change impact, namely the prolonged droughts and extreme heatwaves, as well as the mega-fires, floods, hurricanes and tornedos [1,2]. The extreme meteorological conditions and their possible interactions or interrelationships with natural hazards, can generally pose significant risks on the urban populations; such hazards potential can be based on a single-hazard assessment approach, or can be treated under a multi-hazard concept, e.g. dry thunderstorms can initiate wildfires, earthquakes can trigger volcanoes, torrential rainfalls can lead to flash floods, etc. [3, 4]. Besides the natural hazards, threats may also be posed to communities by manmade disasters, e.g. industrial or technological accidents, like explosions, fires, or chemical spills [5]; a recent technological disaster that was one of the worst in the last century

was the explosion at the port of the city of Beirut, the capital of Lebanon causing at least 200 deaths and leaving an estimated 300,000 people homeless [6]. According to a United Nations survey, it seems that 54% of the world's population now lives in urban areas and this number is expected to increase to 66% by 2050; rapid urbanization is resulting into a growing number of overburdened infrastructure and services, air pollution elevation and unplanned urban dispersion [7]. However, rapid growth and inadequate urban planning make cities more vulnerable to disasters, e.g. a significant number of catastrophic wildland urban interface (WUI) fires have been recorded in a global level the last five years with many casualties and property losses [5]; estimates suggest that by 2050, urban population exposed to cyclones will increase from 310 million to 680 million while exposure to major earthquake will increase from 370 million to 870 million [8]. In that context urban resilience is directly correlated with the city shape, in terms of presence or absence of urban planning [9]. Strengthening the local capacity by appropriate housing, disaster-preparedness, infrastructure and livelihoods is substantial for improving civic resilience to disasters [10]. Specific attention should be given to the vulnerability of population since it is considered a critical factor in terms of injuries and losses under emergencies triggered by natural and/or man-made disasters, e.g. people with disabilities, like mobility or visibility impairment, the elderly, children, etc.; these groups are more likely to be injured or killed in a disaster because they are rarely consulted on provisions for their safety and most of them are not prepared for emergencies. United Nations surveyed 5,450 people with disabilities from 126 countries and found that 71% of respondents have no personal preparedness plan for disasters and only 31% always have someone to help them evacuate, while 13% never have anyone to help them [11]. In the above concept, urban planning seems a crucial element for building effective urban resilience strategies; prepare upon disaster risks; build safer cities towards emerging hazards; consider the “design for all concept” for coping with emergencies; mitigate the possible disaster impacts. This paper strives to explain how the urban planning could generally contribute to the disaster risk reduction of the urban environment; highlight interconnection with civil protection aspects and communities’ resilience, focusing on the vulnerable groups; present the universal urban planning concept.

2. URBAN AND SAFETY PLANNING

In general, the “safety” element can be obtained through a comprehensive risk management plan; the effectiveness of this plan depends on its interaction and correlation with other levels of planning, such as urban planning, regulatory (regulations, laws and policies) and strategic planning [12]. This approach develops a view of urban systems that goes beyond the narrow confines of conventional land use planning; it is considered a macroscopic approach including various tools, such as spatial planning, zoning and regulations of local urban scale [13]. To date, the *safety planning* is generally structured as follows: *(a) Emergency planning*. It refers to measures and actions taken to mitigate the catastrophic effects, from the moment they are foreseen and / or begin to occur, as well as in all the actions carried out during the emergency or immediately after [12] *(b) Recovery-reconstruction planning.* This type of design aims to restore the state of the city and people's lives to pre-disaster levels as quickly as possible and to the future development of a system with reduced vulnerability [14], *(c) Prevention planning.* It refers to medium- and long-term measures, regulations and actions aimed at reducing the vulnerability of the city and therefore minimizing the impact when a phenomenon occurs [12]. In respect to the above three levels, the urban planning can be defined as *(a) Emergency planning.* At this level, the urban planning may facilitate effective disaster management e.g. by defining the evacuation routes, the vulnerable building blocks the emergency shelters etc. [14]; tackle the optimal routes, minimizing the average distance from the points of refuge *(b) Recovery-reconstruction planning*. At this level, the urban planning can assist in the reconstruction of critical infrastructures and production units, with the ultimate goal of restoring the life of the inhabitants and the economy of the city at the same level as

prior the disaster, or even higher [14]. *(c) Prevention - protection planning.* At this level, the urban planning may include safety element as a key part of its procedures and arrangements, as well as the policies it is going to promote in its initial stage [15] - as it is the key means of organizing a city and can in advance prevent or reduce the damage that a risk may cause [14].

3. URBAN & SAFETY PLANNING WITH ACCESSIBILITY DETAILS : "INCLUSIVE DESIGN"

"Universal urban planning" is particularly important for promoting accessibility, as it includes all the necessary features of an accessible chain, namely accessible sidewalks and crossings, accessible facilities and infrastructure etc., helping to create an accessible and comfortable living and working environment; interdependent and complementary interventions ensuring the autonomy, comfort and safety of movement of people with disabilities and impaired people in general. In particular, in case of evacuation emergency and with regard to inclusive urban planning - prevention - disaster protection planning it is vital that the variety of the disability types are considered; e.g. the transition route, should not exceed 300-400 meters to the shelters and 5 km to the camps and assistance areas in case of an earthquake[16]. Accessibility, in terms of safe, autonomous and unobstructed movement through the emergency pedestrian traffic network or the road network is a precondition. In general, the organization of land uses and city functions are an integral part of any form of urban planning; the disaster prevention plan should be designed in full compliance with land use planning, taking into consideration the relevant specific urban vulnerabilities. In that prospect, city vulnerability maps are crucial in order to better organise the prevention and mitigation phases of the emergency managament; physical features related to the geology and hydrology of the area; hydrogeological maps, topographic maps, vegetation maps (e.g. forest density and forest species) etc.; moreover, maps of existing land use and condition of the buildings (structure, use, age, fire resistance design or not); mapping of the road and the pedestrian traffic network with accessibility criteria as a key indicator of reaching substantial infrastructures, like ports, airports, hospital and healthcare units; mapping the open public spaces (squares, sports facilities, schoolyards, etc.) and the green spaces (parks) in order to be used as emergency shelters, taking into consideration the accessibility factor; recording the high-risk buildings and installations (industrial installations, storage facilities for dangerous goods, etc.); population data are also needed (population density, standard of living, age data, etc.) in order to better organize population flows through the recorded channels in case of an emergency avacuation; Table 1 resumes the proposed universal urban planning methodology against disaster risks.

Table 1. Universal Urban planning methodology proposed for copying with disaster risks

UNIVERSAL URBAN PLANNING SCHEME AGAINST DISASTER RISKS

1. Accessibility, in terms of safe, autonomous and unobstructed movement in the urban area
2. Disaster prevention plan of the city designed in full compliance with land use planning
3. City vulnerability maps:
   - Physical features related to the geology and hydrology of the area
   - Hydrogeological, topographic maps
   - Vegetation maps (e.g. forest density and forest species)
   - Maps of existing land use and condition of the buildings (structure, use, age, fire resistance design or not)
   - Road and pedestrian traffic network maps with accessibility criteria as a key indicator of reaching substantial infrastructures, like ports, airports, hospital and healthcare units
   - Open public spaces (squares, sports facilities, schoolyards, etc.) & Green spaces (parks) to be used as emergency shelters, taking into consideration the accessibility factor
   - High-risk buildings and installations (industrial installations, storage facilities for dangerous goods, etc.) maps
4. Population data recording (population density, standard of living, age data, etc.) to better organize population flows through the recorded channels in case of an emergency evacuation.

Recently, Unmanned Aerial Vehicles (UAVs) were used as a state-of-the art tool to analyze the urban environment; mapping of buildings and wider spatial units producing 3D models by using the appropriate software [17]. All the above mapping will provide with crucial information in order to better shield the urban environment upon disaster risk; re-designing of existing infrastructures with the criteria described above should be also considered in order to ensure smooth movement of population in case of emergencies; e.g. use pop-up bike lanes, or pedestrian movement pathways for securing the undisrupted mobility of the supply chain, etc.

4. CONCLUSIONS

It seems that urban planning is directly correlated with civil protection aspects and affects the coping capacity of a city upon disaster risks. In case of existing infrastrustures, the issue of re-designing of the built environment should be considered in order the city to become more resilient and sustainable; in line with the safety planning perspectives and inclusive criteria explained here. Specifically, the urban planning can be used for both the stage of prevention and mitigation of an emergency situation; land use planning, as well as mapping of vulnerabilities are vital for better copying with emerging hazards and for minimizing the possible impacts. This is specifically important for vulnerable groups and hence, accessibility criteria are needed for any type of designing or planning. Interaction with civil protection authorities is critical for anticipating new challenges in disaster management due to climate change situation.

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FLASH FLOOD INTERACTION WITH COMPOSITE INFRASTRUCTURES. FLOODWATER VELOCITY, EROSION AND DEPOSITION

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ABSTRACT
During the floods of West Attica in November 2017, high precipitation accumulated on Pateras Mt., and severely impacted downstream basins with damages, fatalities and morphological changes. Mandra area suffered the most, but the area of Nea Peramos was hit first. The research team managed to be on site (Vlychada-Neraki settlement) shortly after the peak runoff, and captured the flood extent and function at the moment with UAS footage in video and still imagery. Using this footage and pre- and post- flood satellite imagery, floodwater velocity was measured, using mobile object positions, along the Koulouriotiko stream, and features such as flood boundaries, bank retreat and flood deposit distribution were mapped. It is concluded that transportation infrastructures with embankments perpendicular to the stream, namely the National Road (and the construction site upstream), the National Railroad, and a provincial road intersection, as much as the channelling of the stream with concrete, have played a significant role for these features. Perpendicular infrastructures decreased flow velocity, increased flow accumulation and backward erosion upstream and widened flood lateral expansion, while channelling increased flow velocity from one obstacle to the next. The results are depicted in respective maps.

Keywords: UAS, West Attica Floods, Nea Peramos, November 2017.

1. INTRODUCTION
The intensity of the weather phenomenon and the magnitude of impact of the November 15th, 2017 floods in West Attica (Greece) has been recorded and analysed since the first day of the disaster and for long afterwards (1–6). However, the quantity of collected data and secondary analysis has depicted a number of significant mechanisms and processes that took place during the event, bringing new aspects to light. Herewith, an analysis of the role of large scale linear infrastructures in the dynamics and final effects of the flash flood is presented, with focus on the Vlychada-Neraki area in Nea Peramos, which was first hit by the flash flood, suffering one fatality and significant damage. There were imagery and videos available for the first hours after the event, that were shot in the morning of November 15 by the Unmanned Aircraft System of the research team, giving the opportunity to perform calculations and mapping of the area after the peak of the flood, but before the completion of drainage.

2. METHODOLOGY
2.1. Flow velocity
UAS Video footage was used to make a) an initial estimation of flow velocity during the event categorised in high, medium and low velocities for a large number of points along the flow, and atrtributed the velocity vector (flow direction), and b) accurate calculations using the position of light mobile objects at different times, attributing the flow velocity value and direction vector to the mid-point of the distance between the initial and final position, as has been also done for Mandra area (4). Results were shown on a map containing the vectors, along with interpolation of flow velocity values within the boundary of the flood extent.

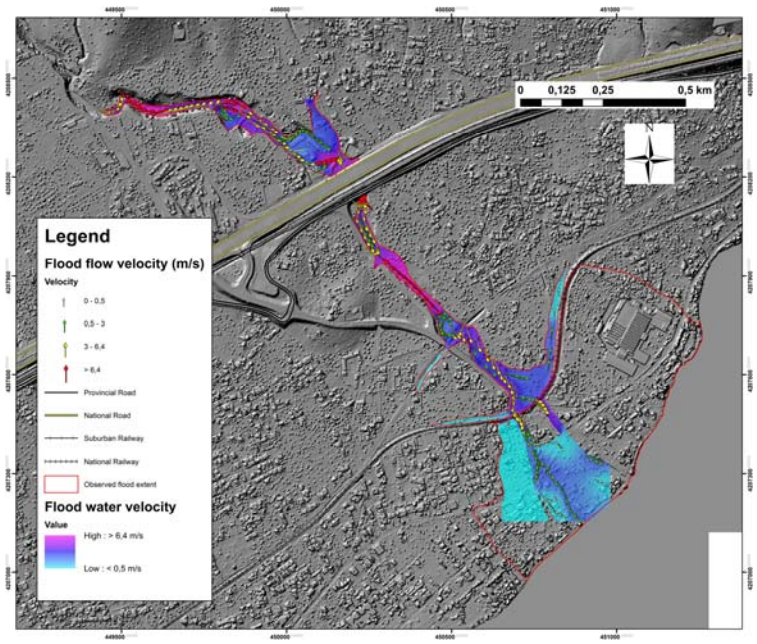


Figure 1. Flow velocity map during the November 15th flash flood in Vlychada-Neraki area, Nea Peramos.

2.2. Erosion and deposition

UAS footage was combined with pre and post flood satellite imagery from Google Earth Pro to outline flood extent (boundary), linear erosion and bank retreat, llood deposits and debris, and coastline. High resolution (5m) base map topography was used to further verify flow concentration in areas with limited observation capacity. Two outcomes on flood extent and flood deposition were outlined, according to level of certainty (verified mapping and possible extention) according to topography.

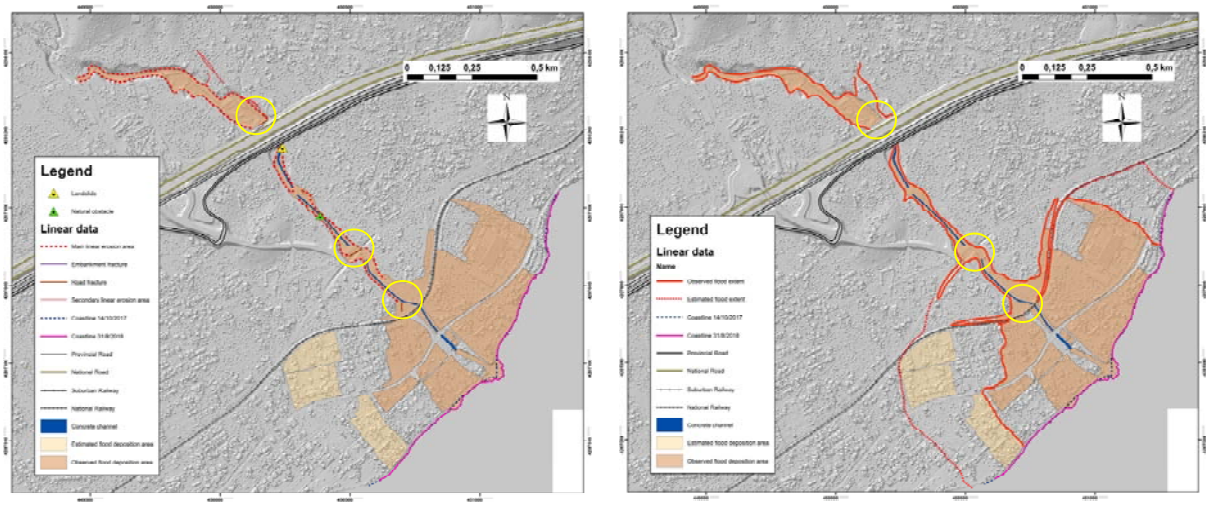
3. RESULTS

3.1. Upstream National Road

The pre-flood riverbed and the area around a factory set beside it overflowed, due to interventions during operations of the construction site and stalling of water along the National Road embankment. Floodwater couldn't be sufficiently drained through the concrete channel which was apparently designed for smaller runoff rates, and whirpool phenomena were generated near the entrance of the channel. The highest velocity value can be noticed near the entrance and was calculated as 10,92 m/s. The effect of the inadequate function of the concrete channel during the flood event is noticable as water was forced to retreat and leaded to whirpool generation and lateral erosion and bank retreat.

3.2. Downstream Provincial Road

More whirpool phenomena were generated near the exit of the concrete channel and furthermore, the flood flow was separated in three new flows, leading to channel overflow and bank erosion. Even though runoff was regulated by the embankment and through the conduit, runoff rates exceeded channel capacity. This is another example of inadequate concrete channel construction for the magnitude of the event. In the next part of the channel, after the peak runoff, floodwater flowed within the channel boundaries and there was a new generation of whirpool and flow seperation phenomena in the area where the channel ended.



(**a**) (**b**)

Figure 2. Map of the study results. (**a**) On the left, linear erosion and bank retreat, verified and possible flood deposits; (**b**) Flood verified and possible extent, flood deposits and coastline before and after. Yellow circles show the areas commented in the results.

3.3. National Railway embankment

Velocity values were moderate through the embankment while values were low/extremelly low in the area of the alluvial fan in the settlement Vlychada-Neraki of Nea Peramos.

3.4. Flood extent

The flood extent had a linear form along the concrete channel, which changed dramatically in the areas where vertical infrastructures in flood flow could be spotted, such as the multilevel intersection and National Railway. Around them, the flood extent expanded sideways and there was a flood zone increase. As a result, the effect of these infrastructures in flood flow is noticeable and the extent expansion is due to the existence of them, as they acted as obstacles in flood flow.

3.5. Erosion and deposition areas

Two main erosion and deposition areas can be defined. More specifically, the area which starts upstream National Road and ends upstream National Railway embankment can be characterized as an erosion area. The area which starts downstream railway embankment and ends on the coastline is the main deposition area. The floodwater erosive ability was increased on the first area, but started to decrease on the embankment area, which acted as an obstacle in flow and furthermore, the slope morphology was extremelly low around this area. As a result, erosion wasn't possible to continue and deposition started. The impact of deposition on coastline is significant and can be seen by comparing two different coastlines of the region, before and afted the flood event. Important distictions between them can be observed because of the creation of new small alluvial fans on the coast of NeaPeramos and the most significant modifications can be spotted in the area where the stream empties into the sea by it's natural riverbed and in the area where an alternative entrance of flood in the settlement flowed into the sea. This entrance was far away from the main one and is a result of the flood diversion downstream National Railway.

Another result of the huge floodwaterd momentum and energy was the creation of road and embankment fractures and landslides near the exit of the concrete channel.

4. CONCLUSIONS

The role of the infrastructures can be summarised as follows:

Table 1. Effects of infrastructures on flood attributes

Infrastructure	Upstream effect	Down stream effect
National Road embankment	O Decrease of flow velocity O Whirpool phenomena O Water accumulation/water level rise O Sideways and upstream backwards erosion O Riverbed overflow	O High erosion water energy O Exit of floodwater with increased velocity and pressure O Bank erosion O Maximum channel capacity reached
Concrete channel	O High velocity values (>6,4 m/s)	
Multilevel intersection	O Decrease of flow velocity O Water accumulation/water level growth O Whirpool phenomena O Lateral erosion and expansion of flood	O Increase of flood zone width
National Railway embankment/bridge	O Decrease of flow velocity O Flood zone expansion lengthwise of embankment because of low morphology	O Diffuse flow O Two entrances of flood (concrete channel & under the railway bridge) which lead to two coastline modification areas because of deposition

The composite topography and channelling capacity of hydraulic works, combined in areas of large linear infrastructures, seems to play a definitive role in flood dynamics during a flash flood. Water accumulation, reverse erosion, turbulence, and flow velocity are largely affected when hydraulic design is exceeded, altering the spatial distribution of impacts. As a result, flood extent is altered and secondary effects occur in areas otherwise naturally unaffected by the phenomena, had the technical works been absent. In our case, this is very clear even on the coastline, by a secondary delta type formation, due to bypass of the floodwaters under the railroad bridge, due to accumulation along the railroad embankment.

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OPTICAL GRANULOMETRY IN FLOOD DEPOSITS. ANALYSIS AND MAPPING

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ABSTRACT
The purpose is to accomplish granulometry analysis in mapped, recent floods and/or debris flows. The study area is west, uphill from Mandra (Attica, Greece) and specifically the stream of Ag. Aikaterini, with sampling site in Agios Ioannis. The data were obtained with Unmanned Aircraft Systems imagery, but also by ground-based means, for analyzing the small fractions of granules. Granulometry analysis was executed with Basegrain, a Matlab-based software. BASEGRAIN combines photogrammetry and optical methods with intelligent algorithms, creating an automated object detection process. However, the program enables user interface (GUI) by converting the process to semi-automatic to improve the result. In this study, three sizes of clasts were distinguished (fine, medium and thick grained), investigating the response of the software in different height as well as comparing the results with the already mapped data. At the same time, data from point images and orthophotomosaic are compared, in order to examine the applicability of mapping in a broader scale. Calculations show that imagery from different distances (heights) result in complementary distributions, due to difference in resolution (px/cm). Mapping results depend mainly on the grid resolution (sampling density).

Keywords: Post flood survey, UAS, Mandra flood, sieve analysis

1. INTRODUCTION
Granulometry and distribution of flood deposits is indicative of the flow conditions during floods and connected events such as debris flows, and optical granulometry has been recently evolving as a useful tool, in combination with the use of UAS photogrammetry [1,2]. Sampling and sieve analysis has always been an accurate procedure, but it is costly and time consuming. A reliable approximation through optical methods can save time and cost, providing a relatively reliable result. In the case at hand, that is, the flash floods of West Attica in November 2017, there have been a number of sites of extensive flood deposition, including an alluvial fan where debris flow phenomena occurred. Deposits were mapped with the use of a composite orthophoto mosaic obtained by UAS, in combination with field observations[3]. This study is exploring the possible refinement of mapping data, by partially replacing the eye of the expert with an optical granulometry analysis, calculating numeric results for points of observation. The research team used handheld and UAV camera footage shooting from different heights, to select the most appropriate practice for massive optical point sampling.

2. METHODOLOGY

2.1. Sampling and analysis
The project was designed towards the following goals:

1. Distinction of three grain sizes (fine, medium and thick grained)
2. Exploration of the capability of the Basegrain software
    a. At different heights

b. With different sampling equipment (with UAV and Camera)
c. With different input data (raw images vs orthophotomosaic)

3. Creation of a mapping methodology for flood deposits

BASEGRAIN is a MATLAB-based automatic object detection software tool for granulometric analysis of top-view photographs of fluvial non-cohesive gravel beds. It is handled via a graphical user interface, which enables post- and pre-processing as well. A quasi grain size distribution is derived from the b-axes of the detected grain top view area following a line-sampling methodology.

Workflow consists of the following steps:

1. Importing (jpg, png, tif)
2. Preprocessing (Scaling, Cropping)
3. Parameters for automatic object detection
4. Postprocessing (merge, depart, blank out)
5. Exporting (ASCII, Excel file, Matlab file, GIS file: shp, kml)

There are certain sampling requirements to ensure the best possible imagery input[4]: Camera at least > 2 Mpx, Perpendicular sampling position, the smallest detectable grain is 23 px, in sunny weather cast shadowing should be minimized, wet stones are not preferable, in sampling area, objects like grass, leaves, mussels, snow or photographers shoes, should be avoided.

The processing procedure is summarized as follows:

1. Detection (a. Interstice detection by double grayscale threshold[5], b. Interstice detection by morphological bottom – hat transform for suppressing the intra-granular noise, c. Interstice detection by edge detection methods and morphological smoothing (Canny and Sober)
2. Separation by watershed transform. The detected grain areas are taking shape by the H-minima transform from the Euclidean distance (excluding elements with<25 px)
3. Measurements. Final operations (Grain areas are replaced with ellipses based on a and b axis)

Transfer to quasi-sieve analysis is made through the line sampling method. It is a user-friendly in-situ sampling method to analyze a gravel surface and to determine grain size distributions of the surface and subsurface bed material. With a string or a measuring tape a line is spanned over an (at least almost) dry gravel bed. The b-axes of all grains are measured that are in contact to the line[6]. This method estimates a percentage of the grain size of the sublayer.

Table 1. Comparative data for the different tests executed for analysis at the same location. Notice the difference in ground sampling distance (GSD) as height is increased. This is the threshold of minimum visible grain size.

Location	Sampling Data	Number of photos	Height (meters)	Sampling Device	Analysis	GSD mm/px
Agios Ioannis	Into point photo	3	<1	Mobile Smartphone	13 Mpx	0.2714
Agios Ioannis	Into point photo	1	1	Drone	4K	0.3540
Agios Ioannis	Into point photo	1	3	Drone	4K	0.8957
Agios Ioannis	Into point photo	1	5	Drone	4K	1.4315
Agios Ioannis	Into point photo	1	10	Drone	4K	2.7290
Agios Ioannis	Into point photo	1	15	Drone	4K	4.2166
Agios Ioannis	Into point photo	1	20	Drone	4K	5.5480
Agios Ioannis	Into point photo	1	30	Drone	4K	8.7279
Agios Ioannis	In row photos	11	5	Drone	4K	≈1.4410
Agios Ioannis	Flight controls	90	15	Drone	4K	≈4.3407
Agios Ioannis	Model	2	15	Drone	4K	4.0309/4.7056

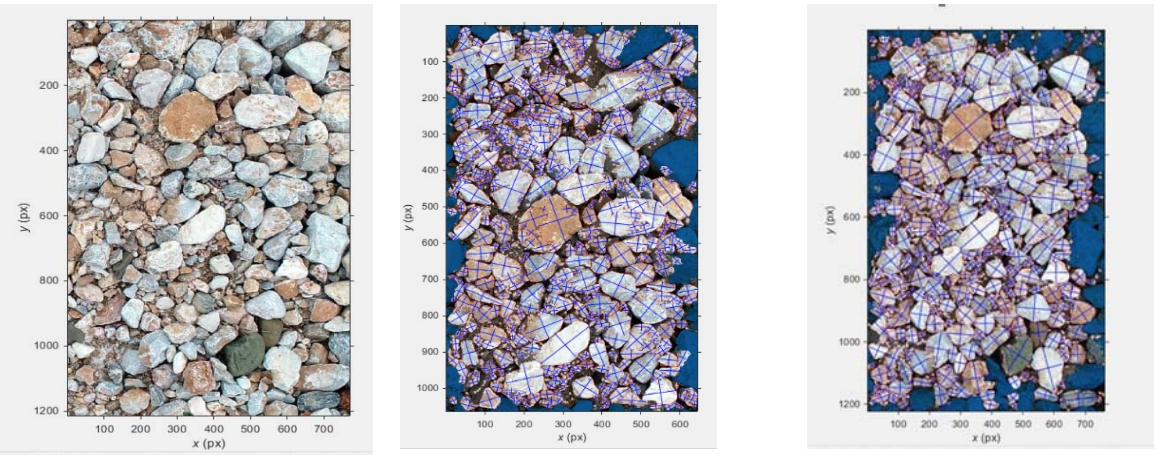

Figure 1. Image processing and object recognition in BASEGRAIN. (a) Selection of area for analysis; (b) Automatic recognition; (c) Corrections and finalization of objects.

2.2. Mapping

The last goal of the study was to create a quick methodology for mapping flood deposits. For this purpose, in ESRI ArcMap environment, a model in which the orthomosaic is separated in squares that are clipped one by one from the original was created. The exporting data are in jpg form for import in Basegrain, followed by an iteration of the previous sampling and analysis methodology. A representative value for each sample was then selected as mapping value (D50, D65, etc, or D84, as in our case). Finally, map is constructed with interpolation.

3. RESULTS - CONCLUSIONS

Results showed the three distinctive classes intended to be analyzed and were verified by comparison to Weibull distribution (Fig. 2). Map deriving from model gridding and sampling showed good results, given the large size of the grid (Fig. 3).

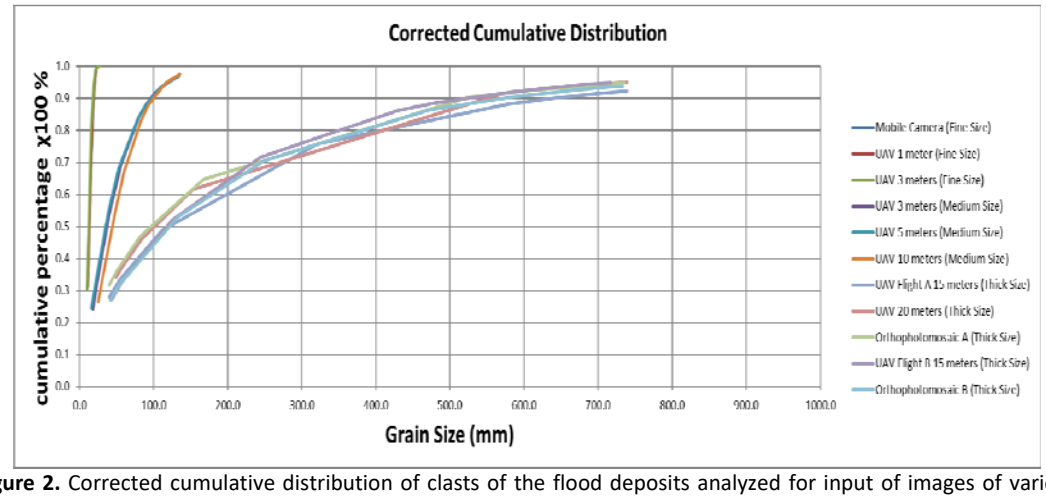

Figure 2. Corrected cumulative distribution of clasts of the flood deposits analyzed for input of images of various equipment and distancing. Verification was done by comparison, using the least squares method and the expected results of the Weibull distribution. Fine, medium and thick granulometric sizes are clearly defined and similar between different inputs over the threshold of the respective size.

The use of UAS footage either with direct vertical imaging at various heights, or with the use of composite orthomosaics deriving from photogrammetry is very encouraging for quick calculations about size distribution of deposition clasts and even mapping of the deposition, if designed properly and sampling grid is dense enough. In any case, this is a methodology that can be at least complementary or used for verification of expert field work, without the immediate need for physical sample collection.

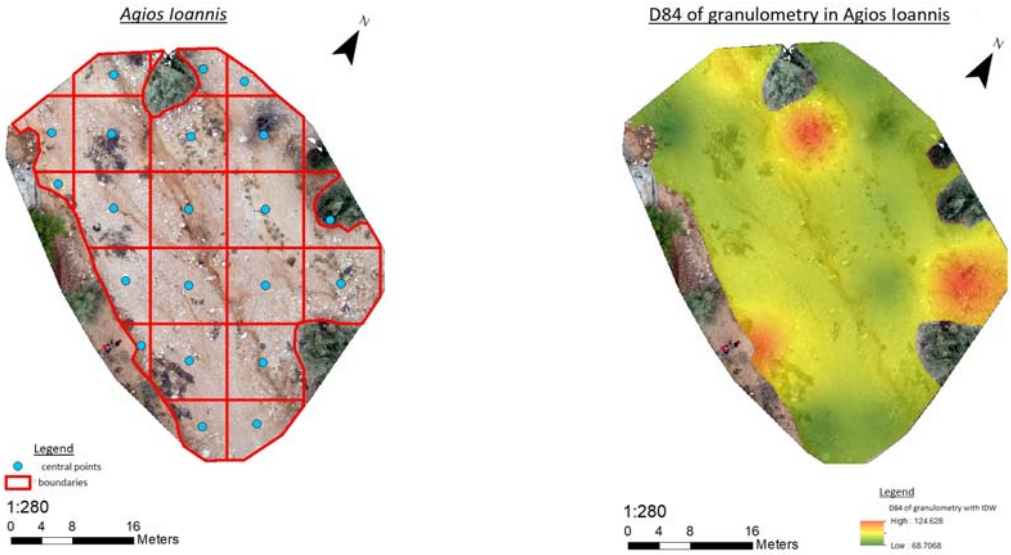

Figure 3. (a) Sampling grid on the orthomosaic and centroids for value attachment; (b) Interpolation and test map of D84 value of the flood deposits.

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APPLYING AN INTEGRATED COASTAL VULNERABILITY INDEX (ICVI) TO SEA-LEVEL RISE FOR THE SOUTHERN COAST OF THE CORINTH GULF, GREECE.

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ABSTRACT

Sea-level rise is an issue of concern that is expected to have various impacts on humans in the near - and long-term future due to global warming and melting of continental ice sheets. Increasing population and human activities in coastal areas tend to make societies more prone to sea-level rise. The complexity of tectonics and the variety of coastal landforms in the northern Peloponnese, combined with a high concentration of human activities led us to calculate an Integrated Coastal Vulnerability Index (ICVI) to a potential sea-level rise in the southern coastline of the Corinth Gulf (Greece), by using physical and socio-economic parameters. All parameters were identified and ranked into a vulnerability index with a scale from 1 to 5. Two mathematical equations (ICVI_1 and ICVI_2) were used, whereby the relative weight values were given for the latter equation. The most vulnerable sections were located mostly in the eastern part of the coastline with low-lying regions of gentle slope and concentrated human activity. The ICVI_1 showed that 18.3% of the total coastline was characterized by very high vulnerability in contrast to ICVI_2 which showed 9.1%. The results revealed that in terms of spatial distribution of the vulnerable areas, the two approaches showed more or less the same highly prone to sea-level rise areas. On the other hand the proportional distribution of the extreme values of vulnerability estimated by the application of the two approaches was different.

Keywords: Sea-level rise, coastal vulnerability, GIS, Corinth Gulf, Greece

1. INTRODUCTION

Long-term sea-level rise is one of the adverse consequences of global warming due to the immediate and long-term impacts of flooding and erosion of coastal areas. Global sea-level rise has been accelerating over the last century with an average rate of 1.7 mm/yr for the period 1901-2010 and 3.2 mm/yr for 1993-2010 [1]. The Hellenic Aegean coastline shows a relatively high geomorphic diversity with moderate to high vulnerability to sea-level rise [2]. Vulnerability is a function of both exposure and coping ability, and is therefore both physically and socially dependent [3]. Various mathematical approaches have been applied for assessing the vulnerability of coastlines as an effect to climate change and sea-level rise, generating an interest in coastal research (see [4]) and secondary integrations with socio-economic aspects (see [5]).

The study area covers approximately a 147 km coastline in the southern Corinth Gulf, Greece, between the towns of Corinth and Rio. The coastal population of the study area is approximately 120.000 inhabitants. The Corinth Gulf is one of the most seismically active zones worldwide. It has a W.NW-E.SE orientation and separates the Peloponnese from the continental Greece [6]. The southern shore of the Gulf is bordered by large north dipping active normal faults like the Psathopyrgos, Aigion, Eliki, and Xylokastro, in which parts of the coastline are tectonically uplifting while others are subsiding. The most common landforms along the studied coastline are beaches developed along coastal plains, and aprons of coastal alluvial fans that consist of coarse sands to gravels sediments, while segments of the shoreline consist of steep coast made up of marls, conglomerates and limestone [7]. The northern section is characterized by marine cliffs, whereas the southern section is characterized by low-lying coastal landscape of gentle slope.

2. METHODOLOGY

The objective of this research was to assess the relative vulnerability of the shoreline along the northern Peloponnese to the anticipated sea-level rise considering physical- and socio-economic parameters. The methodology was adopted from a similar coastal vulnerability assessment in Apulia, Italy [7]. All the involved parameters were utilized in a Geographic Information System (GIS) environment. Two mathematical approaches, the ICVI_1 and the ICVI_2 were used in an attempt to quantify the vulnerability along the coastline of the study area. In the former approach, all parameters were given an equal relative importance based on the method of Thieler and Hammer-Klose (see [4]) whereas in the latter, Analytical Hierarchical Process (AHP) was applied to all parameters, which were evaluated with weight factors. Moreover, the ICVI_2 formulation expresses the arithmetic mean of Physical Vulnerability Index (PVI) and Socio-economic Vulnerability Index (SVI). The four steps of the methodology were: 1) definition of the parameters, 2) data collection, 3) attributing the vulnerability score to each one of the parameters, and 4) calculation of ICVI_1 and ICVI_2. The physical parameters included: coastal geomorphology, erosion/accretion rate, coastal slope, relative sea-level rise, mean wave height, and mean tidal range. The socio-economic parameters included: population density, land use/land cover and distance from both the road and the railway networks. The vulnerability score of all the parameters was calculated, according to Table 1, through the GIS software and was grouped into five classes through the 'Natural Breaks' (or Jenks) classification method.

$$\boldsymbol{ICVI\_1} = \sqrt{\frac{(X1*X2*X3*X4*X5*X6*X7*X8*X9*X10)}{10}}$$

Where X represents the vulnerability score of each parameter, both physical and socio-economic.

$$\boldsymbol{ICVI\_2} = \frac{PVI + SVI}{2}$$

$$PVI = \sqrt{\frac{((W1*X1)+(W2*X2)+(W3*X3)+(W4*X4)+(W5*X5)+(W6*X6))}{6}}$$

$$SVI = \sqrt{\frac{((W7*X7)+(W8*X8)+(W9*X9)+(W10*X10))}{4}}$$

Where *Wi* stands for the APH weight value for each parameter and *Xi* for the vulnerability score of the respective parameter.

Table 1. Ranges of vulnerability ranking for the parameters. The categories for the physical parameters are adopted from [7] while for the socio-economic parameters the categories are modified from [5].

			Physical Vulnerability Categories		
Variables / Vulnerability score	**1**	**2**	**3**	**4**	**5**
Geomorphology	Rocky, cliffed coasts	Medium cliffs, indented coasts	Lowcliffs, alluvial plains	Cobble Beaches, Lagoons	Sandy beaches, deltas
Erosion (-)/Accretion (+) rate (m/year)	> (+1,5)	(+1,5) - (+0,5)	(+0,5) – (-0,5)	(-0,5) –(-1,5)	< (-1,5)
Coastal Slope (%)	>12	12-9	9-6	6-3	<3
Relative Sea Level Rise (mm/year)	<1,8	1,8-2,5	2,5-3,0	3,0-3,4	>3,4
Mean Wave Height (m)	<0,3	0,3-0,6	0,6-0,9	0,9-1,2	>1,2
Mean Tidal Range (m)	<0,2	0,2 -0,4	>0,4 – 0,6	>0,6 – 0,8	>0,8
			Socio-economic Vulnerability Categories		
Population density (pop/km²)	12-116	117-229	230-625	626-1.101	1.102-1.704
Land Use/Land Cover	Water elements	Beaches and grasslands	Forests	Cultivated land	Urban -, industrial areas and road network
Road network (distance from coastline in km)	>2-10	>1,5-2	>1-1,5	>0,5-1	<0,5
Railway network (distance from coastline in km)	>2-10	>1,5-2	>1-1,5	>0,5-1	<0,5

3. RESULTS

The results of the two approaches (ICVI_1 and ICVI_2) for the assessment of coastal vulnerability are depicted in Figure 1, in the form of two parallel coastlines with sections of various levels of vulnerability (from very low to very high), taking into account the assessment of the six physical parameters and the four socio-economic parameters respectively. The first approach (ICVI_1) showed that 18.3% of the coastline in the study area is characterized as having very high vulnerability, while 10.8% as of very low vulnerability. In the second approach (ICVI_2) very high and very low vulnerability stand for 9.1% and 7.1%, of the coastline respectively. This reveals that ICVI_1 shows a higher proportion of very high and high vulnerability values. In general, the two methods showed very high to high vulnerability mainly in the eastern section of the coastline, while in the central and western section the aforementioned values are presented in a shorter overall length. The values of high and very high vulnerability are depicted in the most densely populated settlements, which are Corinth, Kiato and Xylokastro in the eastern section, and Rio in the western. The area between Corinth and Kiato is a gently sloping area with a significant proportion of the built environment consisting of residents, factories and compact road networks. The highway and the railway are characterized as having low vulnerability due to their long distance from the coastline. The lowest vulnerability ('very low') is depicted in Psathopyrgos due to the occurrence of marine cliffs. The dominant land cover type is comprised of crops such as vineyards, fruit trees, olive groves and compound crops, which are also characterized as highly vulnerable according to the methodology. These land use types are allocated to small sections surrounding urban areas. To summarize, a relatively extensive segment of the studied coastline in the southern Corinth Gulf is characterized as highly or very highly vulnerable to a potential sea-level rise. These vulnerable areas host a significant part of the population as well as socio-economically important human activities.

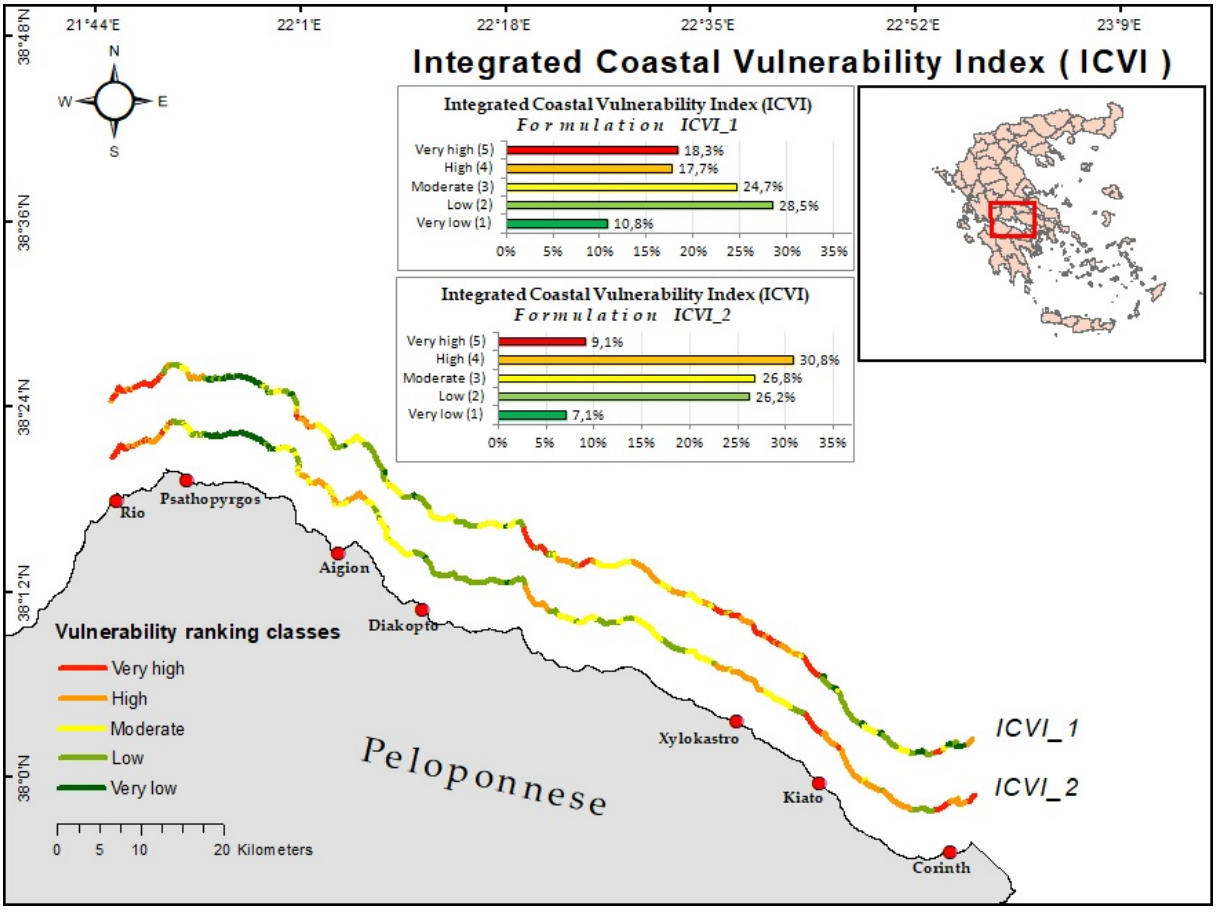

Figure 1. Map showing the vulnerability scores in the coastline of the study area according to the two approaches (ICVI_1 and ICVI_2) projected with colored parallel lines.

4. CONCLUSIONS

This study revealed the complexity of achieving a true and fair assessment and projection of coastal vulnerability when considering both human activities and natural processes. The different results between the two approaches applied in this study can be attributed to the added weight distribution between the parameters in the second approach (ICVI_2). Another reason is the equal importance of both socio-economic and physical parameters in the mathematical equation of ICVI_2, in contrast to the ICVI_1, which gives socio-economic parameters a lower importance. We consider that the second methodology (ICVI_2) rightly expresses the importance of socio-economic parameters, as vulnerability is an inability of human communities to cope with extreme natural processes such as long-term sea-level rise. Equally important are the weights of importance given to each parameter in order for the final result of a coastal vulnerability assessment to correspond to the actual situation. However, an increase in long-term sea-level rise rate appears to adversely affect mainly the eastern coast of the southern Corinth Gulf (between the settlements of Corinth and Kiato), as well as sections that host important urban areas such as Rio, Xylokastro and Aigion. These coastal areas should be protected from flooding and erosion in order to avoid future harmful effects caused by long-term sea-level rise or severe storm surge events.

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A SEMANTIC APPROACH FOR MODELING COMMUNITY RESILIENCE DATA

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ABSTRACT

In this paper, we propose the use of semantic technologies for the representation of concepts and relationships required for the modeling of resilience of local communities. First, we provide some background knowledge and we present basic concepts of resilience of local communities. Then, we present the motivation behind the use of semantic technologies to address modeling issues. The core part of this paper focuses on the work that has been carried out in the context of the European project Resilient Europe and Societies by Innovating Local Communities (RESILOC) for the semantic representation of community resilience aspects. Finally, we give an overview of the layered semantic framework consisting of interconnected ontological models and we give examples where the use of semantic-based query answering can prove beneficial.

Keywords: Community resilience, semantic modeling, risk perception, knowledge representation and reasoning.

1. INTRODUCTION

Resilience is defined by the United Nations [1] as “the ability to resist, absorb and accommodate to the effects of a hazard, in a timely and efficient manner”. Thus, resilient communities are those in which their citizens, environment, businesses, and infrastructures have the capacity to withstand, adapt, and recover in a timely manner from any kind of disaster they face, for which they may be either prepared or not. In recent years efforts have been spent to understand and increase resilience and there is, still, a long way forward in defining an EU valid and sound approach to this issue. Although resilience strategies are being developed on national or city level, still there is not enough focus on the needs of local communities, where particular challenges are understanding the behaviour towards risk of the members of a community exposed to risks and the optimization of the allocations of limited resources available.
With the ambition of closing this gap, the RESILOC project [2] aims to increase the understanding of resilience in local communities and to generate strategic tools empowering local actors to assess the resilience of their communities and identify actions to increase it. RESILOC will deliver a cloud-based platform able to strategically support stakeholders in modelling and assessing resilience for a city or a community. The resilience profile will serve as a basis for identifying localised resilience-building strategies, enabling “what-if” scenarios and suggesting actions to be implemented. During a disaster, the RESILOC platform will be used to collect information that will allow to re-assess the indicators previously generated and help stakeholders analyse the impact and identify effective new actions.

2. BACKGROUND KNOWLEDGE

Data related to the resilience of local communities may originate from different information sources (e.g., static official data from local and regional authorities, internet and statistical data, dynamic sensor data, social media), it may be of different types (e.g., social data, physical and digital infrastructure, economic data) and may come in a wide range of formats (e.g., numerical data, qualitative data, unstructured data from social media). Such an increased data complexity calls for a well-defined and, at the same time, agile data architecture that will faciliate data management procedures and will serve

data needs of the upper-level services and, finally, users (e.g., civil protection agencies, local administrators and municipality officers). To cover the wide range of needs stemming from this data heterogeneity, systems usually need to combine heterogeneous modeling approaches for data representation that considers the use of both relational and non-relational data structures.

A Relational Database Management System (RDBMS) is usually a good candidate technology for storing data that do not frequently change. RDBMS is a type of database management system (DBMS) that stores data in a row-based table structure which is easy to understand. This is the main reason that this kind of DBs are used mainly to describe datasets with predefined structure. Hence, it constitutes a storage technology suitable for static data that needs to be queried and processed often. On the other hand, NoSQL technologies are usually considered for storing and managing dynamic data. NoSQL allow for data to be stored in a schema-less fashion making this approach more appropriate for dynamic data that do not comply with specific structures (e.g., social media data such as tweets or sensor data). While SQL databases have traditionally sacrificed performance and scalability to achieve reliable transactions, NoSQL databases have largely ditched such guarantees for speed and scalability.

The combination of both Relational and NoSQL database technology (i.e., hybrid approaches) could offer higher data availability, scalability, and performance (Figure 1). A hybrid approach offers the characteristics of both an in-memory database (NoSQL) and an on-disk database (RDBMS) in a single integrated engine. On top of the data storage, the use of a semantic model allows for establishing connection links between the relational and the non-relational approach. Semantics can also support automated classification and correlation of data coming from different communities. Specifically, we envisage a multi-layered semantic framework that will be used to semantically describe, integrate and manage the community data that will be collected by the system. The main goals of the semantic layer are to (i) facilitate information integration for data coming from communities based on different locations and with different characteristics, and (ii) improve system intelligence by allowing for the deduction of new knowledge based on semantic reasoning techniques.

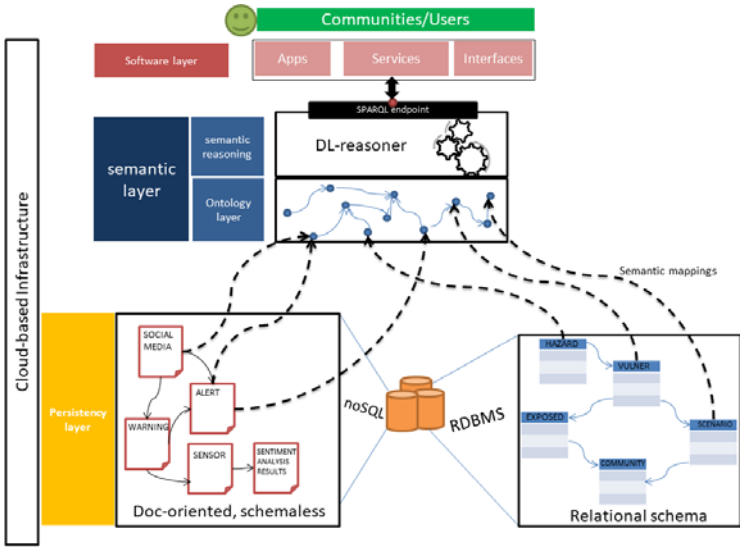

Figure 1. Data storage approach for resilience-related data

3. A SEMANTIC ARCHITECTURE FOR MODELING THE RESILIENCE OF LOCAL COMMUNITIES

3.1. Motivation

The Semantic Web is considered as "*a web of data that can be processed directly and indirectly by machines*" [3]. Practically, it constitutes an extension of the World Wide Web (WWW) in which web resources are supplemented with semantic notations that describe their intended meaning in a formal,

machine-understandable way. The Semantic Web (SW) is considered as an integrator across different content, applications and systems connected to the WWW. Ontologies play a key role in SW, providing the machine-interpretable semantic vocabulary and serving as the knowledge representation and exchange vehicle. The Web Ontology Language (OWL) has emerged as the official W3C recommendations for creating and sharing ontologies on the Web [4]. The rationale behind the selection of semantic technologies is justified by the clear need to support:

1. *Heterogeneous data integration at semantic level*. The semantic models should be built as a network of interconnected ontologies that will act as the "glue" to link heterogeneous concepts and individual component-level data models. The core ontology will be the common representation framework of the project for the semantic modelling and integration of information stemming from local communities. A set of community-specific ontologies will be linked to the core ontology to specialize Indicators and Proxies according to the local policies and procedures.
2. *System intelligence.* A set of reasoning tasks should facilitate a wide range of decision-making processes. The knowledge base will be capable of integrating, combining and, finally, inferring new knowledge based on existing data that has been fed to the system. In particular, ontological models are interconnected with a querying and a reasoning module (e.g., a SPARQL/SPIN endpoint for semantic queries and a DL-reasoner, respectively). Models and business rules will be expressed in Semantic Web languages such as OWL(2) and SPARQL/SPIN [5] to balance between the expressiveness of the knowledge representation methodologies and the performance (i.e., tractability) of query answering tasks (e.g., instance checking, classification, consistency checking).

3.2. The RESILOC ontology network

The semantic architecture is designed as a network of ontologies organised in three layers (Figure 2):

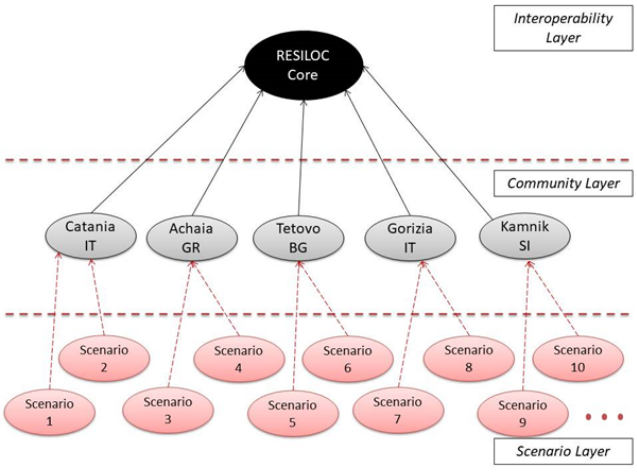

Figure 2. Structure of RESILOC semantic architecture

Interoperability Layer: It consists of the core upper level ontology that will serve as a semantic model for the representation of the static data of the system. It will be the heart of the semantic approach where the rest of the models will be connected. The core ontology will provide semantic descriptions, terminology and relationships for the different types of resilience data considered by the system.

Community Layer: Each community will be able to specialise the core ontology according to its own procedures, policies and regulations that are followed at community level. For each community a low-level ontology will be specified to cover all the local aspects. Each community will be able to define its own proxies in order to describe a certain resilience indicator according to local/regional/national procedures, the availability of data and relevance for the community authorities and actors. For

instance, the city of Catania may use the proxy Human Development Index - HDI" to represent the 'Wealth and Socioeconomic status' indicator while the municipality of West Achaia may use the proxy "Human Poverty Index – HPI" to represent the same indicator.

Scenario Layer: A set of community-specific scenarios will be modelled to represent different incidents where the community resilience needs to be evaluated against a certain risk. Each one of these scenarios will describe the semantic parameters of either a real incident or a virtual event that a community may want to respond. For example, the Achaia community that suffers from coastal forest fire incidents will be able to re-use the terminology of the upper layers (i.e., Core ontology and Community Layer) to semantically represent a Fire Incident scenario by defining a set of parameters.

In Figure 3 some basic concepts of the core ontology are depicted while Figure 4 depicts the proxies' alignment at a specific dimension (i.e., Social).

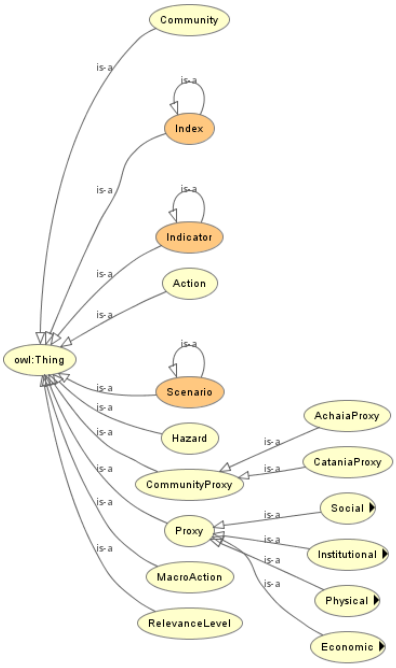

Figure 3. Core Taxonomy

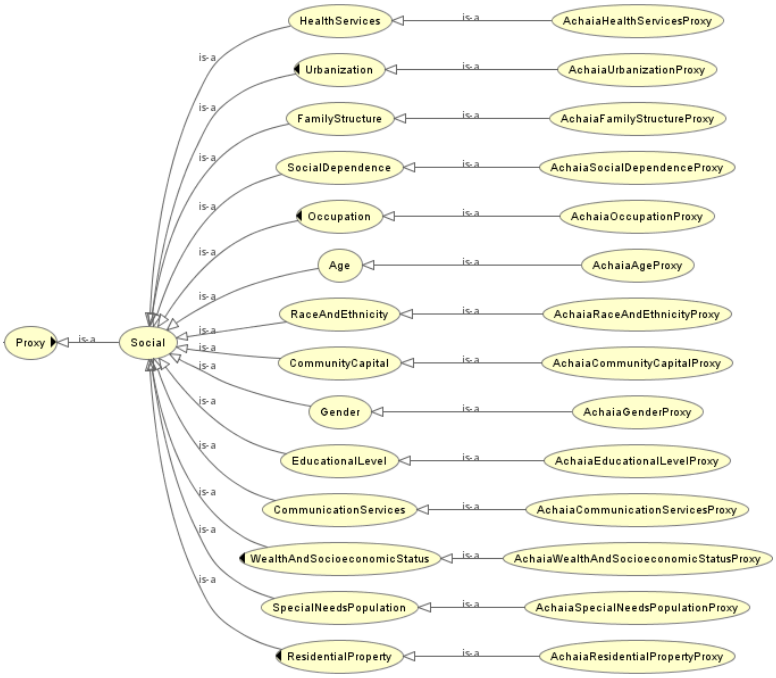

Figure 4. Social Proxy Alignment Example

ACKNOWLEDGEMENT

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FLOOD HAZARD ASSESSMENT IN MEGALO REMA (RAFINA) DRAINAGE BASIN (EAST ATTICA, GREECE)

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ABSTRACT
In the present study, the prone to flood hazard zones in the drainage basin of the Megalo Rema (Rafina) River are estimated utilizing GIS techniques and multi-criteria decision analysis. Six factors were considered as the most flood influencing parameters and were taken into account. To evaluate these factors the results of the Analytic Hierarchy Process (AHP) performed for a similar catchment were used. The final outcome was a flood hazard map. Approximately 27 km^2 which corresponds to ~23 % of the total area of the catchment belongs to the high flood risk zone while around 16 km^2, corresponding to ~14 % of the catchment area, is of very high flood risk. The highly and very highly prone to flooding areas are characterized by lowland morphology of gentle slope and intense urbanization. They are located mostly at the southern as well as at the western parts of the catchment and on both sides of the main channel along the lower reaches of the stream.

Keywords: Multi-criteria analysis, GIS, Flood hazard, Megalo Rema (Rafina) River, Eastern Attica.

1. INTRODUCTION

Floods are among the most frequent and dangerous natural hazards and the leading cause of natural disaster fatalities worldwide. They represent about one-third of all global hazardous events and severely affect the development of an area [1]. Rapid urbanization coupled with population growth has brought significant impact on the natural environment. Flood-hazard assessment is essential for flood hazard mitigation and a necessary step for land use planning in flood-prone areas.
This paper aims at the assessment and mapping of flood hazard in the catchment of Megalo Rema (Rafina) River, a peri-urban area in the greater southeast Mesogeia region in Eastern Attica. For this purpose a methodology based on GIS functionality with the integration of various critical factors has been applied.
The Megalo Rema (Rafina) River is of ephemeral flow and drains an area of 116 km^2. The drainage basin has a roughly circular shape and reaches a maximum elevation of 900 m at its northeastern border (Penteliko Mt.). It hosts residential areas with total population coverage of ~85,000 residents. The main channel of the river has a length of 25 km, follows a W.SW – E.NE flow direction and discharges into the South Evoikos Gulf. The drainage system is well developed north of the main channel whereas to the south a few channels of small order exist [2]. The catchment can be morphologically divided into two areas: (a) the northern relatively mountainous part of rough relief consisting mainly of metamorphic rocks (schists and marbles) of Mesozoic age belonging to the autochthonous Almyropotamos geotectonic unit and (b) the southern area of lower elevations, gentle slopes and a generally smoother relief that is composed mainly of lacustrine marls, silts, marly limestones and conglomerates of Upper Miocene age [2]. The climate of the study area is typical subtropical Mediterranean with mean annual precipitation ranging from 362 mm at the mouth of the River to 473 mm, while the mean annual air temperature is 17.2 ^{o}C. The catchment is highly prone to flash-flooding because of extensive wildfire

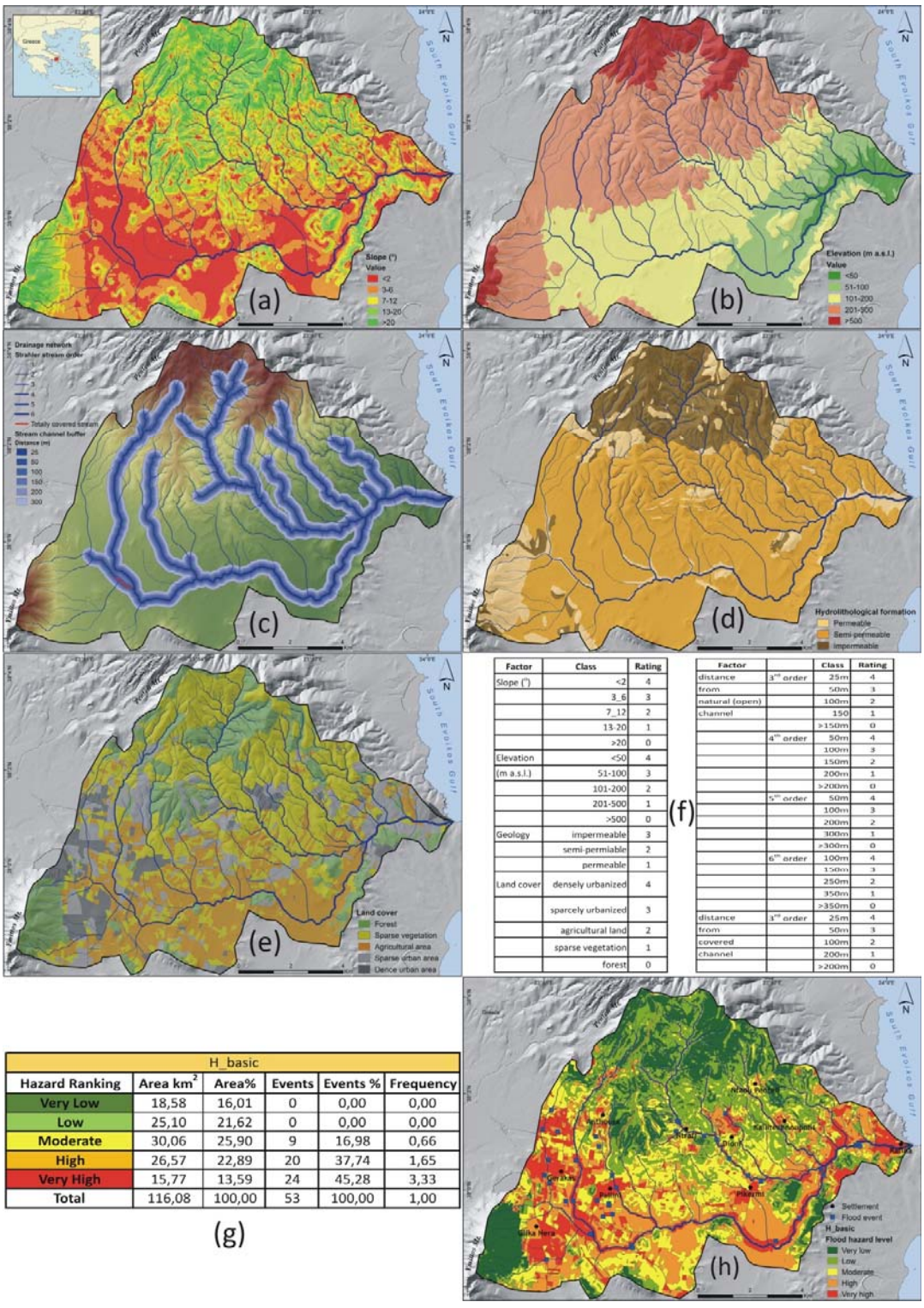
burnt territories, increased urbanization, mild topographic slopes and the absence of efficient inundation protection [1, 2]. During the last 27 years one flash-flood event occurs every 2.7 years [3].

2. METHODOLOGY

For the flood hazard assessment, a multi criteria model has been applied. The model was based on factors controlling the water route when drainage system capacity is exceeded by high runoff. The selected factors include slope, elevation, distance from both natural (open) and artificially covered channels of the higher order streams, hydro-lithological characteristics of the geological formations and land cover. Each factor was divided into various classes with specific boundary values. The slope was derived from the detailed DEM (5X5) of the catchment and the slope values were classified into five classes (Figure 1a). The elevation grid was also produced by the DEM and elevation values were divided into five categories (Figure 1b). The drainage network was also automatically extracted from the DEM. The streams were divided into natural (open) channel and artificially covered ones. Regarding the factor of the distance from the channel, buffer zones were created on either side of the channels of the higher order streams (Figure 1c). The geological formations of the catchment were derived from the corresponding 1:50,000 geological map of the IGME, and were classified into three categories namely, permeable, semi-permeable and impermeable according to their hydro-lithological behavior (Figure 1d). Permeable geological formations include limestone, marbles, sandstones and alluvial deposits. Marls, conglomerates and silts are considered as semi-permeable formations while schist is considered as impermeable rock. The land cover types of the drainage basin were obtained from CORINE ILOTS 2012 and were classified into five categories: (1) densely urbanized areas, (2) sparsely urbanized areas, (3) agricultural land, (4) land covered by sparse vegetation, and (5) forests (Figure 1e). The classes of the involved factors were standardized to a uniform suitability five-grade rating scale. Integer numbers, ranging from 0 to 4, were assigned to every class (Figure 1f). The class which was rated as 0 represented low hazard level whereas the one rated as 4 represented very high hazard level. The final weights for each factor are based on the results of AHP conducted by Bathrellos et al. [4] at a similar nearby catchment. For the verification of the flood hazard assessment, the spatial distribution of the severe flood events occurred in the Megalo Rema (Rafina) River catchment was used. The verification was done by calculating the frequency distribution of flood events for each zone of the basic flood hazard map.

3. RESULTS AND DISCUSSION

Concerning the produced H_b map (Figure 1h), the areas of very high and high flood hazard are distributed mostly on both sides of the channels of the main streams especially along the lower reaches of Megalo Rema (Rafina) River, and around the mouth of the River. Additionally an extensive area at the southern as well as at the western part of the catchment belongs to the zones of high and very high flood hazard risk. It is obvious that these parts of the drainage basin are relatively low-lying, gently sloping and extensively urbanized and host the densely populated settlements of Rafina-Pikermi, Penteli, Pallini, Peania, Spata, Glika Nera, Gerakas and Anthousa. Additionally, few regions of limited area at the northern part of the catchment are classified as of high and very high flood risk. These regions include the settlements of Dion, Kallitechnoupolis and Drafi. Regarding the spatial development of the prone to flood hazard zones, their percentages to the total catchment area are: 22.89 % for the ‘‘high flood risk’’ zone and 13.59 % for the ‘‘very high flood risk’’ zone (Figure 1g). The accuracy of the produced flood hazard map was verified using flood events of the last 30 years. The results demonstrated that the vast majority of the flood events, 44 out of 53 occurred within the limits of the high and very high flood risk zones (Figure 1h). The frequency ratio statistical analysis proved



Factor	Class	Rating
Slope (°)	<2	4
	3_6	3
	7_12	2
	13-20	1
	>20	0
Elevation	<50	4
(m a.s.l.)	51-100	3
	101-200	2
	201-500	1
	>500	0
Geology	impermeable	3
	semi-permiable	2
	permeable	1
Land cover	densely urbanized	4
	sparcely urbanized	3
	agricultural land	2
	sparse vegetation	1
	forest	0

Factor		Class	Rating
distance	3rd order	25m	4
from		50m	3
natural (open)		100m	2
channel		150	1
		>150m	0
	4th order	50m	4
		100m	3
		150m	2
		200m	1
		>200m	0
	5th order	50m	4
		100m	3
		200m	2
		300m	1
		>300m	0
	6th order	100m	4
		150m	3
		250m	2
		350m	1
		>350m	0
distance	3rd order	25m	4
from		50m	3
covered		100m	2
channel		200m	1
		>200m	0

H_basic					
Hazard Ranking	Area km^2	Area%	Events	Events %	Frequency
Very Low	18,58	16,01	0	0,00	0,00
Low	25,10	21,62	0	0,00	0,00
Moderate	30,06	25,90	9	16,98	0,66
High	26,57	22,89	20	37,74	1,65
Very High	15,77	13,59	24	45,28	3,33
Total	116,08	100,00	53	100,00	1,00

Figure 1. Spatial distribution maps of (**a**) slopes; (**b**) elevations; (**c**) distance from higher order stream channels; (**d**) geological formations and (**e**) land cover types; (**f**) Table including the assigned rate values for each adopted factor/class; (**g**) Table including the frequency ratio values of flood events within each flood hazard zone; (**h**) The basic flood hazard assessment map H_{basic} of the Megalo Rema (Rafina) River catchment.

satisfactory results about the positive relationship between the flood hazard assessment map and the flood events since the flood hazard intensity raises as the frequency ratio values increase. The resultant flood hazard map is in accordance with the results of the delineation of the potentially flooded area on both sides of the main channel of the river performed by Andreou et al., [3] by simulating the river hydraulics behavior using HEC -RAS Model in GIS Environment for a channel length of about 4 km before the river mouth. The detection of the potentially flooded areas was performed for three different high discharge values that correspond to the peak discharges of the storm events on 22/02/2013 as well as to the discharge values over return periods of 25 and 50 years respectively. The potentially flooded areas coincide with the highly and very highly prone to floods areas mapped in this study. The results of our approach are also in good agreement with the quantitative geomorphological analysis of the Megalo Rema (Rafina) River drainage network conducted by Karymbalis et al. [2]. The analysis revealed irregularities in the hierarchical drainage by stream order that enhance flash floods. The most significant among them concerns fourth-order streams that drain directly into the sixth-order main channel of the Megalo Rema (Rafina) River. The reason for this anomaly is the Neos Voutzas stream which joins the main channel at its lower reaches enhancing its discharge during extreme rainfall events. This assumption is supported by the flood hazard map of the present study in which the broader area of the confluence of these two streams belongs to the very highly prone to flooding zone.

4. CONCLUSIONS

The flood hazard assessment map showed that approximately 42 km^2 of the study area (primarily the southern as well as the western parts of the catchment) is of high and very high flood risk. This area corresponds to ~36 % of the total area of the catchment and hosts socio-economically important land. The results of our approach provides valuable information for land-use planning at a regional scale leading to the determination of the safe and non-safe for urban development areas. This is very important particularly for the study area since the land cover properties are constantly changing. This can be attributed primarily to two factors: forest fires that devastated a significant part of the forested land of the area and increased urbanization rate of the area, especially during the last 40 years (e.g. according to the Hellenic Statistical Authority the increase in the population of the municipalities of the study area for the period between 1981 and 2011 was estimated up to 70% and 60% respectively). One of the main reasons for this increase is the construction of several public works in this area (i.e. the new international airport of Athens in Spata, the Attiki Odos motorway and the developing Rafina port), which contribute to a significant increase in the private building activity in the neighboring settlements and Municipalities.

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