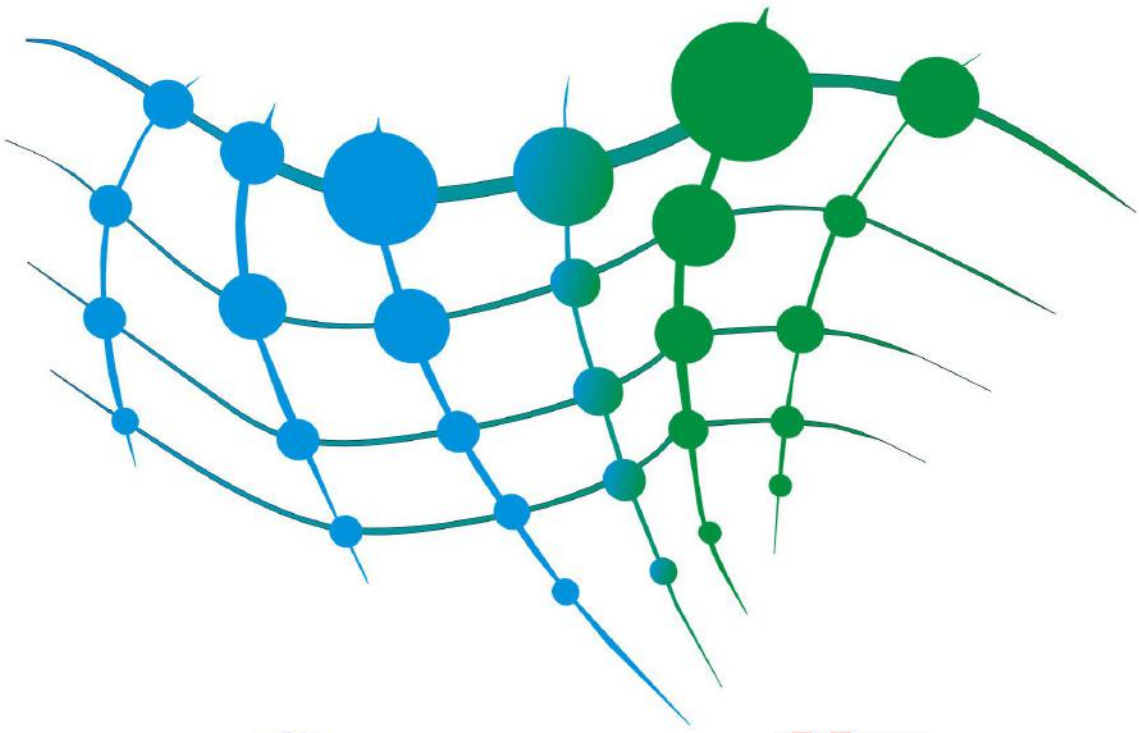
2022
SEMI-ANNUAL
Vol. 2
No. 2

ISSN 2720-2682

GIS Odyssey Journal

Previously: Conference proceedings (GIS Odyssey)



SILGIS Association

Croatian-Polish
Scientific Network

Vol. 2 No. 2 (2022): GIS Odyssey Journal

DOI: https://doi.org/10.57599/gisoj

The electronic version of the journal is the primary one.

The articles published in the “GIS Odyssey Journal” have been given a favourable opinion by the reviewers designated by the Editorial Board.

Cover designer: Assist. Prof. Anna Żemła-Siesicka Ph.D., University of Silesia in Katowice, Poland
Technical support: Assist. Prof. Krzysztof Świtała, Ph.D., Cardinal Stefan Wyszyński University in Warsaw, Poland

ISSN 2720-2682 (on-line)

Publisher: SILGIS Association, Będzińska Street 39/401, 41-200 Sosnowiec
tel. +48 32 3689716, e-mail: silgis@us.edu.pl, www.silgis.us.edu.pl
Co-publisher: Croatian-Polish Scientific Network, e-mail: cpsn@us.edu.pl, www.cpsn.us.edu.pl

Contact: gisjournal.us.edu.pl, www.us.edu.pl

Articles:

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.5

Eliezer Jose Arellano Garcia[1]

ANALYSIS OF OPERATIONAL RISKS ASSOCIATED WITH THE CONSTRUCTION OF JORGE CHAVEZ INTERNATIONAL AIRPORT IN LIMA-PERU

Abstract: In the daily operation of an airport, there are a multitude of hazards that can compromise operational safety; therefore, it is critical to monitor and identify these hazards as well as the associated risks. This work's main objective was to assess the operational risks and hazards that may arise from construction works in the airport environment by applying a methodology for the risk assessment based on historical data of aircraft incidents obtained from SKYbrary Aviation Safety and The Aviation Herald from 2000 to 2015. For this study, it was taken as a reference the expansion work at Jorge Chávez International Airport in the city of Lima, Peru. This is a large-scale project, with the construction of a second runway, a new control tower, taxiways, parking aprons, etc. Ten generic hazards were identified, from which thirty-seven potential risks were derived. However, most of them had a low probability of occurrence, so an "acceptable" tolerability prevailed. Among the recommendations presented (ATIS, NOTAM, visual signs, phraseology, signage, procedures, etc.), these are mainly focused on human factors and in phases 1 and 2 of the construction works, the critical phases where the current runway section is connected to the new taxiways giving access to the second runway.

Keywords: airport, safety, risk management, construction, aviation

Received: 2 November 2022; accepted: 15 November 2022

[1]Polytechnic University of Madrid, School of Aeronautical and Space Engineering, Department of Aviation Management, Madrid, Spain, ORCID ID: https://orcid.org/0000-0001-5298-3676, email: ej.arellano@alumnos.upm.es

Introduction

All airports need to undertake construction and/or maintenance activities to evolve and grow. However, no matter how necessary these activities may be, airports assume considerable risk in carrying them out. Construction activities at airports can be difficult and dangerous, so airports must take appropriate precautions to reduce potential risks.

There are intrinsic hazards in day-to-day operations that constantly compromise the safety, so it is vitally important to keep these potential hazards and their associated risks identified and under control, since airport construction can lead to ambiguity and confusion for the flight crew and operators, sometimes with catastrophic results.

There are currently a large number of airport construction and expansion projects underway or in the planning stages to meet current and anticipated increases in air traffic demand. These projects include both the construction of new facilities and the expansion of existing terminals, runways, and taxiways. Jorge Chávez International Airport, in Lima, Peru, is undergoing a comprehensive expansion process.

One of the main challenges in the management of works in this type of project is the proximity of construction resources, such as equipment, materials and personnel to critical areas of the airport, which poses a greater risk to the airfield safety. The characteristics of the works developed at Jorge Chavez International Airport make it a case study that meets the ideal characteristics for the development of the identification of the possible potential hazards involved in the execution of such construction works to the operations, and the assessment of the associated risks, resulting in the proposal of a series of recommendations and mitigation measures.

Methodology and scope of the safety study

Airports take proactive steps to address operational vulnerabilities through situational awareness, training, efficient airport infrastructure, procedures, and technology. Airport safety requires a coordinated approach between the various stakeholders and workers involved. Previous literature reviewed have included several articles and publications related airport safety and recommended practices (Bris, 2015; Bassey, 2015; ANAC, 2019; Tirado, 2019), based on the literature review a study methodology was established for the present paper, trying to evaluate the accident risk increase when there is a construction site in progress nearby the aircraft operations at an airport.

The methodology followed includes the extraction of data from previous incidents and accidents occurred from 2000 to 2015 obtained from SKYbrary Aviation Safety and The Aviation Herald where the operational safety of aircraft has been seriously compromised and which were related to the performance of 43 construction works on the runway or its surroundings. Once built the database, data is analyzed, and statistics are produced to identify the possible hazards and assess the risks.

Work on the airside of aerodromes, or on the maneuvering area and apron, is planned and executed in accordance with the requirements established by the International Civil Aviation Organization in relation to the airport accreditation process

and its implementation, supported by the safety management system implemented at the airport in question.

Jorge Chávez International Airport is currently being renovated and expanded, with the construction of a second parallel runway, a new control tower, new taxiways, passenger terminal, and related buildings that will allow for a greater flow of passenger arrivals (CORPAC, 2020). The aim of this work is to identify the operational hazards that may arise from the airport expansion works while continuing with normal air operations, as well as to assess the safety scope (the scope refers to the identification of the transcendence or importance, through a qualitative risk analysis of all identified hazards (their tolerability) in the execution of the expansion processes of Jorge Chávez International Airport), establishing a set of recommendations and mitigation measures.

To identify the potential risks in the different activities carried out at the airport, the objective is to start with a study of the airport in question. The specific objectives include analyzing any factor that may influence the different airport operations, such as the physical characteristics of the airport, human factors, the physical environment, traffic density, types of aircraft, etc., and especially during works on the airfield. A set of mitigation measures will be proposed with the aim of minimizing the likelihood and reducing the severity of the risks, concluding this procedure.

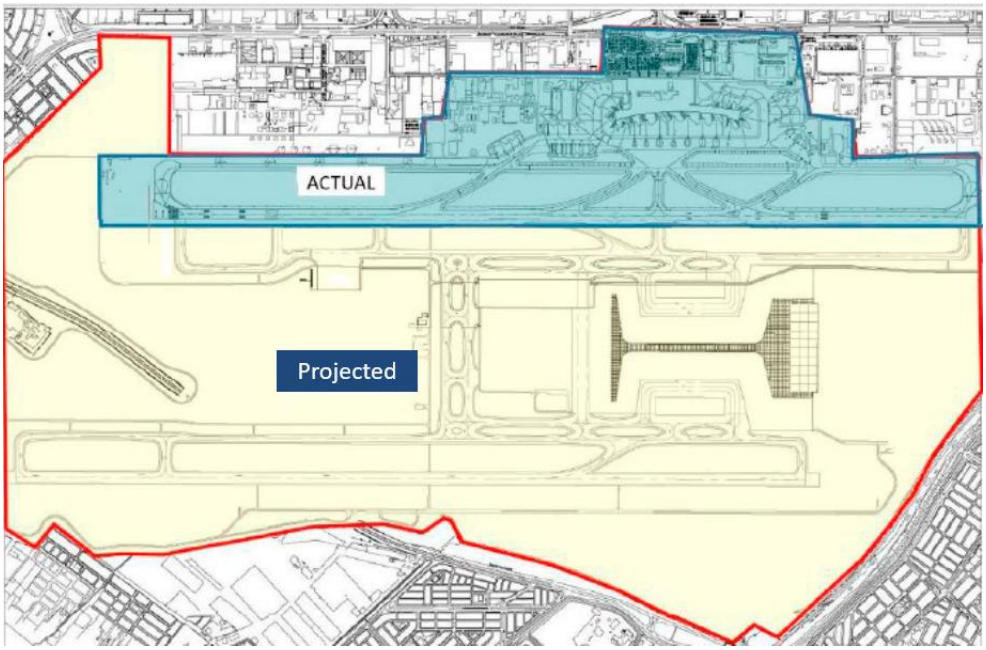


Fig. 1. Projected airport expansion area of the airport
Source: CORPAC, 2020

Risk Management System

The Risk Management System is a process of the Operational Safety Management System that aims to identify, analyze and eliminate or reduce to a tolerable or acceptable level, those hazards that lead to the Operational Safety of an aerodrome being compromised by the threat of such hazards (AESA, 2014; ICAO, 2016).

Consequently, the environment is examined to identify situations that could lead to an accident, followed by the hazards that could threaten operational safety as a result of the daily work at the airport and the associated risks. Once identified, their importance for operational safety is analyzed and, based on this, measures for their elimination or mitigation are proposed. Finally, those responsible for carrying out the mitigation measures are selected and, once implemented, their effectiveness is monitored. This system focuses on those activities, infrastructure and procedures related to operational safety which are carried out on the airside of the aerodrome. For this reason, the system aims to establish a methodology that includes, as far as possible, part of the following points (OACI, 2009; ICAO, 2016):

- Description of the system, i.e., a preliminary study of the scenario under assessment is carried out. Identification of existing hazards at the airport.
- Risk assessment.
- Risk assessment.
- Risk mitigation.
- Monitor existing hazards at the airport.

To carry out this risk assessment process, where risks are first identified and classified, personnel are equipped with a series of specific techniques and procedures to identify the risks associated with each hazard, and to determine the tolerability according to their probability of occurrence, as well as the severity of the consequences. In this work, a five-step process will be used and described that can be used to evaluate all those aspects that may influence the operational safety of the airport under study (ICAO, 2016):

- Detailed description of the scenario.
- Hazard identification.
- Probability and severity of identified risks.
- Assessment of identified risks.
- Mitigation of identified risks.

It should be noted that in most cases risks cannot be eliminated in their entirety, therefore, the objective becomes the reduction of such risks to a level where the probability of an unfavorable outcome is as low as possible. That is, to the extent that is practically and reasonably possible, ALARP (as Low as Reasonably Practical, a term originating in British occupational health and safety legislation. However, it is widely used in guidance material for aviation safety-related matters, where the severity of a risk is reduced as low as is reasonable in practice – ICAO, 2016). Therefore, it can be said that risk management is about taking action to control those risks that are deemed unacceptable while at the same time using resources to increase the quality of operational safety. A key component of risk management is risk ranking. Through ranking, risks can be scored based on their acceptability, thereby providing a benchmark or scale for comparison, regardless of the function, project, or area of the airport on which it is focused. Therefore, applying the same standards allows for comparisons, prioritization, and therefore more rigorous and effective management.

Another objective of the assessment is to determine the level of tolerability to have the risks identified and controlled through subsequent mitigation measures (ICAO, 2016):

- High risk category: operation is restricted or ceased if deemed appropriate, mitigation measures are implemented as a matter of urgency.
- Medium risk category: those located between the high and medium risk categories, the airport applies the ALARP methodology.
- Low risk category: no extra work for security officers, just management of the measures already in place.

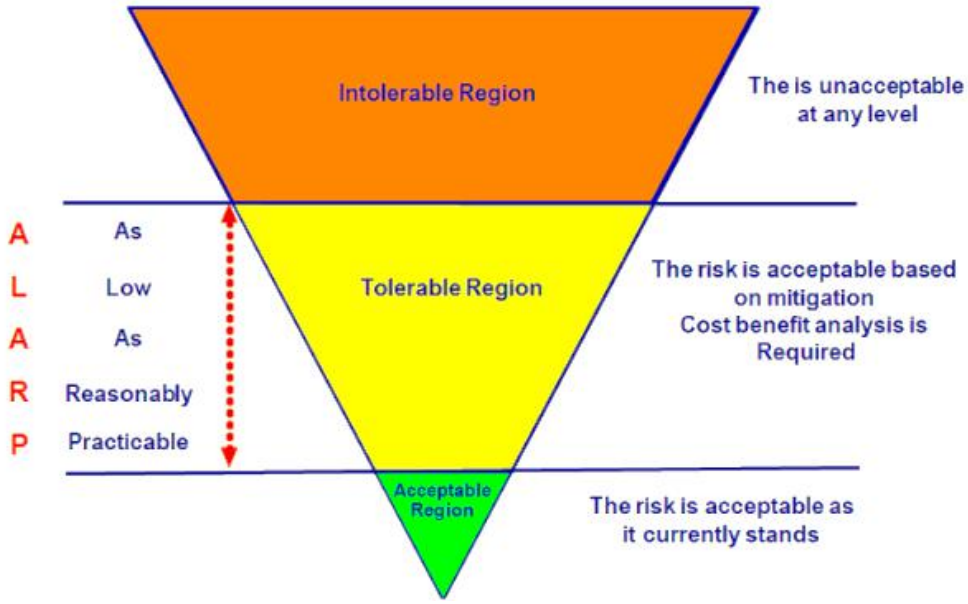


Fig. 2. Safety Risk Management
Source: ICAO, 2016

The likelihood of these risks is then indicated in terms of the proportion that these risks may contribute to the occurrence of an incident or accident. There are two main ways of assessing likelihood, either qualitatively or quantitatively.

At the qualitative level, when there is not a substantial amount of data on incidents or accidents and therefore it is not feasible to perform a quantitative assessment in a precise way. This situation is common as data are scarce in most cases and are not sufficient to perform a quantitative assessment, so previous experience must be applied by making a judgement on the likelihood of a hazard resulting in an accident or incident.

From a quantitative approach, numerical analyses tend to be carried out with a statistical adjustment of the data collected on accidents and incidents at the airport. Thus, depending on the number of times an accident is expected to occur, the authorities have established guidance material illustrating different categories (ICAO, 2016).

Table 1. Safety Risk Probability Table

Event probability		
Probability	Qualitative definition	Value
Frequent	Likely to occur many times (has occurred frequently)	5
Occasional	Likely to occur a few times (has occurred infrequently)	4
Remote	Unlikely to happen, but not impossible (it has rarely happened)	3
Improbable	Very unlikely to occur (not known to have occurred)	2
Extremely unlikely	Almost inconceivable that the event would occur	1

Source: Own elaboration based on ICAO, 2016

The next step in this risk assessment is the assessment of the consequences of undesirable events on the course of operations. Severity is considered as the second component of the risk, the one corresponding to the most unfavorable case will always be applied. These categories are purely qualitative, and the criteria used for their description are based on previous experience, as are the various databases containing statistics on accidents and incidents (ICAO, 2016).

Table 2. Safety Risk Severity Table

Gravity of the event	Meaning	Value
Catastrophic	- Destruction of equipment - Multiple deaths	A
Dangerous	- Significant reduction in safety margins, physical damage, or a workload such that operators cannot perform their tasks accurately and completely - Serious injuries - Major damage to equipment	B
Major	- Significant reduction of safety margins, reduction in the operator's ability to respond to adverse operational conditions as a result of increased workload, or as a result of conditions that impede their efficiency - Serious accident - Injuries to people	C
Minor	- Interference - Operational constraints - Use of emergency procedures - Minor incidents	D
Insignificant	- Little consequences	E

Source: Own elaboration based on ICAO, 2016

Once the severity and probability assessment has been carried out, the level of risk present is calculated by cross-referencing the information in tables 1 and 2 regarding probability and severity, obtaining table 3 for risk level. This level of risk identified can also be known as risk tolerability, proceeding to classify it according to whether it is a high, medium or low risk. The matrix shows three clearly differentiated zones, according to the type of risk, as indicated above, high, medium, or low, the probability of this event taking place and finally the severity associated with its consequences (ICAO, 2016).

Table 3. Safety Risk Assessment Matrix

Probability / Severity	Extremely improbable (1)	Improbable (2)	Remote (3)	Occasional (4)	Frequent (5)
Catastrophic (A)	1A	2A	3A	4A	5A
Hazardous (B)	1B	2B	3B	4B	5B
Major (C)	1C	2C	3C	4C	5C
Minor (D)	1D	2D	3D	4D	5D
Negligible (E)	1E	2E	3E	4E	5E

Source: Own elaboration based on ICAO, 2016

Database

Table 4. Database of previous accidents or incidents

Tamale (TML)	Oct-15	A BAe 146 received substantial damages in ending its landing in the works of a runway extension.
Krasnodar (KRR)	Aug-15	LD of a BAe 146 on a runway closed for rehabilitation. No injuries.
Oslo (OSL)	May-15	A 737 ended its landing on the paved surface of the RESA.
El Paso (ELP)	Apr-15	733 cleared to land on a closed runway. Workers evacuated when seeing the ACFT. No injuries.
Katowice (KTW)	Jul-14	LD of a CRJ on a RWY in construction. Closed by two white crosses on a black square. No injuries.
Abuja (ABV)	Dec-13	A 747 overran the RWY and collided with machines, trucks and a construction cabin. No injuries.
Prague (PRG)	Jul-12	Too long takeoff of an A319 based on full RWY lengths. Construction cleared by a short margin.
Vnukovo (VKO)	May-11	Landing overrun of a Yak 42.
Menorca (MAH)	Apr-11	LD on a runway closed by ICAO white crosses. Agents and a vehicle on the RWY. No injuries.
Mumbai (BOM)	Nov-09	Two interrupted approaches of an A320 over the initial THR before landing on the DTHR.
Mumbai (BOM)	Oct-09	Landing overrun of an ATR72 on a wet and shortened runway.

Chicago (ORD)	Sep-09	Too long takeoff of a 747 based on full RWY lengths. Construction cleared by a short margin.
Chicago (ORD)	Sep-09	Too long takeoff of a MD10 based on full RWY lengths. Construction cleared by a short margin.
Chicago (ORD)	May-09	Touchdown of a MD80 before the temporary DTHR and Go Around.
Chicago (ORD)	May-09	A CRJ ended its landing after the temporary end of the runway and stopped on the pavement.
Paris (CDG)	Aug-08	Too long takeoff of a 737 based on full RWY lengths. Blast fences cleared by a short margin.
Perth (PER)	May-08	Two interrupted approaches of a B737 over the initial THR before landing on the DTHR.
Auckland (ACK)	Mar-07	Too long takeoff of a 777 based on full RWY lengths. Work vehicles cleared by 28 m (92 ft).
Yerevan (EVN)	May-05	Landing short of an A300-600 before the temporary DTHR.
Paris (CDG)	Jul-05	3 ACFT cleared to T/O only by the TWY providing the longest TORA, entered by intermediary TWY.
Perth (PER)	Apr-05	Landing short of an A340-200 before the temporary DTHR.
Auckland (AKL)	Nov-04	Landing short of a B777 before the displaced threshold on a construction area.
Manchester (MAN)	Jul-03	Too long takeoff of a 737 based on full RWY lengths. 14 ft-high machine cleared by 17 m (56 ft).
Manchester (MAN)	Jul-03	Too long takeoff of a 737 based on full RWY lengths. 14 ft-high machine cleared by 17 m (56 ft).
Taipei (TPE)	Oct-00	Takeoff of a 747 from the wrong closely-spaced and parallel runway. Crash into the construction.

Source: Own elaboration based on: the Aviation Herald, 2022; SKYbrary Aviation Safety, 2022; Bris, 2015

Table 5. Database statistics

Description	Number
Landing short before the temporary DTHR	6
Landing below the approach path to the DTHR	1
Takeoff long toward the constructions	7
Runway excursion toward the construction site	3
Runway excursion back to the construction site	3
Take-off / Landing on a closed runway	5

Source: Own elaboration

Results of the Hazard Identification and Risk Assessment

Risks to air operations arise when airport operating patterns are modified or interrupted due to work being carried out at the airport. As a result, both pilots and airport personnel are forced to perform their work in an unusual environment.

In the following Table.5., will be identified the type of operation, the generic hazards, specific causes, consequences related to the hazard, probability associated as well as severity and finally the assigned tolerability. Available information from the Jorge Chávez International Airport was taken into consideration (LAP, 2014; LAP 2018 a; LAP, 2018 b; LAP 2021).

Table 5. Hazard identification and risk assessment

Generic Hazard	Specific component (causes)	Consequences related with the hazard(risk)	Probability	Severity	Tolerability
Landing/ aircraft takeoff on closed runway	- The crew does not have aeronautical information on the closed runway. - The pilots confuse two ways. - Pilots mistake ATC clearance. - Runway closure markings are missing or not clearly visible.	Collision with the construction site and/or with heavy vehicles that causes the accident of the aircraft.	Rare	Hazardous	1A
		Collision or explosion of a jet on the workers with the consequent serious or catastrophic injuries that it may cause to the employees.	Rare	Catastrophic	1A
Taxiing operations while construction work is being carried out at the airport	- Reopening of airfield areas without adequate conditions for traffic. - Deficient vertical and horizontal signaling. - Incorrect aircraft guidance. - Vehicle incursion. - Poor stockpiling of work materials.	Aircraft collision with obstacle on the ground.	Improbable	Hazardous	2B
		Aircraft collision with passing vehicle.	Improbable	Major	2C
		Damage to airport facilities.	Improbable	Minor	2D
		Damage to vehicles and ground handling equipment.	Improbable	Major	2C
		Aircraft collision due to taxiway departure.	Improbable	Major	2C
		Aircraft hydroplaning / sliding.	Negligible	Major	1C
Aircraft excursion in construction work zone	- Deficient horizontal and vertical signaling on the airfield. - Incorrect aircraft guidance. - Aeronautical information is not clear and simple. - External factors. - Reopening of areas of the airfield without suitable conditions for traffic.	Aircraft collision with obstacle on the ground.	Improbable	Hazardous	2B
		Aircraft collision with passing vehicle.	Improbable	Major	2C
		Injuries to persons by FOD (Foreign Object Damange) impact due to motor jet.	Improbable	Hazardous	2B
Obstacles in construction sites	- Materials improperly stockpiled and in violation of permitted height limits. - Reopening of areas of the airfield without	Aircraft collision due to taxiway or runway departure.	Negligible	Major	1C
		Injuries to persons by FOD (Foreign Object Damange) impact due to motor jet.	Improbable	Hazardous	2B

	suitable conditions for traffic.				
Deficiencies in the accesses to the site	- Deficient horizontal and vertical signage on the airfield. - Deficient communication protocol between site personnel and the airport manager. - Confusing signaling of accesses to the construction site.	Vehicle incident.	Remote	Major	3C
		Incident with aircraft on the ground.	Improbable	Major	2C
		Collision of vehicle with aircraft.	Negligible	Major	1C
		Vehicle collision with stationary object.	Remote	Minor	3D
		Vehicle collision with airport facilities.	Improbable	Major	2C
		Physical injuries to workers at the construction site.	Occasional	Minor	4D
		Inadvertent access of unauthorized vehicles on the construction site.	Occasional	Minor	4D
Incursion into areas open to aircraft traffic	- Inadequate passage of vehicles through areas open to air traffic. - Deficient horizontal and vertical signaling. - Deficient communication protocol between site personnel and the airport manager. - Lack of knowledge or incorrect information of the contractor's personnel regarding Operational Safety.	Incident with aircraft on the ground.	Negligible	Major	1C
		Vehicle incident.	Improbable	Major	2C
		Aircraft-vehicle collision.	Negligible	Hazardous	1B
		Unnoticed access of unauthorized vehicles in the movement area.	Improbable	Hazardous	2B
		Damage to vehicles and ground handling equipment.	Improbable	Major	2C
Generation of dust and/or FODs	- Dust from the construction area can be carried by the wind to the airfield. - Lack of knowledge or incorrect information of the contractor's personnel regarding Operational Safety. - Incorrect stockpiling of materials and construction machinery.	Aircraft incident on the ground.	Negligible	Major	1C
		Damage to vehicles or injury to persons due to impact of FOD absorbed/projected by engine jet.	Improbable	Hazardous	2B
		Damage to vehicles or injury to persons due to impact from wind driven FOD.	Improbable	Hazardous	2B
		Damage to aircraft due to impact of FOD projected by engine jets.	Negligible	Hazardous	1B
		Damage to aircraft due to absorption of objects by the engines.	Negligible	Major	1C

Glare to pilots or operators caused by work or machinery lighting sources	- Incorrect control of the lighting elements used on site. - Poor lighting or low visibility in operational areas. - Loss of situational awareness or even disorientation on the part of the crew and/or operators.	Aircraft incident on the ground (taxiway).	Improbable	Major	2C
		Aircraft collision with obstacle on the ground.	Improbable	Major	2C
		Aircraft collision with obstacle in flight.	Negligible	Catastrophic	1A
Violation of obstacle limitation surfaces.	- Incorrect marking of elements that violate maximum heights. - Poor stockpiling of materials and construction machinery. - Lack of knowledge or incorrect information of the contractor's personnel regarding Operational Safety.	In-flight aircraft incident.	Negligible	Catastrophic	1A
		Aircraft collision with obstacle in flight.	Negligible	Catastrophic	1A
Fuel leakage and/or different types of potentially flammable liquids on the airfield.	- Vehicle accident transporting flammable material. - Hose or pipe rupture causing leakage. - Lack of knowledge or incorrect information of the contractor's personnel regarding Operational Safety.	Fire	Remote	Major	3C
		Aircraft damage due to hydroplaning/sliding.	Negligible	Hazardous	1B

Source: Own elaboration

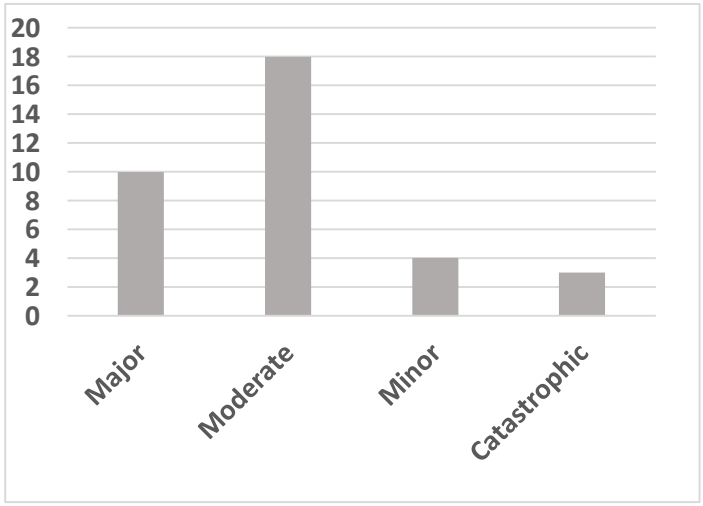


Fig. 3. Severity of the identified hazards
Source: own elaboration

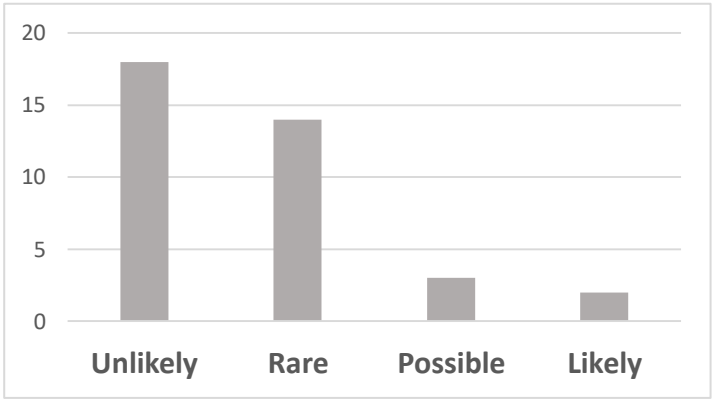


Fig. 4. Likelihood of the identified hazards
Source: own elaboration

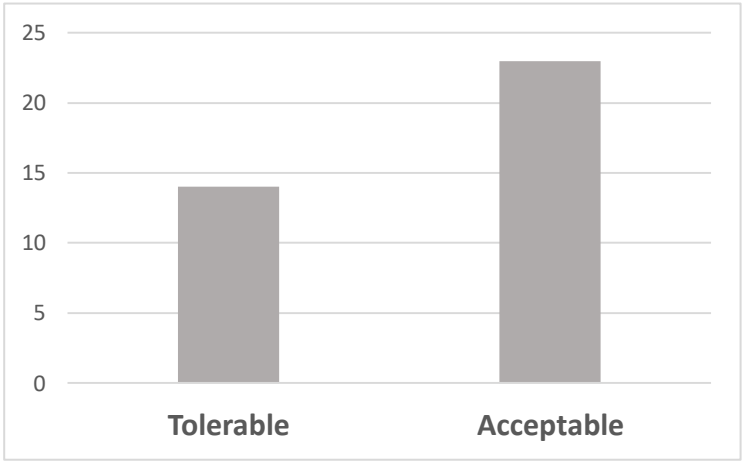


Fig. 5. Tolerability of risks
Source: own elaboration

After completing the corresponding risk identification tables, different readings have been obtained. Regarding the qualitative assessment of risks related to the expansion of Jorge Chavez International Airport, it is concluded that ten generic hazards were identified, resulting in a total of 37 potential risks of the construction works to air operations.

It can be seen that this is a high-risk quantity, although more than half of them have a severity ranging from "major" or "hazardous", the probability of occurrence is low, as more than half of them are rated "Improbable" to "Negligible". This results in a major "acceptable" tolerance for the identified risks. However, 40% of the risk is tolerable, demonstrating the need for constant effort to identify and propose mitigations, and then apply them, as described in the next section of this article.

Discussion of recommendations and mitigation measures

The review of construction-related safety events reveals a set of frequently recurring causal factors that should be considered with special focus during construction work at Jorge Chavez International Airport, such as: the Automatic Terminal Information Service (ATIS), the "notice to airman" (NOTAM), characteristics of visual signals, air traffic controllers' phraseology, airport diagrams and graphics, signage indicating runway closures or modified operational procedures. (FAA, 2006).

The ATIS broadcast at large airports usually contains a significant amount of information in addition to airport construction data. Construction NOTAMs are sometimes mixed with other operational information and may not be heard by the crew. In other cases, the ATIS does not include declared distances and other critical construction-related information, especially when the TORA (Take-off Run Available) is modified. For this reason, the airport's aeronautical information office must emphasize the clear, concise, and complete transmission of relevant information on the construction work carried out that may affect the operational safety of aircraft. (Ratto, 2016).

Large airports, such as Jorge Chavez, in general tend to have a significant number of NOTAMs, and this number is especially increased during construction works. This can lead to information being unnoticed by the people who really need it: pilots, dispatchers, and air traffic controllers. In addition, the information contained in NOTAMs sometimes slips out of the memory in critical phases: during takeoff or landing phases, when workload and risk tend to reach a peak. In addition, the format of NOTAMs (capital letters and rarely used abbreviations) is often difficult to interpret and subject to misunderstanding.

Driver phraseology can sometimes lead to ambiguity or misleading conclusions about the actual condition and specifications of the surfaces affected by the construction, as well as the content of the signage and how it is written. Airport signage, taxiway markings and runway markings for airports are runways, and other visual cues can help or hinder flight crews when trying to dis88tinguish enclosed from active surfaces, as was well noted in the section on accident and incident compilation. The lack of visual

cues or deficiency of visual cues has contributed to aircraft operating on closed surfaces and to runway excursions impacting machinery, landing before the displaced threshold, narrowly missing obstacles at the end of the runway heading, etc. (ANAC, 2019).

Over the years it has become evident that the publications of airport diagrams generally tend to lag the terms of the works and are sometimes not updated as frequently as desired while the works progress. Increasing the workload of the crews and affected parties who must constantly compare these diagrams and the content of the NOTAMs to obtain an overview of the status of the work. In some cases, an airport may publish a certain configuration before the construction is completed, so that the diagram does not correspond to the actual configuration at the date of publication, compromising safety. For this reason, when airfield diagrams are published, some operators assume that the latest surface configurations are represented, however it is possible that these may be omitted due to the temporary nature of the work. (Bris, 2015).

The development and distribution of NOTAM charts to present critical NOTAM information in an intuitive and user-friendly format. These graphics are based on the information system. The active promotion of the development and implementation of checklists to ensure consistently safe construction projects through process documentation. Improvements to airport signage and lighting to increase pilot and operator situational awareness of the impacts of airport construction on aircraft operations. Both signage and lighting can be considered as one of the first safety "nets".

As previously stated, at Jorge Chavez International Airport, once the second runway is completed, a maintenance process of the first runway, currently in operation, will be carried out, at first it is planned to close this runway entirety for the corresponding work, being from an operational safety point of view one of the most conservative measures. However, if such planning is altered and for different reasons to be assessed by the airport operator, LAP, it is deemed convenient to carry out the maintenance work in a staggered manner, a series of recommendations are presented below:

If a threshold displacement is intended, the markings on the runway should be precisely erased or hidden, avoiding any trace. The eventually closed section should be clearly marked as unusable. Signage and lighting are considered the first safety net; therefore, simplicity and clarity must prevail.

In the most plausible case, which is to close the runway in its entirety, it is worth noting that in a document presented by Gaël Le Bris, Director of airside development at Charles de Gaulle Airport (Bris, 2014), where safety in the construction of runways and taxiways was analyzed, it was found that in runways closed 24H:

- Crossings are not always in place when the runway is closed;
- The crossings are not always on the runway (69%);
- They do not always comply with the regulations (incorrect size, dissymmetry, etc.), (69% non-compliance with Annex. 14 and 31% with Part. 139 (FAA)).

Nowadays, mobile crosses are an excellent alternative, due to the cost reduction and flexibility with respect to painting. There are different options, from fabrics of different colors and backgrounds to create greater contrast, to a wooden frame covered by

a white fabric and with wheels at the bottom for easy transport, which can be removed and repositioned very easily.

As for the color of the signs, different studies have been conducted and several airports in the United States and other countries have tested different alternatives. The feedback from pilots and operators is that orange background with black lettering, where there is a short but clear message is the best type of sign. It is therefore an economical, simple, and efficient mitigation measure to prevent miscalculated takeoffs with respect to TORA, for example.

Fig. 6. Yellow cross over the runway
Source: Bassey, 2015

Fig. 7. Signal with orange background and black letters
Source: Bris, 2014

Aeronautical information is a major concern during construction work. Best practices include:

- Transmitting clear information on ATIS,
- Sending emails to information providers (LIDO, Jeppesen, among others),
- Reporting directly and by email to airlines and pilot representatives.

Information before and during this process of continuous airport change is a real challenge, where the information in Annex 15 is useful but perhaps not sufficient.

To avoid take-offs from closed runways it is considered essential to block all possible access to the runway, and to avoid using sections of the runway for new taxiing procedures. If there is no other alternative, the trajectories through the closed runway should be protected by a continuous line of red and white concrete blocks and red edge lights. Thus, following the ALARP methodology, it could be reasoned that it is less severe for an aircraft to hit a concrete block at taxi speed than a construction machine at takeoff speed.

The following is an illustration of what is mentioned in the previous paragraph, where it is suggested to close all possible accesses to the runway out of operation.

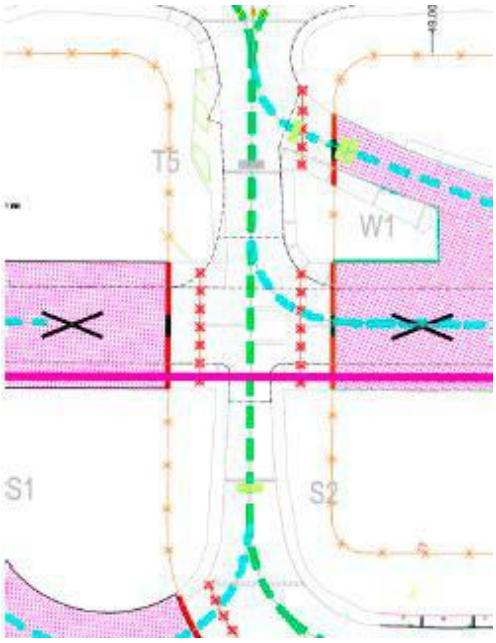


Fig. 8. Closure of access to inoperative runway due to construction work
Source: Bris, 2014

Most of the measures presented in this section are useful for the works at Jorge Chavez International Airport, where, although most of the construction works are being carried out in the west, and do not directly affect the current runway in operation, in Phase 1 of the work there will be a part where operations will be affected and takeoffs and landings must cease, and in Phase 2 it is also planned to maintain runway 16–34, which will be renamed 16L–34R.

In this Phase 2, the impact will be greater as it involves the closure of the runway, resulting in all operations being carried out on the new runway. Passenger boarding and disembarkation operations will be carried out from the current apron as well as from the forward apron.

Conclusions

The identification of hazards and risk management applied to the airport was supported by the thorough compilation of accidents and incidents that occurred over an extensive period, where construction work on the runway or its surroundings were determining factors in increasing both the severity and probability. In this way, the risk identification table focused on the airport expansion process, obtaining ten generic hazards which result in a total of thirty-seven potential risks.

As mentioned above, although this is a high number of risks and more than half of them have severities ranging from "important/major" or "hazardous", it should be considered that the probability of occurrence is quite low because more than 50% are subject to a rating of "improbable" to "negligible", prevailing an "acceptable" tolerability of the risks identified. However, 40% of the risks are tolerable, which is why it is vitally important to reinforce the process of identification, risk management and definition of mitigation measures, as well as their subsequent application.

The recommendations and mitigation measures presented in the paper cover a wide selection of alternatives to ensure operational safety throughout the works, especially during Phase 1 and 2 of the project when the current runway will be connected through taxiways L3 and L5, as well as the closure of runway 16–34 for maintenance.

It is worth mentioning that this safety analysis has its limitations. Data was extracted only from two sources over a period of 15 years, so the sample may not reflect most of the incidents or accidents occurred; future studies can include a larger database from different sources and time periods. Looking ahead, into areas worthy of further research would be the ones related to human factors and communication in an airport environment undergoing construction works.

References

AESA (2014). Guía Técnica para el Desarrollo del Sistema de Gestión de Seguridad Operacional en Aeródromos Verificados. *(Technical Guide for the Development of the Operational Safety Management System at Verified Aerodromes).* Madrid.

ANAC (2019). Manual de Obras y Servicios de Mantenimiento. *(Works and Maintenance Services Manual).* Buenos Aires.

Bassey R. (2015). Development and Evaluation of Safety Orange Airport Construction Signage. FAA. Washington.

Bris G.L. (2014). Keeping aircraft operations safe during construction works. Washington.

Bris G.L. (2015). Safety of the Runway Operations during Construction Works. Washington.

CORPAC (2020). AIC 07/20 Proyecto de Ampliación del AIJC (NEW-LIM). (AIC 07/20 AIJC Expansion Project (NEW-LIM)) Lima.

FAA (2016). Tips for Operational Safety on Airports During Construction. Washington.

LAP (2014). Manual de Aeródromo *(Aerodrome's Manual).* Lima.

LAP (2018 a). Anexo 1, Plan de Emergencia del Aeropuerto Internacional Jorge Chávez *(Annex 1, Emergency Plan for Jorge Chávez International Airport).* Lima.

LAP (2018 b). Manual de uso de plataforma del Aeropuerto Internacional Jorge Chávez *(Jorge Chávez International Airport Apron User's Manual).* Lima.

LAP (2021). Plan de Negocios *(Business Plan).* Lima.

OACI (2009). Operational safety management manual. Montreal.

OACI (2016). Annex 14, Aerodromes. Montreal.

OACI (2016). Annex 19, Operational safety management manual. Montreal.

Ratto F. (2016). Seguridad Operacional de Obras en Aeropuertos Operativos *(Operational Safety of Works at Operational Airports).* Ciudad de Panama.

Skybrary.aero. (2010). Skybrary.aero. https://skybrary.aero/articles/runwaytaxiway-construction-risks [access: 01.06.2022].

The Aviation Herald (2022). https://avherald.com/ [access: 01.06.2022].

Tirado M.J. (2019). Diseño básico funcional y constructivo de una plataforma de estacionamiento de aeronaves. Aeropuerto Internacional Jorge Chávez *(Basic functional and constructive design of an aircraft parking apron. Jorge Chávez International Airport).* Madrid.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.23

Agnieszka Besiekierska[1], Kamil Czaplicki[2]

CYBERSECURITY OF SPATIAL INFORMATION

Abstract: Services related to the broadly understood spatial information are subject to constant and intensive digitization. In addition to many positive sides, such as broad access to services, digitization also brings negative phenomena such as cyber attacks, which have intensified in recent years. Responsibilities in the area of cybersecurity are subject to legal provisions, including the act on the national cybersecurity system. Unfortunately, these obligations are still not sufficiently fulfilled, which is reflected in the results of the Supreme Audit Office (NIK). Advice on safety measures can be found in the letter of the Surveyor General of Poland dated 24 February 2022. The measures indicated in the letter should be considered insufficient.

Keywords: spatial information, cybersecurity, Surveyor General, GIS

Received: 31 October 2022; accepted: 12 November 2022

[1] Cardinal Stefan Wyszyński University, Faculty of Law and Administration, Warsaw, Poland, ORCID ID: https://orcid.org/0000-0002-1223-1442, email: a.besiekierska@uksw.edu.pl
[2] Cardinal Stefan Wyszyński University, Faculty of Law and Administration, Warsaw, Poland, ORCID ID: https://orcid.org/0000-0002-3777-4339, email: k.czaplicki@uksw.edu.pl

Introduction

Entities dealing with broadly understood spatial information, including in particular public administration bodies such as surveying offices, are subject to constant and dynamic digitization. One of the most popular terms in recent years, if not decades, is the word transformation – initially referring to political, economic or systemic transformation. Currently, the term is more and more often associated with digital transformation. This term can be understood as the use of technology to transform analog into digital processes. It is an integration of digital technology in all areas of operation. It influences the change of existing behaviors and processes through the increased use of information technologies (Szpor et al., 2021).

From transformation digital one should distinguish between the concepts of computerization and digitization. In the case of computerization, the emphasis was mainly on the increased use of computers as tools supporting human work. Digitization emphasized the transfer of processes to the virtual world, the creation of new digital services and efforts to create a new communication tool. The digital transformation emphasizes the increased use of supporting technologies, such as Big Data, the Internet of Things, artificial intelligence or data analytics. Digital transformation is often equated with business – the term economy 4.0 as the embodiment of digital transformation in industry is becoming more and more popular. This approach is not entirely correct. Digital transformation goes beyond the sphere of business, it affects every area of social activity, including public administration (Kaczyńska et al., 2021). Entities dealing with spatial information are among the most computerized entities. Spatial information is based, among others, on the analysis of huge amounts of data and the use of information technologies supporting their analysis.

This article introduces the importance of cybersecurity in the field of spatial information, presents the legal requirements and threats related to the provision of spatial information access services, as well as assesses the effectiveness of their implementation, pointing to areas for improvement.

Relevant terms: spatial data services, cybersecurity and cyberthreats

The principles of creating and using the infrastructure for spatial information are specified in the Act of March 4, 2010 on the infrastructure for spatial information. The Act defines two key terms in this area: spatial data and spatial data services (art. 3 points 1 and 10). Spatial data means data relating directly or indirectly to a specific location or geographical area. The concept of spatial data services is related to spatial data, understood as services that are operations that can be performed with the use of computer software on data contained in spatial data sets or on related metadata.

The Act does not use the term "geographic information system" (GIS), which is commonly used in practice and is defined in the literature as "a system for acquiring, processing and sharing data containing spatial information and accompanying descriptive information about objects distinguished in the part of the space covered by the system's operation" (Ładysz, 2015). Pursuant to the Act, administrative bodies keep

public registers that contain collections related to spatial data, create and maintain, within the scope of their competence, a network of services related to spatial data sets and services. spatial data sets and services include searching for spatial data sets and services, viewing sets, downloading, copies of sets or parts thereof, and transforming sets in order to achieve the interoperability of spatial data sets and services (Article 9 (1)). The most important portal enabling access to spatial data services is the Geoportal, which is created and maintained by the Surveyor General of Poland. In Poland, the construction of GIS systems is dominated by administrative units – provinces and cities, for which it is one of the most important elements in the development and functioning of the local community, being at the same time a rich source of information for potential investors and tourists. Administrative bodies report sets and spatial data services to the Surveyor General of Poland.

"Cybersecurity" means actions necessary to protect networks and information systems, users of such systems and other persons against cyber threats"(Article 2 point 1 of the Regulation (EU) 2019/881 – Cybersecurity Act). In the Act of July 5, 2018. on the national cybersecurity system "cybersecurity" is defined as the resistance of information systems to activities violating the confidentiality, integrity, availability and authenticity of the processed data or related services offered by these systems.

Unfortunately, technological development, including digital transformation, is not free from threats. Cyberattacks are becoming more common and then more and more dangerous - that is, attacks made by digital means through cyberspace with the intention of causing damage, blocking access, destroying or taking over data (Szpor et al., 2021). The Cybersecurity Act, in Art. 2 point 8, defines a cyber threat as any potential circumstances, events or activities that may cause harm, disrupt or otherwise adversely affect network and information systems, users of such systems and other persons.

Legal obligations related to the cybersecurity

The role of entities dealing with spatial information is to ensure the security and integrity of data. The first legal act that imposed obligations in this area of data security, obliging them to ensure confidentiality, integrity, availability and resilience of IT systems, was the Regulation on the Protection of Personal Data. GDPR obliges both data controllers as well as data processors to ensure a level of security of data processing, taking into account the state of the art, the costs of implementation and the nature, scope, context and purposes of processing as well as the risk of varying likelihood and severity for the rights and freedoms of natural persons. The proper level of security must be ensured through implementation of adequate technical, organizational and procedural measures (Art. 32 of the GDPR) (Czaplicki, 2018).

In accordance with the Act on the national cybersecurity system, public entities that have IT systems containing spatial information have obligations related to ensuring cybersecurity, such as appointing a person responsible for maintaining contact with the entities of the national cybersecurity system (Art. 21), managing incidents in a public

entity (Article 22 (1) point 1), reporting incidents (Article 22 (1) point 2) and publishing information about cybersecurity on the website (Article 22 (1) point 4).

The Act on the national cybersecurity system is not the only legal act that imposes cybersecurity obligations on public entities (Besiekierska, 2019). Further obligations result from the Act on computerization of the activities of entities performing public tasks and more precisely from § 20 of Regulation of the Council of Ministers on the National Interoperability Framework,, issued on the basis of that Act. The Regulation requires the entity performing public tasks to maintain an information security management system. This system should include, inter alia, internal regulations, inventorying equipment, ensuring an appropriate level of security in the ICT system, minimizing the risk of information loss as a result of a failure, periodic risk analyzes, trainings, annual audits. The Regulation does not answer the question on how to perform individual obligations. A certain hint is provided in § 20.3, according to which the cybersecurity requirements resulting from the Regulation are deemed to be met if the information security management system has been developed on the basis of the Polish Standard PN-ISO / IEC 27001, and establishing security, risk management and auditing are carried out on the basis of Polish Standards related to this standard, including PN-ISO / IEC 27002, PN-ISO / IEC 27005 and PN-ISO / IEC 24762.

Materials and methods

The following materials were used in the study:

- Informacja o wynikach kontroli NIK, Realizacja usług publicznych dla obywateli z wykorzystaniem platformy ePUAP (2021) (*Information on the results of the NIK audit, Implementation of public services for citizens using the ePUAP platform*), source: https://www.nik.gov.pl/kontrole/P/20/004/.
- Informacja o wynikach kontroli NIK, Zarządzanie bezpieczeństwem informacji w jednostkach samorządu terytorialnego (2019) (*Information on the results of the NIK audit, Information security management in local government units*), source: https://www.nik.gov.pl/kontrole/P/18/006/.
- Informacja o wynikach kontroli NIK, Bezpieczeństwo informacji w pracy na odległość i mobilnym przetwarzaniu danych (2022) (*Information on the results of the NIK audit, Information security at remote work and mobile data processing*), source: https://www.nik.gov.pl/kontrole/P/21/081/LOL/.

The research was based on the following methods: literature review, analysis of the materials above, quantitative research and internal surveys.

The article uses quantitative research on training in cybersecurity carried out as part of the Project Model regulacji jawności i jej ograniczeń w demokratycznym państwie prawnym (*Regulatory Model of Disclosure and its Limitations in a Democratic State of Law*), as well as internal surveys conducted during training courses organized by the Cardinal Stefan Wyszyński University in Warsaw and partners supporting the university, including Naukowe Centrum Prawno-Informatyczne (*the Scientific Center Legal and IT*).

Results and discussion

Despite the binding legal obligations to ensure the security and integrity of data, many entities still do not comply with basic security principles and are exposed to cyberattacks. This is indicated by the information published in recent years on the audit results of the Supreme Audit Office (Polish "NIK"). NIK assessed negatively the performance of tasks related to ensuring the security of the processed information, indicating that the offices lacked a systemic approach to ensuring information security. The offices did not have information about their IT resources, did not perform risk assessments, did not carry out an annual audit, and the system access policy was affected by irregularities. In 48% of offices, irregularities were found, consisting in failure to make backups, improper storage of backups and failure to check the correctness of the copies made (Information security management in local government units, 2019). Similarly, in the information on the results of the inspection carried out in 2020, it was indicated that most of the inspected units did not ensure proper organization of information security, which may pose a threat to the security of data processing and ensuring the continuity of the office's work. In particular, 57% of the controlled units lacked an Information Security Management System, and 39% of offices lacked complete and up-to-date information about their IT resources for data processing. In 57% of them, mandatory information security audits were not carried out (Implementation of public services for citizens using the ePUAP platform, 2021).

There is no information available in the media as to whether and to what extent the attacks concerned spatial data services. There is a known attack on the IT systems of the Aleksandrów Municipal Office in the spring of 2021, as a result of which databases were encrypted, which were also used by the Commune Social Welfare Center. It was the week before Easter, when some of the inhabitants of the commune were waiting impatiently for the payment of their benefits (Laurisz, 2022). The cyber criminals demanded a ransom. Other municipalities that have been attacked by cybercriminals are the Kościerzyna Municipal Office, Tuczna Municipal Office, Małopolska Marshal's Office, Poviat Starosty in Oświęcim, Kościerzyna Municipal Office (Municipalities targeted by criminals, 2022).

A consequence of the increasing scale of threats was a letter sent by the Surveyor General of Poland to starosts and mayors of cities regarding cybersecurity of data and related services (Letter of the Surveyor General of Poland dated 24.02.2022). In this letter, the Surveyor General drew attention to the statutory obligations to secure data and the consequences that may result from inadequate protection of spatial data. The letter pays particular attention to the necessity to make electronic backup copies of the geodetic resource. According to the Regulation of the Minister of Development, Labor and Technology on the organization and procedure of the state geodetic and cartographic resource, it is necessary to back up the resource at least once a quarter. In the current situation, it has been suggested to increase the frequency of backups and make them on a weekly basis. The suggestion of the Surveyor General should be assessed moderately positively. It seems that making a 3-month backup (once a quarter)

was dictated only by staff shortages and relieving offices from employing additional specialized IT specialists. The resource of spatial data is crucial for administration, citizens and business. Performing a backup once a quarter means that in the event of a failure or cyberattack, we may lose data from the previous backup (in the worst case it will take up to 3 months). In the case of processing such sensitive data, the scope of lost data seems to be enormous. Recommendation of the Surveyor General shortening this period to 7 days, although positive, does not solve the problem for several reasons. First, the loss of 7-day data is also enormous and difficult to make up for in a short period of time. Second, it's not just the backup itself that counts, but making an effective backup. For the case, it is worth giving the example of the office in Krakow, where despite the backups, in the event of a failure, it turned out that they were not performed correctly and ultimately were not usable (One month after the cyberattack, the IT system in the Małopolska Marshal's Office is still not operational, 2021). Third, backing up is defensive. It is a possible response to an attack or failure, but not an attack defense tool in itself. Not every attack is related to e.g. data deletion. A large proportion of attacks focus on data theft. Therefore, it seems that the Surveyor General, in cooperation with CERT ABW or CERT NASK, should promote methods of offensive resource protection.

Further, the security of the processed data is not only the responsibility of IT departments (or more often one person acting as an IT specialist), but each employed employee. Cybersecurity training must be common and cyclical. Training seems to be a key element of security, however, because usually human is the weakest element of security and effective attacks are often a consequence of human error. Unfortunately, the practice based on own research conducted during the training shows that most of the employees are not trained, and those who attended the training in cybersecurity very often did not understand much of it. This is also confirmed by the results of the NIK audit, where it was indicated that in the audited units the training took place by providing training materials for self-familiarization (Information security at remote work and mobile data processing, 2022). However, this form of knowledge transfer also turned out to be insufficient in the event of a breach of personal data protection. The Polish supervisory authority, the Office for Personal Data Protection, decided that the mere provision of information by the Court as the administrator of personal data about the need to encrypt portable drives, without implementing this security measure, does not satisfy the obligations resulting from the Regulation on the Protection of Personal Data (Decision of UODO of 13 July 2021)

Conclusion

Subsequent audits of the Supreme Audit Office, as well as the authors' own observations, indicate that organizational and technical measures implemented by public entities to protect broadly understood spatial information are insufficient, which means that they are kept at a minimum level (e.g. backup at least once for seven days) or they are not present at all (the lack of information security management systems in some local government units indicated during the audit). In light of the increasing

number of cyberattacks, issues related to cybersecurity should be treated as a priority by all stakeholders.

References

Act of 5 July 2018 on national cybersecurity system Dz. U. (*Journal of Laws*) of 2018, item 1560.

Act of 4 March 2010 on spatial information infrastructure. Dz. U. (*Journal of Laws*) of 2021, item 214.

Act of 17 February 2005 on computerization of the activities of entities performing public tasks Dz.U. (Journal of Laws) of Dz. U. of 2017, item 570, with changes.

Besiekierska A. (2019). Ustawa o krajowym systemie cyberbezpieczeństwa. Komentarz (Act on cybersecurity system. Commentary). C.H. Beck, Warsaw.

Czaplicki K. (2018). Security of geographical information systems – how to ensure their confidentiality, integrity, availability and resilience. 25th Anniversary Conference, Geographic Information Systems Conference and Exhibition GIS Odyssey 2018.

Decision of UODO of 13 July 2021, https://uodo.gov.pl/pl/138/2130 [access: 28.10.2022].

Gminy na celowniku przestępców (*Municipalities targeted by criminals*), https://wartowiedziec.pl/serwis-glowny/aktualnosci/62785-gminy-na-celowniku-cyberprzestepcow [access: 28.10.2022].

Gryszczyńska A., Szpor G. (2020). Internet, Cyberpandemia. Cyberpandemic. C.H. Beck, Warsaw.

Informacja o wynikach kontroli NIK, Realizacja usług publicznych dla obywateli z wykorzystaniem platformy ePUAP (2021) (*Information on the results of the NIK audit, Implementation of public services for citizens using the ePUAP platform*), https://www.nik.gov.pl/kontrole/P/20/004/ [access: 28.10.2022].

Informacja o wynikach kontroli NIK, Zarządzanie bezpieczeństwem informacji w jednostkach samorządu terytorialnego (2019) (*Information on the results of the NIK audit, Information security management in local government units*), https://www.nik.gov.pl/kontrole/P/18/006/ [access: 28.10.2022].

Informacja o wynikach kontroli NIK, Bezpieczeństwo informacji w pracy na odległość i mobilnym przetwarzaniu danych (2022) (*Information on the results of the NIK audit, Information security at remote work and mobile data processing*), https://www.nik.gov.pl/kontrole/P/21/081/LOL/ [access: 28.10.2022].

Kaczyńska A., Kanduła S., Przybylska J. (2021). Transformacja cyfrowa z punktu widzenia samorządu terytorialnego – wybrane zagadnienia (*Digital transformation from the point of view of local government – selected issues*). Nierówności Społeczne a Wzrost Gospodarczy, 65 (1/2021).

Laurisz M., Gmina która padła ofiarą cyber-ataku dzieli się doświadczeniami i radzi innym samorządowcom, jak i gdzie szukać pomocy (*A municipality that has fallen victim to a cyber-attack shares its experience and advises other local government officials on how and where to seek help*) 5.01.2022, https://itreseller.com.pl/gmina-

ktora-padla-ofiara-cyber-ataku-dzieli-sie-doswiadczeniami-i-radzi-innym-samorzadowcom-jak-i-gdzie-szukac-pomocy/ [access: 28.10.2022].

Letter of Surveyor General of Poland dated 24.02.2022, https://www.geoportal.gov.pl/documents/10179/1113443/zabezpieczenie+danych+w+powiatach.pdf/28071ba3-9af4-4956-99a4-3d089243299a [access: 28.10.2022].

Ladysz J. (2015). Technologia GIS w inżynierii bezpieczeństwa (*GIS technology in security engineering*). Wrocław.

Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), Official Journal of the European Union L 119/1.

Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act), Official Journal of the European Union L 151/15.

Regulation of the Council of Ministers on the National Interoperability Framework, minimum requirements for public registers and electronic information exchange and minimum requirements for ICT systems, Dz.U. (*Journal of Laws*) of 2017, item 2247.

Regulation of the Minister of Development, Labor and Technology of 2 April 2 2021 on the organization and management of the state geodetic and cartographic resource, Dz.U. (*Journal of Laws*) 2021, item 820.

Szpor G., Grochowski L., Fischer B. (2021). Tom XXII – Prawo Informatyczne (*Volume XXII – Informatics Law*). Fundacja Ubi societas, Ibi Ius, Warsaw.

W miesiąc od cyberataku w małopolskim urzędzie marszałkowskim wciąż nie działa system informatyczny (*One month after the cyberattack, the IT system in the Małopolska Marshal's Office is still not operational*), 10.03.2021, https://samorzad.pap.pl/kategoria/e-urzad/w-miesiac-od-cyberataku-w-malopolskim-urzedzie-marszalkowskim-wciaz-nie-dziala [access: 28.10.2022].

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.31

Paweł Nicia[1]

SOIL LIMING AS A TOOL FOR IMPROVING THE ECONOMIC EFFICIENCY OF AGRICULTURAL PRODUCTION AND REDUCING EUTROPHICATION OF SURFACE WATERS

Abstract: Soils along with their properties, climate and mineral fertilisation level are among the most important environmental elements impacting the quality and quantity of agricultural crops. Agricultural practices as well as crop varieties also have an impact on crop quantity and quality, but the method of cultivation of agricultural crops and selection of varieties depend on soil quality and local climate conditions. One of the most important soil parameters is pH. Acidic soils result in a range of negative phenomena that, on the one hand, impact crop quality and quantity, while, on the other hand, place a burden on the natural environment. Most soils used for crop cultivation in Poland originated from noncarbonate rocks and, consequently, are acidic. In order for agricultural production to reach an appropriate level of economic efficiency, systematic deacidifying fertilisation should be applied. However, the level of deacidifying fertilisation in Poland is far too low relative to the requirements of most plants. The necessity of using deacidifying fertilisers in crop production is a known problem and has been described in both scientific and popular scientific literature. Nevertheless, current trends indicate that farmers still use deacidifying fertilisation to a small extend, despite the fact that it is a simple way to significantly increase the quality and quantity of agricultural crops while maintaining the same level of fertilisation by mineral fertilisers. The paper describes, based on the National Agricultural Census 2012–2022, the current level of soil fertilisation by deacidifying fertilisers in Poland and analyses the reasons for this level as well as potential consequences.

Keywords: soil pH level, liming, economic efficiency of farms, soil quality

Received: 6 December 2022; accepted: 11 December 2022

[1] University of Agriculture in Kraków, Faculty of Agriculture and Economics, Department of Soil Science and Agrophysics, Kraków, Poland, ORCID ID: https://orcid.org/0000-0002-6556-5868, e-mail: rrnicia@cyf-kr.edu.pl

Introduction

The properties of soils used for agriculture largely determine the economic aspects of crop production on agricultural land. It is the properties of soils used for agriculture that determine the quality and quantity of crops. For most plants cultivated in Poland, the optimum soil pH for appropriate growth should be neutral or at most slightly acidic.

Soil pH, like most of the other soil properties, depends on genesis (Dobrzański et al., 1995; Hillel, 2012; Mocek, 2015). Soil properties are closely connected with the bedrock from which soils were formed and which impacted their further development. In the area of today's Poland, the Quaternary, or – more precisely – the Pleistocene, when most of our country's surface was covered by glacial sediments, were most important for the formation of soil bedrock. These sediments consisted of strongly acidic material such as sands and noncarbonate clays. Soils that were formed from these sediments are also characterised by acid pH due to lack of carbonates in the bedrock. Other factors that significantly contribute to soil acidification, apart from the lack of carbonates in soil bedrock, are natural biological processes occurring in the soil environment during plant cultivation which contribute to soil degradation as a result of soil decalcification (Hillel, 2012; Rice & Herman, 2012; Mocek, 2015).

In soils used for agriculture, the problem of acidification is compounded by the type of water management, which in Poland's climate results from precipitation outweighing evapotranspiration (Mocek, 2015). Precipitation causes the leaching of calcium and magnesium ions into deeper layers of soil profile. The problem of leaching of alkaline ions is connected, among other things, with the particle size distribution of soils. Highly permeable soils cover not only a significant part of Poland, but also most of the earth's crust. When precipitation outweighs evapotranspiration, light and very light soils, which account for around 2/3 of agricultural areas (Jadczyszyn, 2013), become gradually acidic as a result of decalcification and pedologic processes (Filipek et al., 2015). Analysis of the impact of precipitation on soil acidification demonstrates that for Poland the average dose of calcium fertilisers in the form of CaO necessary for offsetting the decalcification caused by precipitation should be 37.2 kg/ha of agricultural land per year (Fertilisation recommendations part II. Optimum doses of fertilisers on agricultural land, 2022).

The above-listed causes of soil acidification can be classified as natural ones. Equally important causes of soil acidification are anthropogenic ones, connected with intensive drainage of alkaline components with crops, mineral fertilisation and air pollutants emissions such as: SOx, NOx, and NH_3 (Filipek & Skorońska, 2013). The amount of deacidifying fertilisers intended to offset the drainage of calcium and magnesium as a result of these factors will depend not only on the crops produced on such land but also on the level of mineral fertilisation.

Acidic pH of soils, which constitute the most important element of agricultural production environment, has a negative impact on the economic efficiency of farms. This impact is significant, as only 0.5% of agricultural areas in Poland have properties allowing them to be in quality class I (the best arable soils), i.e. soils that guarantee crops with minimum needs for deacidifying and mineral fertilisation and agricultural

practices. Most of the other soils formed from noncarbonate bedrock belong to lower quality classes. These soils require much more agricultural practices on the part of farmers, with liming being one of the most important ones.

The aim of the paper is to analyse the use of calcium fertilisers based on the results of the National Agricultural Census for 2010-2022 as well as an attempt to verify the factors impacting the low level of calcium fertilisers use by farmers in Poland.

Material and methods

The problem of acidification of soils used for agriculture in Poland and across the world has been thoroughly described in the relevant literature (Pierre & Scarseth, 1931; Mehlich, 1942; Pondel et al., 1979; Siuta, 1974; Curyło, 1996; Dobrzański et al., 1995; Bednarek & Lipiński, 1998; Filipek et al., 2015). Large scale field studies into the effects of deacidifying fertilisation on soils with varying particle size distribution were conducted in Poland in the 1970s and 1980s (Boguszewski, 1980; Fotyma & Zięba, 1988). Analysis of the results of these experiments resulted in creation of scientific foundations for deacidifying fertilisation published as "Zalecenia nawozowe cz. II. Optymalne dawki nawozów na gruntach rolnych" (*Fertilisation recommendations part II. Optimum doses of fertilisers on agricultural land*). These recommendations have been followed throughout Poland to this day and constitute a basis when applying for subsidy for the purchase of calcium fertilisers under "The Polish-wide programme for environmental regeneration of soils through liming" (BIP KSChR, 2022).

This programme is scheduled for implementation in the years 2019-2023 and is coordinated by the National Fund for Environmental Protection and Water Management. The final beneficiaries of the programme are holders of agricultural areas. Holders of agricultural areas can receive aid through WFOŚiGW (Voivodship Fund for Environmental Protection and Water Management).

The last National Agricultural Census (NAC) was conducted across Poland between 1 September and 30 November 2020. The results of the NAC, carried out by Statistics Poland every ten years, provide data that enable statistical analysis of the changes taking place in the Polish agriculture, which makes it possible to conduct appropriate agricultural policy and develop and verify programmes to support agricultural activity, such as: "The Polish-wide programme for environmental regeneration of soils through liming".

In the paper, a comparative analysis of the use of mineral and calcium fertilisers was conducted. Cereals' reactions to mineral fertilisation and pH optimisation of the soils in which they had been grown were compared. The paper also discussed the scale of farmers' use of subsidy for deacidifying fertilisation under "The Polish-wide programme for environmental regeneration of soils through liming". The source data were the results of the National Agricultural Census for 2010–2020.

Results and discussion

One of the most important elements of agricultural production environment is soil, with its properties determining the quality and quantity of agricultural crops, and thus profitability of agricultural production. The properties of the majority of soils in Poland developed in the Pleistocene and the Holocene. Currently, most soils in Poland used for agriculture are soils formed from intensely leached and sorted glacial sediments. Due to their genesis, these sediments are mostly characterised by lack of carbonates. The lack of carbonates in the bedrock of soils used for agriculture determines the pH of such soils. Over 70% of the soils in Poland are slightly and strongly acidic (pH< 6.5). Unfortunately, this has a negative impact on the yield of plants that are most important for population feeding, including cereals.

According to the literature (Dobrzański et al., 1995; Kabata-Pendias & Pendias, 1999; Lipiński, 2013; Mocek, 2015), at low values of soil pH:

- there is a decrease in the yield of most cultivated plants as a result of decreased assimilability of micro and macro elements from soil solution,
- the capacity of sorptive complex to retain fertilising substances decreases,
- fertilising substances (macro- and micro elements) can be leached into groundwater under conditions of acidic pH resulting in groundwater eutrophication – this applies to such elements as calcium, magnesium, nitrogen, phosphorus and potassium,
- there is increased plant capacity to assimilate heavy metals, which can decrease the quality of crops, including exchangeable aluminium, which can be toxic at low pH values,
- there is decreased activity of various groups of soil microorganisms whose activity impacts the decomposition of crop residues and deposition of humus in soil, which is responsible (along with clay minerals) for soil sorption capacity and water retention.

Soil liming recommendations have been repeatedly published in numerous scientific periodicals as well as instructional and popular scientific publications (Zalecenia nawozowe, 2010; Igras et al., 2013; Filipek et al., 2015; Jadczyszyn, 2021; Jadczyszyn & Lipiński, 2022). However, the level of theoretical knowledge does not translate into the appropriate level of liming applied in practice by farmers to agricultural areas. Based on data from chemical and agricultural stations, interviews with agricultural and environmental advisers and employees of Agricultural Advisory Centres (own studies), it can be concluded that farmers have increased the amount of applied calcium fertilisers over the last 10 years. However, as the results of the 2020 National Agricultural Census demonstrated, between 2019 and 2021, soil liming was only applied in just over 21% of farms. According to the Code of Agricultural Good Practice (Jadczyszyn & Lipiński, 2022), soil liming should be applied once every 2–4 years depending on soil type. Farmers do not examine the soils to determine their liming needs often enough, and systematic liming is even a less frequent practice.

Analysis of the amount of used calcium fertilisers showed that the biggest increase in their use was recorded in 2020. This increase was a result of "The Polish-wide

programme for environmental regeneration of soils through liming", which was launched in 2019 by the Management of the National Fund for Environmental Protection and Water Management Under the programme, farmers can apply for subsidy for the purchase of calcium fertilisers in the amount of PLN 100 to 300 per tonne of pure deacidifying component (CaO and MgO), depending on the size of the farm and value of soil pH.

The number of the applications submitted by farmers was gradually increasing within the duration of the program. In 2019, farmers submitted 5788 applications for liming subsidy, whereas in 2020 the figure increased to 13509, and in 2021 – it was 14797. This amounts to a total of 34 094 applications submitted by farmers in the 3 years of the programme's duration, which is a very small number. It accounts for only a small percentage of 1 317 000 farms registered in Poland (Table 1).

Table 1. The number of applications for liming subsidy under "The Polish-wide programme for environmental regeneration of soils through liming" in the period 2019–2021

Number of applications	Years		
	2019	2020	2021
	5788	13509	14797

Source: own study

Given the number of applications submitted under the programme by 2021, it can be concluded that farmers do not take full advantage of this instrument which would allow them to reduce liming costs. Farmers also do not use their own funds to apply sufficient amounts of calcium fertilisers to increase the soil pH to an optimum level. This is puzzling as the impact of soil pH on the yield is unquestionable and has been thoroughly described in numerous scientific and popular scientific publications. This problem is also a subject of a great deal of training courses offered to farmers.

A positive effect of deacidifying fertilisation applied systematically in certain farms has been confirmed by the results of the National Agricultural Census (2020). Analysis of data for the years 2010–2020 shows that soil fertilisation with calcium fertilisers increased more than twice. The increase in soil fertilisation with calcium fertilisers should be associated with the 20% increase in cereal yields, including the 34% increase in wheat yields (Fig. 1).

It should be stressed that this increase occurred while there was a low increase in fertilisation by mineral NPK fertilisers NPK (by only 10.2%), (Fig. 2), thus it can be assumed that it resulted from increasing the pH level of soils used for agriculture.

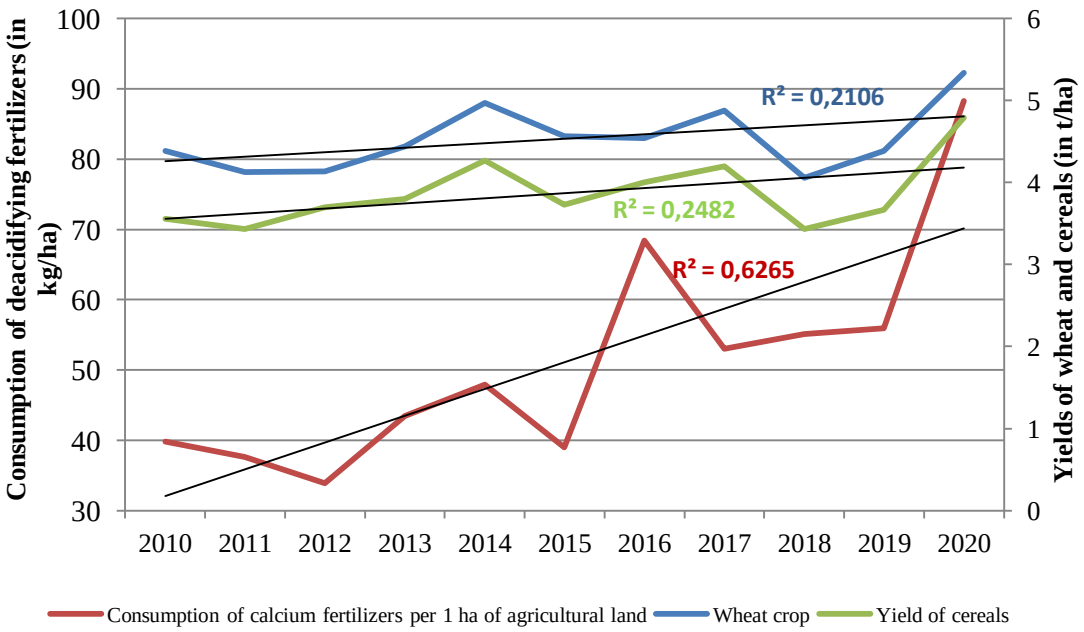


Fig. 1. Total yields of cereals, including wheat, depending on the level of application of calcium fertilizers (2010–2020)
Source: GUS, 2020

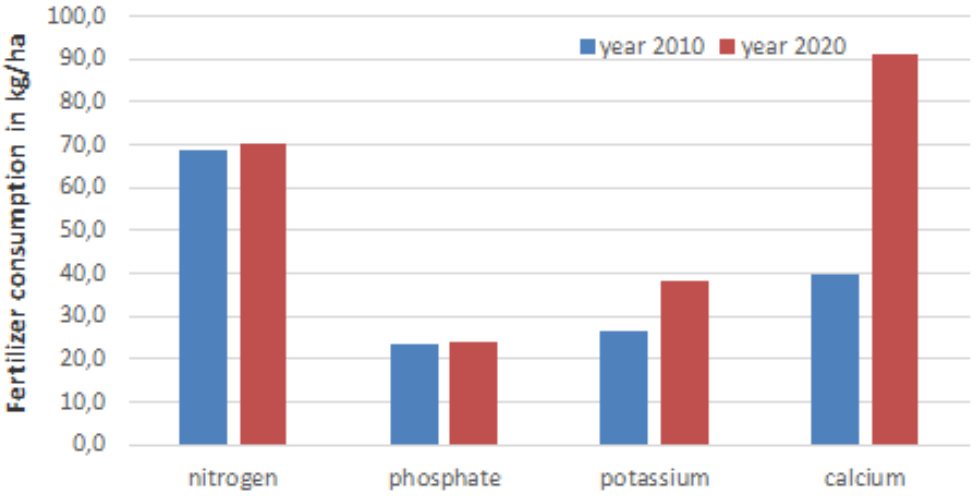


Fig. 2. Consumption of mineral and calcium fertilizers (2010–2020)
Source: GUS, 2020

According to data from Statistics Poland (2020), there is a significant spatial variation in plant production and its intensity in Poland. There is also variation in the level of soil fertilisation – the largest amounts of calcium fertilisers in 2020 were used in Opole Voivodeship, whereas the smallest in Świętokrzyskie and Lesser Poland Voivodeship (Fig. 3).

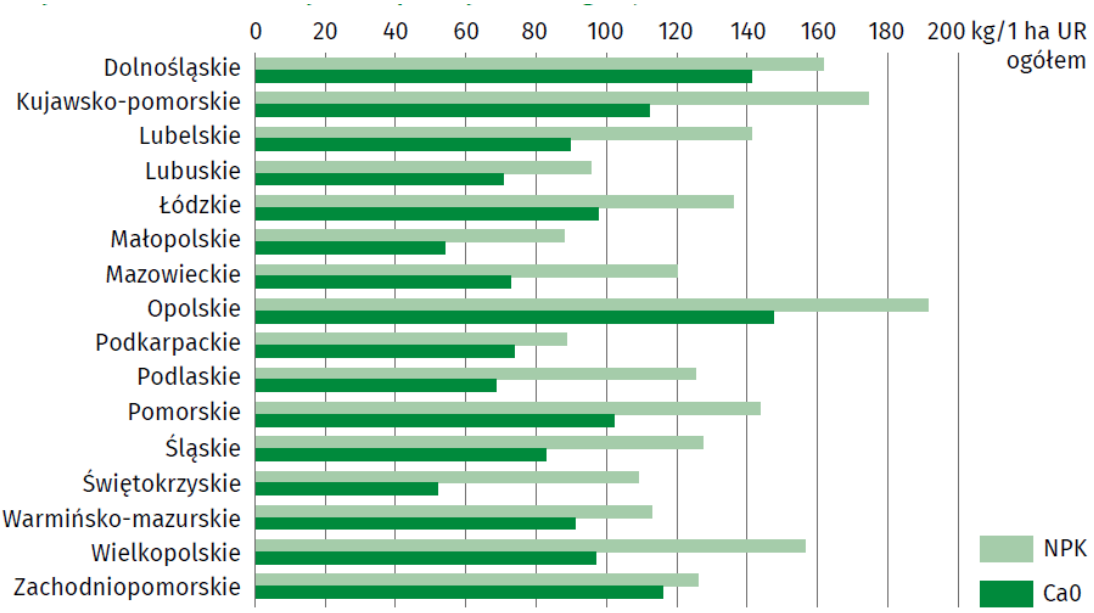


Fig. 3. Usage of mineral and calcium fertilisers by voivodeship in 2020
Source: cited after: Agricultural Census, 2020

Such a large variation in the use of calcium fertilisers in Poland is connected with a number of factors, the most important of which are as follows:

- crops specificity in the different regions of the country,
- the type of soils in which the crops are grown,
- liming needs determined based on soil analysis,
- farm size – larger farms cannot take full advantage of liming subsidy,
- farm fragmentation,
- farmers' knowledge on agricultural technology.

Taking into consideration the genesis of the soils used for agriculture in Poland, lack of carbonates in most of the bedrocks and farming intensity, it can be argued that the above-presented doses of calcium fertilisers are by far too low to ensure appropriate conditions to obtain optimum, much higher yields of high quality agricultural products. The doses of deacidifying fertilisers applied by farmers are often only slightly higher than the losses of calcium and magnesium as a result of them being leached from the soils by precipitation.

The Institute of Soil Science and Plant Cultivation – National Research Institute in Puławy (IUNG), estimates the demand of the national agriculture for lime at around 31 million tonnes of CaO, i.e. around 2 tonnes of CaO/ha of AA on average. This means that the amounts of calcium fertilisers applied by farmers in Poland are a dozen to 38 times lower that they should be.

High acidification of soils used for agriculture, especially in the case of crops sensitive to acidification, leads to a significant decrease in the economic efficiency of farms and, simultaneously, an increased negative impact on the natural environment. According to data contained in the 2022 Krajowy raport o stanie użytków rolnych w Polsce: zakwaszenie gleb oraz ich regeneracja (*National report on the state of*

agricultural areas in Poland: soil acidification and regeneration), financial losses sustained by Polish farms connected with the leaching of mineral nutrients supplied into acidic soil reach PLN 2–6 billion. The biggest losses resulting from the leaching of fertilising substances supplied into the soil and from reduced quality and quantity of crops are suffered by crops that exhibit a very strong and strong reaction to soil acidification, for example: beetroot, pea, lucerne, clover, corn, wheat, barley, oilseed rape, field bean, white and narrowleaf lupin. Losses per 1 ha of agricultural area as a result of the leaching of fertilising substances may reach PLN 400. They may even be 4 times higher, depending on soil acidification and decrease in the yield of plants sensitive to acidification (the 2020 National report on the state of agricultural areas in Poland: soil acidification and regeneration).

Apart from measurable financial losses connected with the leaching of nutrients from acidic soils, another important issue is soil structure degradation (Mocek, 2015). At acid pH, soil capacity to create soil aggregates decreases, which leads to reduced capacity to store precipitation water. This is a significant problem, especially in the context of physiological drought, a frequent phenomenon in recent years. According to Państwowe Gospodarstwo Wodne Wody Polskie (Polish entity responsible for water management) (2020), the area's most likely to be affected by this phenomenon are: Lublin Voivodeship, Pomeranian Voivodeship, Greater Poland Voivodeship and the West Pomeranian Voivodeship.

When discussing cultivation of agricultural crops on acidic soils, it is necessary to mention eutrophication of surface waters, which takes place as a result of the leaching of fertilising substances from the soils of agricultural areas. In light soils, the sorptive complex, which is characterised by low sorption capacity, is unable to retain the fertilising substances supplied into the soil along with fertilisers (Dobrzański, 1995). As a result of the process of leaching, even 30–50 kg of nitrogen, 70–80 kg of phosphorus and 40–70 kg of potassium from 1 hectare of agricultural areas of acidic soils may end up in surface waters. Along with macroelements, microelements may also be leached into surface waters, including heavy metals, which are very dangerous to the environment and people.

As was already indicated, despite unquestionable advantages of soil deacidification, some farm holders still do not apply deacidifying fertilisers or apply them sporadically, do not have the soil analysed in order to determine the dose of deacidifying fertiliser and do not apply for programmes that provide subsidy for soil liming. As a result, the profitability of agricultural production in their farms is significantly lower, whereas the burden on the environment – greater.

Conclusions

The problem of soil acidification is global in character and connected, just as in Poland, with soil genesis and lack of deacidifying fertilisation. In the EU, acidification was identified as one of key threats to soils, which was articulated in the European Parliament Resolution of 28 April 2021 on soil protection (2021/2548(RSP)).

In this resolution, the European Parliament calls EU member states to ensure sufficient financial support and incentives to promote soil protection, sustainable soil management, soil conservation and remediation as well as innovations and research as part of common agricultural policy, cohesion policy funds, Horizon Europe programme and other available financial instruments.

Given the level of soil acidification of agricultural areas in Poland, decisive steps should be taken to minimise the negative effects of this process. One of the first steps should be taking actions towards an in-depth diagnosis of the reasons for deacidifying fertilisation of soils in our country remaining at a very low level. Factors that may cause farmers' unwillingness to use deacidifying fertilisers and apply for programmes subsidising such activities include:

- erroneous assumptions among farmers regarding liming – they may think that financial investments in these practices will not result in a quick increase in crops,
- failure to spread information about programmes subsidising liming,
- lack of sufficient flow of information between farmers and agriculture-related institutions where a farmer could receive information about liming,
- complicated procedure for obtaining liming subsidy,
- fragmentation of agricultural areas,
- a too high pH of the soils that a farmer wants to lime relative to the requirements specified in the programme,
- limited frequency of subsidising the same plots,
- a too small size of a farm.

A detailed analysis of all existing and potential barriers reducing the level of liming is vital due to the plan to implement the European Green Deal in the EU, which is a strategy for achieving sustainable development of the economy and society. One of the strategic goals of the European Green Deal in the area of agriculture is to reduce the use of mineral fertilisers and pesticides by 20% and 50% respectively in the coming years. Thanks to optimising the pH of soils used for agriculture, meeting the above-described requirements will be easier. A programme that is designed to help optimise the level of fertilisation is the National Strategic Plan for Common Agricultural Policy for 2023–2027, which envisages liming in eco-scheme I 4.4 – Development of and compliance with the fertilisation plan.

References

Bednarek W., Lipiński W. (1998). Kationy wymienne w glebie poddanej oddziaływaniu zróżnicowanego nawożenia mineralnego (*Exchangeable cations in soil subjected to differential mineral fertilisation)*. Zeszyty Problemowe Postępów Nauk Rolniczych, vol. 456, pp. 147–153.

BIP KSChR. (2022). Nowe zasady ustalania dawek wapna (*New rules for setting lime doses)*. https://www.schr.gov.pl/p,149,aktualnosci [access: 01.12.2022].

Boguszewski W. (1980). Wapnowanie gleb *(Liming of soils).* Warsaw, pp. 173.

Curyło T. (1996). Wpływ odczynu gleby na pobieranie cynku, miedzi i niklu przez rośliny owsa *(Effect of soil reaction on uptake of zinc, copper and nickel by oat plants).* Zeszyty Problemowe Postępów Nauk Rolniczych, vol. 434, pp. 49–54.

Dobrzański B., Gliński J., Konecka-Bentley K., Kossowski J., Kowaliński St., Kuźnicki T., Smyk B., Stępniewski W., Zawadzki S. (1995). Gleboznawstwo *(Soil science)*. Warsaw, pp. 561.

Igras J., Jadczyszyn T., Lipiński W., Pudełko R. (2013). Dobre praktyki rolnicze w nawożeniu użytków rolnych *(Good agricultural practices in the fertilisation of agricultural land).* J. Jgras (ed.), Centrum Doradztwa Rolniczego w Brwinowie, pp. 67.

Filipek T., Badora M., Lipiński W., Brodowska M.S., Domańska J., Harasim P., Kozłowska-Strawska J., Skowron P., Skowrońska M., Tkaczyk P. (2015). Zakwaszenie i wapnowanie gleb *(Acidification and liming of soils)*. Wydawnictwo Fundacja Programów Pomocy dla Rolnictwa FAPA, pp. 236.

Filipek T., Skorońska M. (2013) Aktualnie dominujące przyczyny oraz skutki zakwaszenia gleb użytkowanych rolniczo w Polsce *(Current dominant causes and effects of acidification of agriculturally used soils in Poland)*. Acta Agrophysica, vol. 20, no. 2, pp. 283–294.

Fotyma M., Zięba S. (1988). Przyrodnicze i gospodarcze podstawy wapnowania gleb uprawnych *(Natural and economic basis of liming of arable soils).* Warsaw, pp. 250.

Hillel D. (2012). Gleba w środowisku *(Soil in the environment)*. Państwowe Wydawnictwo Naukowe, pp. 344.

Jadczyszyn T., Lipiński W. (2022). Zasady ustalania dawek wapna w doradztwie nawozowym, nowe zalecenia w zakresie wapnowania gleb gruntów ornych i trwałych użytków zielonych *(Principles for determining lime doses in fertiliser advice, new recommendations for liming of arable land and permanent grassland soils)*. Wydawnictwo Instytutu Uprawy Nawożenia i Gleboznawstwa – Państwowy Instytut Badawczy, pp. 19.

Jadczyszyn T. (2021). Nowe zalecenia w zakresie wapnowania gleb *(New recommendations for soil liming)*. Studia i Raporty Instytutu Uprawy Nawożenia i Gleboznawstwa – Państwowy Instytut Badawczy, vol. 65 (19), pp. 99–109.

Jadczyszyn T., Ochal P. (2013). Zakwaszenie gleb i potrzeby wapnowania *(Soil acidification* and *the need for liming)*. Studia i Raporty Instytutu Uprawy Nawożenia i Gleboznawstwa – Państwowy Instytut Badawczy, Puławy, vol. 34 (8), pp. 9–18.

Kabata-Pendias A., Pendias H. (1999). Biogeochemia pierwiastków śladowych *(Biogeochemistry of trace elements)*. Państwowe Wydawnictwo Naukowe, pp. 400.

Krajowy raport o stanie gruntów rolnych w Polsce: zakwaszenie gleb oraz ich regeneracja poprzez wapnowanie – stan obecny i propozycje systemowych rozwiązań *(National report on the state of agricultural areas in Poland: soil acidification and regeneration)* (2022). St. J. Pietr, M. Krysztoforski (ed.), pp. 32.

Lipiński W. (2013). Problematyka zakwaszenia gleb, efektywność wapnowania *(Problems of soil acidification, effectiveness of liming)*. In: Dobre praktyki rolnicze

w nawożeniu użytków rolnych *(Good agricultural practices in farmland fertilisation)*. Centrum Doradztwa Rolniczego w Brwinowie, pp. 67.

Mehlich A. (1942). Base unsaturation and pH in relations to soil type. Soil Science Society of America, Proceedings, vol. 6, pp. 150–156.

Mocek A. (2015). Gleboznawstwo *(Soil science)*. Warsaw, pp. 571.

Państwowe Gospodarstwo Wodne Wody Polskie (2020). Najnowszy raport STOP SUSZY *(Latest STOP DUSH report)*. https://wody.gov.pl/aktualnosci/1200-czy-w-polsce-nadal-mamy-susze-najnowszy-raport-stop-suszy-2020 [access: 01.12.2022].

Pierre W.H., Scarseth G.D. (1931). Determination of percent base saturation of soil and its value for different solis at definite pH values. Soil Science, vol. 31, pp. 99–114.

Pondel H., Terelak H., Terelak T, Wilkos S. (1979). Właściwości chemiczne gleb Polski *(Chemical properties of Polish soils)*. Pamiętnik Puławski, vol. 71, pp. 5–20.

European Parliament Resolution of 28 April 2021 on soil protection (2021/2548(RSP), https://www.europarl.europa.eu/doceo/document/TA-9-2021-0143_EN.html [access: 1.12.2022].

Rice K.C, Herman J.S. (2012). Acidification of Earth: An assessment across mechanisms and scale. Applied Geochemistry, vol. 27, pp. 1–14.

Siuta J. (1974). Kształtowanie przyrodniczych warunków rolnictwa w Polsce *(Shaping the natural conditions of agriculture in Poland)*. Warsaw, pp. 121.

Zalecenia nawozowe dla roślin uprawy polowej i trwałych użytków zielonych *(Fertiliser recommendations for arable crops and permanent grassland)* (2010). Puławy. Wydanie II. St. J. Pietr (ed.). Uniwersytet Przyrodniczy we Wrocławiu, pp. 27.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.43

Małgorzata Ganczar[1]

PROCESSING OF SPATIAL DATA ON THE EXAMPLE OF A WATER MANAGEMENT INFORMATION SYSTEM

Abstract: The Water Management Information System is an important instrument of water resource management that enables the collection, processing, publishing and sharing of water management data. The Water Management Information System is an integral part of proper and effective water management, the vision of which has been shaped over the last decades, transforming into an increasingly effective system adapted to the applicable legal and organizational conditions. The main feature of the information system is its multi-tier nature, providing access to other information resources, which will allow the utilization of data imported from other thematic databases. In this manner, on the basis of appropriate regulations, access to current data from various sources, a uniform reference system and proper use of water management data in planning and programming socio-economic development will be ensured. In the paper, WIMS will be characterized as a public register, taking into account the categories of data collected in the context of restricting access to data.

The subject of the considerations will be the identification of important elements in the field of ensuring access to information on water management, as well as its dissemination through the WMIS.

Keywords: spatial data, public register, restricting access to data

Received: 24 November 2022; accepted: 13 December 2022

[1] Catholic University of Lublin John Paul II, Faculty of Law, Canon Law and Administration, Lublin, Poland, ORCID ID: https://orcid.org/0000-0003-0880-4647, email: mganczar@kul.pl

Introduction

Water is an environmental component which plays major social and economical role. Furthermore, water is a limited resource and should be primarily destined for human consumption. Only then water can be used to pursue other goals: economic development, tourism or recreation (Hauser et al., 2018, p. 466). Water economy is primarily regulated by the Water Law Act of 20th of July 2017 (uniform text, Journal of Acts of the Republic of Poland 2022, item 2233 as amended) which covers the issues of managing waters consistently with the principles of sustainable development, in particular development and protection of water resources, utilizing water resources and managing water resources. The act also governs the issues of ownership of waters and land covered in water as well as the principles of managing these components as a part of the property of the State Treasury (articles 1 and 2 of the Water Law). The information-based civilization developing in the recent years influences effective development of land-use policies, also in regards to managing water resources, on nation-wide and regional levels. The justification of act's draft refers to the European Parliament and Council Directive 2000/60/EC of 23rd of October 2000 establishing a framework for the Community action in the field of water policy (OJ UE L 327/1) (hereinafter: framework water directive) The preamble of the directive states that the common water policy requires transparent, effective and cohesive legislative framework – a statement which should be interpreted as a postulate of implementation of legal provisions ensuring full and reasonable legal regulation of this area on the national level. The water economy reform requires forming such legal, organizational, financial and technical solutions regarding water management which will ensure permanent and sustainable social and economic development of the country and which will take into account using water for satisfying economic needs and which will ensure access to water resources of proper quality in an appropriate amount.

Water resources management is regulated in detail in chapter VII of the Water Law. Apart from the regulations concerning maintaining the Water Management Information System these regulations are comprised of provisions regulating the issues of planning and controlling water management and monitoring waters. Consistently with art. 10 of the Water Law the water resources management serves to satisfy the needs of the populace and economy as well as preserving waters and related natural environment. This ordinance is effected through various implements which were listed in art. 11 of the Water Law. These instruments cover water management planning, Water Law permits, fees for water services as well as other receivables, water management control as well as the water management system.

Material and methods

The Water Management Information System (WMIS) was developed in the aftermath of the water economy reform of 2017 and supplanted the existing water cadaster. The Water Management Information System is a major implement of managing water resources which enables collecting, processing, publishing and sharing the data

regarding water economy. The ordinance of the Minister of Maritime Economy and Inland Waterways of 10th of September 2020 regarding the Water Management Information System (Journal of Acts of the Republic of Poland 2020, item 1656) regarding the system came into effect in the October of 2020. The analysis of provisions of the act and the ordinance enables us to isolate the procedures for sharing the data operating on the basis of the statutory tasks imposed on the National Water Management Authority Polish Waters (hereinafter NWMA PW). In relation to the changes in the provisions regarding the extent of the data collected in the existing water cadaster and development of the Water Management Information System the subject of the analysis covers the statutory regulations and encompasses both the analysis of the provisions of the Water Law act as well as analysis of various other legal regulations which have to be taken into consideration in order to define the analyzed regulations; furthermore, the analysis covers the assessment of the existing procedures for sharing information along with the prospective conclusions as the components necessary for development of the WMIS. The main research method used to make relevant findings will be the analysis of literature and legal acts.

Spatial Data

Managing waters is a component of national spatial management. The spatial management (spatial economy) is defined as a rational use of the environment through proper placement of fixed assets. Land management defines the principles of rational selection of placement, spatial relations, spatial organization, and venues for development of location, interaction and organization systems. The land management should be considered as a system comprised of numerous active components (owners of plots of land, public administration) and passive components (differently utilized plots of land, technical infrastructure). The land management is a human activity resulting in specific spatial outcomes, both positive as well as detrimental (Zawadzki, 1969, p. 118; Domański, 2007, p. 28). Proper understanding of the concepts of spatial information and spatial data is crucial for defining the spatial management tasks. Spatial information is a collection of pieces of information regarding location, geometrical properties and spatial relations between the objects referred against the surface of the Earth. Spatial objects consist of both the natural objects such as lakes, forests, designated forest areas or any other classification units of land or artificial objects erected therein. These objects may be characterized as natural, social or economical phenomena (Miś et al., 2001, p. 15; For comprehensive analysis of the term „spatial information" check: Jankowska, 2017).

In turn, rapidly collecting and processing data is necessary in order to procure necessary and credible information. Contemporarily we gather increasing amount of data but, characteristically, this data primary comes from vastly differing sources. The classical sources of data such as documents and measurements were in recent years expanded with photographs, maps, sounds, websites or video recordings. This data is of a different character and gathering this data and processing it accordingly presents a major challenge.

It is also prudent to take note of the geoinformation concept defined as presenting the data regarding any objects located in the surroundings, land use and developing utility infrastructure through using tools specially developed for this purpose. The advantage of the geoinformation included in various information systems is the fact that the phenomena not directly connected to their location on the surface of the Earth can be assigned a new metric – a specific location defined through geographical coordinates. Bodies of spatial information can be divided into those which are being developed under the legal obligation and the bodies which are being developed under own initiative by various organizations and natural persons for the purpose of realizing their goals (Szpor, 1998, p. 85). The potential possibilities regarding utilizing geoinformation are dependent on the material scope of the information which is inherently extensive. Geoinformation cover knowledge regarding objects such as facts, events, items and processes. Furthermore, the contemporary maps are capable of not only graphically displaying the geographical horizon but also enable "conducting complex thematic analyzes, useful in making decisions regarding components of a complex structure. It is possible thanks to the multi-tier structure of digital maps integrated with text databases" (Ganczar, 2020, p. 93). Quality and credibility of this data, along with the willingness of private entities to pay for access to a specific data set, are of primary and basic significance for the practical application of this data, also its application for the needs of the judiciary system (Flaga-Gieruszyńska, 2018).

A piece of information can be properly utilized only when it is complete, credible, sorted and presented in appropriate form. Complete information can be collected only when the gathered data fully describes all aspects of the reality we are interested in and when the data accurately reflects its area of analysis. Incomplete data may be misleading if its user is unaware of the incompleteness of the data. In turn, when the user is aware of the incompleteness of the data, the user has to seek additional information in other sources if he wishes to minimize his knowledge-related shortcomings (the degree of ignorance) related to the specific field of knowledge the user is interested in (Bartman & Sobczyński, 2015, p. 244). Unreliable information is worthless information. The unreliability of information results from unreliability of data.

It is prudent to emphasize that limiting multiplying the instances of collecting the same spatial data will be significant for managing water economy. The reference data against which users are able to locate the objects and phenomenons they are interested in plays major role. This task is realized through: developing topographical reference data bases for the local, regional and national level; developing databases containing metadata which enable checking what data are or will be made available in the future; assigning unique identifiers which enable integrating data from various databases containing spatial data for geographical objects (Linsenbarth & Ney, 1999, p. 174). Databases containing reference data are developed with the goal of preserving cohesion of the spatial data contained within numerous specialized data sets; at the same time developing such databases enables effecting previously impossible to realize analyses based on the combined data. Reference data is the data which may constitute a foundation for gathering specialized, more detailed data and the basis for visualizing

thematic data. Utilizing reference data is significant due to the opportunity for reducing costs of gathering and updating spatial data for various databases. Furthermore, utilizing reference data facilitates cooperation of the Geographical Information Systems based on the same source data. Undeniably one merit of reference databases is limiting financial expenditures on developing separate databases containing similar data, facilitating updating the data contained within registers – a change in the reference register enables access to the up-to-date data for all of its users. Furthermore, it enables providing citizens, public administrations and entrepreneurs with uniform, cohesive information and makes any comparisons and aggregated analysis of the data contained in reference registers and thematic databases easier. Currently the central geodesic and cartographic resource node GEOPORTAL plays the role of a reference database.

The WMIS maintained under an IT system

Consistently with art. 329, section 1 of the Water Law the Water Management Information System is maintained under a computerized IT system. Differentiating between these two types of systems appears to be important. Within the doctrine (Ficoń, 1998; Kisielnicki & Sroka 2015; Walasek, 2015) an information system is defined as a multi-tier structure which enables its user to transform input information into output information through using a specific model and through applying specific procedures. An information system constitutes a central link coordinating processes within an organization and integrating it with the external environment. The greater the rate of information turnover the greater the topicality and substantive value of the system in the process of developing and making decisions. Apart from the internal information processing technology the manner in which information is distributed internally within the system and externally is also of great importance for effective operation of the system. The information links between individual elements of the information system must be lasting, sustainable and methodical and the communicated information must be highly credible, synthetic in nature and up-to-date.

An information system should enable: gathering information; transmitting information between at least two users; storing information; processing information; sharing information in a specified place and at a specified time (Kucyk, 2013). An information system should: provide complex and up-to-date information, ensure selective and effective application of information and proper two-way exchange of information between organizational cells, supervisors and subordinates; ensure simplicity of use and providing constant, automatic method for gathering data from specified sources; enable accessing data immediately, even from the lowest management level, searching and collating information from various sources, presenting data and results of their analysis in various reporting systems; ensure flow of information based on feedback (Janczak, 2011).

The concept of an IT system must be distinguished from the concept of an information system. An information system shall be understood as a separate part of a social, economic or technical system consisting of such components as personnel

(people), information processes and data resources, realizing their tasks and goals. The primary tasks of an information system include satisfying information needs of an organization in order to enable making accurate and proper decisions. A digitized separate part of an information system becomes an IT system (Fajfer, 2011). An information system requires support of IT systems which are defined as formal computer systems enabling gathering, processing, sharing and integrating data from various sources in order to deliver necessary information at an appropriate time and to support decision-making processes (Chmielarz, 1996). It covers such technological attributes as: the type and structure of data, the data selection type, type of the user interface and types of reactions. Consistently with art. 3, section 3 of the act on the IT development of the bodies performing public tasks (uniform text, Journal of Acts of the Republic of Poland 2021, item 2070 as amended, hereinafter the ITact) a computerized IT system is a body of cooperating IT hardware and software ensuring processing, storage, sending and receiving of data through telecommunication networks through use of an output device understood as stipulated in the provisions of the act of 16th July 2004 – Telecommunications Law (uniform text, Journal of Acts of the Republic of Poland 2022, item 1648 as amended) – appropriate for a given type of a telecommunication network (these concepts and their correct use are discussed by Kuraś (2009).

The above distinction is of great importance for the appropriate and law-consistent processing of data under the WMIS. During the reading of the justification for the draft of the ordinance regarding the Water Management Information System the following statement draws attention: "*the ordinance does not bear the quality of the technical guidelines for developing the system and refers solely to sharing the data. The project is to enable proper realization of tasks without a uniform computerized IT system, on the basis of the existing software-hardware infrastructure and simultaneously to provide the guidelines for development of the Water Management Information System*" (Ministerstwo Gospodarki Morskiej i Żeglugi Śródlądowej, 2018). The ordinance projects that under the Water Management Information System, developed as a computerized IT system, standardized databases divided into water resource regions will be maintained. This system is maintained in a manner which shall facilitate managing water resources. In regards to the technological aspects of operations of a computerized IT system the provisions of the act on the IT development of the bodies performing public tasks and regulations of the National Interoperability Framework shall apply (Journal of Acts of the Republic of Poland 2017, item 2247). The obligation of meeting the minimal requirements for computerized IT systems established under art. 14, section 1 of the ITact is being met in consideration of art. 3, point 9 of the ITact according to which it is a body of organizational and technical requirements meeting which by a computerized IT system utilized to realize public tasks enables exchanging data with other computerized IT systems utilized to realize public tasks and ensures access to the information resources shared through these systems and shared consistently with the issued regulations of the National Interoperability Framework. The Council of Ministers determines the minimum requirements for the computerized IT systems in order to ensure cohesive operation of the computerized IT systems utilized to realize public

tasks (through defining at least the data format specification and communication encryption protocols which are to be applied in the interface software and at the same time ensuring that these specifications will be possible to apply free of charge. The efficient and safe electronic exchange of information between public entities and between public entities and bodies of other countries or international organizations should also be ensured.

The premises for the operations of the Water Management Information System

The Water Management Information System comprises an inseparable component of correct and effective management of water economy the vision for which was developed over the last decades transforming into an increasingly effective system adapted to existing and binding legal and organizational regulations. The WMIS operates as one of the primary components of the Informatics System for the Protection of the Country from extraordinary dangers (ISPC). In supplanting the existing systems and software for realization of the tasks regarding water cadastre the WMIS is to implement additional functionality resulting from the provisions of law and other tasks related to modern demands regarding managing water economy. Thus through implementing the provisions of the new Water Law act the water cadastre was transformed into the Water Management Information System maintained by the National Water Management Authority Polish Waters for the complex of catchment basins and water regions and the scope of the gathered data was expanded through, among others, the land improvement record keeping, previously maintained by Marshals of regions through the Land Improvement Administration.

The primary premise of the information system is a multi-tier structure ensuring access to other information; this structure will enable importing data from other thematic databases. In this manner, on the basis of appropriate procedures, the access to up-to-date data from various sources will be ensured along with a uniform reference system and proper application of water economy data in planning and designing social and economical development. Providing access to and sharing information are crucial. In this manner uniform information cohesive in terms of time and location will benefit conducting research and development works, determining opinions and views in regards to crucial quantitative and qualitative issues of water economy (Ganczar, 2021, p. 172).

The primary task of the WMIS defined in the legal provisions is gathering the information regarding water management (art. 329, section 2 of the Water Law). However, this role should serve as a departure point for further, intermediate functionality of the system. A database containing all information concerning water management should become a "core" of the system and support other implements of water resources management such as, e.g. water management planning, Water Law permits, fees for water services and remaining receivables, water management control and ensuring that the documentation is up-to date. Analysis of the data available in the WMIS may enable marking hot spots for issues, locations requiring investigating or the

locations generating discrepancies which should be investigated first. The system may also constitute a tool for planning the order of carrying out audits and inspections. The WMIS was developed primarily with the goal of establishing a centralized and cohesive source of information where all information is gathered, stored and updated. However, being a core of the water management system due to aggregating all aspects of this field in one place the WMIS should be also utilized as a tool supporting other instruments of water resources management and serve as a departure point for taking further steps. Provisions of the Water Law (art. 330, section 3) also indicate that works should be carried out towards ensuring interoperability understood as stipulated in the act on the IT development of the bodies performing public tasks. In relation to the aforementioned facts the system should be maintained in an open manner, ensuring safety of the processed data, oriented for co-creation of the system by the authorities realizing the tasks stipulated in the act and on the exchange of information between the entities realizing public tasks stipulated in art. 2, section 1 of the ITact (art. 330, sections 4 and 5 of the Water Law).

Centralization of such institutions as the NWMA PW, creating one organization which took over the responsibilities previously scattered across various bodies, became a challenge in the field of integrating IT systems on all levels of operations: infrastructural, format-related and pertaining to the scope of the collected data, related to application of the system. The ISPC system implemented in the organization, of which the WMIS is an integral part, does not yet cover all the changes introduced by the Water Law act of 2017. The wide range of responsibilities resulting from legal provisions gives birth to new demands and needs in terms of functionality of the software, harmonizing and digitizing the data as well as integrating computer systems and reaching mutual compatibility. A need exists in regards to development of the WMIS concerning developing reference registries, expanding the system with further categories of data, digitization and migration of the data until now collected in the paper form, standardizing and replenishing structures with numerical data, securing the technical infrastructure through manufacturer's support, expanding the WMIS with the functionality enabling inputting and editing data, introduction of a platform supporting charging fees for water services, developing a solution supporting submitting reports to institutions of the EU and supporting issuing Water Law permits.

The scope of the data processed under the WMIS

As indicated by the wording of art. 330 of the Water Law: "1. the Water Management Information System for the area of the country which takes into consideration the division of the country into catchment basins and water regions is maintained by the Polish Waters". Therefore all the obligations related to collecting, processing and sharing information through the WMIS are borne by the NWMA PW.

Moving to the issue of the sources of the information collected in the WMIS we should indicate that collecting the information is a material and technical action. The scope of the data collected and shared in the WMIS is defined in art. 329, section 2 of the

Water Law. The catalogue of the information contained therein is open. The newly developed system which is to serve as a basic tool for water resources management shall be expanded with a number of data which until now were not collected by the units responsible for water economy. The provisions of the regulation specify in detail the scope of the information collected and stored in the WMIS as well as the organization, manner and technical standard for maintaining the system. The following types of data will be available in the WMIS: the data concerning the hydro-graphical network depicted on a Hydrographic Division Map in a 1:10000 scale, the location of borders and catchment areas, water units, protection zones for water intakes and protection zones for inland waters, land improvement hardware and improved lands, the plans for flood emergency management, the plans for counteracting results of drought, flood hazard maps, the data shall cover the spatial information database as well as the cartographic version, Water Law permits, Water Law assessments and integrated permits.

The analysis of the provisions of art. 331 of the Water Law enables us to assess that the sources of the data collected in the WMIS come from the following entities: a) administration bodies (including: the Minister for Water Economy, water administration bodies, the bodies of the Environmental Protection Inspectorate, the bodies of the Chief Sanitary Inspection, bodies issuing integrated permits (the Marshal, the regional environment protection director, the starost), voivodes, b) research institutions – the basic measurement and observation network, the state environment monitoring, the state hydro-geological service and the groundwater research and monitoring network, c) other public authorities – water companies and their unions, d) owners of water units. The scope of the entities providing the WMIS with information is expansive and diverse.

The scope of the provided information is determined by the statutory requirements defined in broad terms; the category of the data should be defined broadly, not the specificity of particular data. Only in reference to the data submitted by owners of water units the legislator decided to define the objective scope of this obligation; the data provided by owners of water units must cover: 1) name, location and address of the owner as well as description of the manner in which water is being utilized; 2) parameters of the water unit and its technical condition; 3) location of the water unit including name and number of the surveying district along with the number or numbers of the land lots as well as their coordinates; 4) the data regarding the Water Law act permit determining the conditions for utilizing waters (art. 331, section 4 of the Water Law) along with the obligation to update the data within 30 days from the changes occurring. Realization of this obligation is secured with a criminal-regulatory sanction indicated in art. 478, point 3 of the Water Law.

In analysis of the provisions of the ordinance regarding the Water Management Information System we may ascertain that the system is maintained in a manner which facilitates supporting water resources management and the manner which enables controlling access to the WMIS and authorizing WMIS users; developing, saving, updating, securing and maintaining data sets; controlling quality of data sets; controlling correctness of the topological relations between the spatial objects disclosed by the

WMIS; searching, viewing and in case of spatial data sets – visualizing map compositions of data sets; conducting spatial analyses; transforming and processing data sets; sharing data; generating reports and comparisons; feeding publication databases of the Hydroportal.

The aforementioned functionality and technical standards the WMIS meets were defined in §4 of the ordinance. The computerized IT system under which the WMIS is maintained assigns to the objects disclosed under the system a unique identifier but in the case of the objects (provided) by an administrative body stipulated in art. 9, section 1 of the act on the infrastructure of spatial information (hereinafter: INFSPact) such objects retain the unique identifier they already possess. In case of the spatial objects understood consistently with the art. 3 point 5 of the INFSPact the unique identifier consist of: a) a namespace, developed on the basis of the identifier of the spatial data set to which a given spatial object belongs according to the register and spatial data services provided under spatial information infrastructure, b) a local identifier explicitly differentiating a given object contained in the database from other objects contained therein. In case of the spacial objects other than the spatial objects understood consistently with art. 3, point 5 of the INFSPact the unique identifier consist of a local identifier stipulated in letter b. Furthermore, the unique identifier as understood by the discussed ordinance consist of the elements discussed in letters a and b which are unique and cannot be changed. Such solution remains consistent with §10 of the National Interoperability Framework ordinance according to which the following types of objects are distinguished in public registers: a natural person, an entity and a spatial object, to which a unique identifier is assigned within a given type of objects.

This provision defines the three main types of objects in reference to which all other data is collected. It is so because everything happens in a specific point in space which can be defined (thus a reference to an addressable spatial object exists), in relation to activity of a particular person (explicitly identifiable through PESEL number) or operations of a specific entity (explicitly identifiable through REGON number). Among the information which is to be gathered under the WMIS there are personal details, incl. names and surnames, addresses, contact details and phone numbers of natural persons. The scope of this data should be commensurate to the goal of data's processing and consistent with the specific provisions which order gathering such data.

The varied personal details may also end up as specific information in other groups of information indicated in the attachment to the designed ordinance, including ending in copies of documents (Water Law permits, Water Law assessments, Water Law reports and integrated permits). This information may include the information regarding entrepreneurs who are natural persons – in this case the basic data identifying the entrepreneurs is public. This information may also concern natural persons representing entrepreneurs. The information collected by the WMIS, defined in general terms in individual groups in the ordinance, also contains the information regarding persons who are a party to administrative decisions as well as persons who made the decisions or participated in the decision-making process as well as the information regarding natural persons. We must bear in mind the diverse character of the personal

data and that the specific provisions which may order disclosure of the specific data (e.g. the data of persons entitled to fish in a fishing district) are of decisive importance. Therefore it is necessary to analyze what personal details are collected in the WMIS and to what extent this data should be protected on the grounds of the binding legal provisions. In submitting personal details or copies of documents containing personal details in the WMIS an assessment must be carried out regarding acceptability of making this type of date available. In circumstances when personal details should not be commonly available and a document is subject to sharing the process of anonymization must be conducted in order to prevent ascertaining identity of a person to which the data pertains. The same rules for verifying the acceptability of sharing the data should also concern processing undisclosed information and the information which constitute statutory protected secrets.

The Hydroportal

Defining the role and place of the Hydroportal under the WMIS, or rather defining their relation in regards to processing data in the WMIS and the Hydroportal, is necessary. Consistently with art. 240, section 2, point 12 of the Water Law the National Water Economy Authority develops and maintains the Hydroportal as the central access point referred to in art. 332, section 3. In analysis of the provisions of art. 332, section 3 of the Water Law according to which Polish Waters maintain the Hydroportal as a node of the national spatial information infrastructure and the access point to the services discussed in art. 9 of of the act of 4th March 2012 regarding spatial information infrastructure as well as other information pertaining to managing waters we must emphasize that a wide range of implementations of the indicated services was adopted. Currently the Hydroportal as a public service concerning broadly understood issue of water in the area of Poland enables its users to browse the data concerning flood risk, counteracting drought or presentation of water management plans.

Consistently with the premises of data integration the Hydroportal contains a range of data collected in one place. In its design the Hydroportal is to serve as a component of the WMIS utilized to search and browse the contained data. Currently it is only possible to print out a screenshot of the data. The WMIS feeds publication databases of the Hydroportal. In turn, in the context of developing and modifying the WMIS and in the context of open data, in regards to maintaining the Hydroportal it may be assumed that the portal is developing towards implementation of further services of copying, generating and downloading a part of or whole documents, i.e. all the services indicated in art. 9 of the INFSPact. It is a direction for development valid also from the perspective of utilizing the potential of the data contained in the WMIS in the context of digital transformation as discussed in the draft of the new Integrated State Informatization Programme of May 2019 which draws attention to the potential of the data in the process of digital transformation.

Regulations for operations of the Hydroportal were published (Regulamin korzystania z Hydroportalu). As stipulated by §2, section 1 of the regulations the data

presented in the Hydroportal is solely illustrative in character and cannot be treated as an official document under any circumstances. This data also cannot serve as a basis for any administrative or official actions or legal claims. Furthermore, §4, section 3 stipulates that the Administrator does not bear any responsibility for the damages caused due to improper use of the information posted in the Hydroportal. No responsibility can be claimed for lost profits. It is even more so surprising due to the fact that the Hydroportal is supposed to serve as a reflection of the data contained in the WMIS which is openly available. The regulations worded in this manner rise reservations concerning credibility of the data collected under the WMIS. The regulations for processing data under the Hydroportal should be defined in an act-rank document if it is a system maintained by an appropriate body and if the system reflects the data processed and available in the WMIS system. If the WMIS operating as a public register processes the information which form a foundation for the water economy and feeds the data to the Hydroportal with the goal of rendering the service of browsing the data the assumption that the data contained therein is incorrect is unacceptable.

The WMIS as a public register

The WMIS is also a public register. Consistently with art. 3, point 5 of the ITact a public register is understood as a register, a filing system, a list or any other form of registry which is used for realization of public tasks, is maintained by a public entity on the basis of separate statutory provisions. The WMIS is maintained by a public entity on the basis of separate statutory provisions and it contains information defined by legal provisions collected under an organized structure. A public entity maintaining a public register is obliged to: maintain said register in a manner ensuring meeting the minimal criteria for a computerized IT system if the said system operates on a basis of computerized IT systems; to maintain said register consistently with the minimal requirements for public registers and exchange of information in an electronic form; and to enable inputting information into this register and sharing information from this register through electronic means if said register operates through utilizing computerized IT systems.

The discussed minimum requirements are indicated in the National Interoperability Framework ordinance. Consistently with §11 of the National Interoperability Framework ordinance a public entity maintaining a public register sharing information contained in this register through exchange is obliged to ensure accountability of such operation. An appropriate level of accountability (ensured through analysis of actions of users and system objects, monitoring automatic system logs and discovering other irregularities) is a crucial element of supervising security and safety. The computerized IT systems utilized by the entities realizing public tasks must be obligatory furnished with the tools ensuring full accountability for actions of users or system objects within the range defined by the risk analysis. The idea is to maintain a reasonable balance between security of the system and possible dangers. It is known that the greatest threat to a computerized IT system and the data contained and processed therein is humans –

irrespectively of them being an employee of the entity managing the system or an outside person. The motives behind actions of a person presenting a threat, whether such individual is aware of the effects of his actions or not, are irrelevant. Ongoing, periodic analysis of system logs (records contained in the logs) enables controlling and preventing the attempts at breaching integrity of the data, infecting the system, effecting actions beyond control of other users or carried out through non-authorized persons attempting to effect any actions within the system (Martysz et al., 2015).

The intentionality of collecting this or other data in a register is justified through the necessary functionality. This functionality boils down to e.g. enabling realization of public tasks by other public entities under the assumption of the possibility of utilizing a public register or through referencing the reference data directly (§13, section 2 of the National Interoperability Framework ordinance) or through exchange of the data under a different mode (§13, section 3 of the National Interoperability Framework ordinance). Public registers serve various purposes (Oleński, 2006, p. 539; Stawecki, 2005). One of the primary assumed functions of public registers is the cadastral function, at times referred to as the cadastral-registry function. We may indicate that its primary goal is to maintain a complete and perfectly ordered collection of information of a specific type. The goal of a body maintaining a register is collecting specific information and preserving it, primarily through making appropriate entries in registry books: files, databases etc. as well as storing documents. The cadastral function is frequently based on a register assigning identification numbers or symbols later utilized in other aspects and disciplines of life, including utilizing the assigned identifiers in other registers. Analyzing the provisions of art. 329, section 2, point 20 of the Water Law we discover that the Water Management Information System aggregates the information regarding water management, in particular the information concerning land improvement hardware and improved lands indicated in art. 196, section 1. Article 329, section 2 point 20 of the Water Law serves as a foundation for legislator's intention regarding integrating the water management data in a single information system. Integrating databases instead of developing separate computerized IT systems is recommended in order to service the assets from a single category. It is also consistent with the direction indicated in the draft of the new National Integrated Informatisation Programme – the development programme for the 2018–2022 period (May 2019) according to which the interoperability will enable efficient cooperation of institutions in the field of realizing complex administrative processes and will benefit information exchange. The National Integrated Informatisation Programme demonstrates the problems regarding multiplying data on the central, regional and local levels, lack of further use of the data to a satisfying degree resulting in increasing expenditures on collecting data and inconsistencies of information. Scattered and uncoordinated IT resources management results in significant costs related to developing and maintaining public systems and registers.

Ultimately the continuously updated databases, registers and repositories of data for the entirety of the public administration are to be established which will eliminate the need for constantly repeating a number of operations related to realization of daily

tasks. The data collected in the public systems and registers will enable methodical analysis of said data which will support implementation of public policies and the national decision making process. Implementation of the WMIS appears to meet these premises and facilitate the drive for nullifying the reported problems; furthermore, the WMIS presents an opportunity of avoiding or eliminating said problems altogether.

Conclusions

The Water Management Information System is supposed to provide processes in the field of: collecting data – consisting of inputting new data, frequently from varied sources, into the system; updating data – ensuring that the data contained in the WMIS remains topical and up-to-date in regards to the reference data. The reference data comprise the core of the database forming the WMIS in this meaning that the reference data serves as a departure point for numerous other data. Therefore the quality of reference data is a prerequisite for the quality of the entire system. Sharing the data is the last process – it is the most diverse and varied process during which various optional forms of the system operations emerge – an administrative decision (denying access), a material and technical action (making the information available, passing the application consistently with its properties), other acts or actions from the field of public administration operations (the information regarding due fee) etc.

Processing data in the field of water management is highly desirable and possible; however, it hinges on meeting the specified technical and technological conditions primarily regarding the data format, guaranteeing topicality and credibility of data and ensuring remote access to the data without the need for authentication as well as guaranteeing anonymization of the personal details and protecting the remaining statutory secrets. The WMIS is maintained under a computerized IT system and is to ensure the opportunity for searching for, browsing and visualizing map compositions for data sets as well as conducting spatial analyzes. The WMIS is to serve as a tool for controlling the water economy which on one hand is supposed to determine the range of competences of administrative bodies and on the other is supposed to indicate the need for taking into consideration and reconciling the interests of individual entities with the public interest. Establishing and developing the WMIS faces certain obstacles in the form of lack of cohesion between the databases which constitute a source of the data for the WMIS. Furthermore, the blurred responsibility of the entities for credibility and quality of the inputted data is also noticeable. The premises of operations of the WMIS should be assessed positively; however, it is necessary to ensure interoperability which will enable greater and broader access to the data contained in the WMIS and will result in the data being credible and capable of serving as a foundation for developing further information necessary in the decision-making process. Only meeting these requirements will result in increasing confidence of citizens in the digital services rendered by the public administration.

References

Bartman J., Sobczyński D. (2015). Dane przestrzenne w relacyjnych bazach danych *(Spatial data in relational databases)*. Edukacja-Technika-Informatyka, vol. 6.

Chmielarz W.(1996). Systemy informatyczne wspomagające zarządzanie. Aspekt modelowy w budowie systemów *(IT systems assisting management. Model aspect in developing systems)*, Warszawa.

Domański R. (2007). Gospodarka przestrzenna. Podstawy teoretyczne *(Spatial Economy: Theoretical Basics)*. Warsaw, p. 28.

Fajfer P. (2011). Wdrożenie systemu informatycznego – korzyści płynące z użytkowania systemu ERP *(Implementation of an IT system – benefits of utilizing an ERP system)*. Organizacja i zarządzanie, no. 2.

Ficoń K. (1998). Logistyczne systemy informacyjne podstawą budowy informatycznych systemów zarządzania *(Logistical information systems as a foundation for developing computer management systems)*. In: Systemy logistyczne Wojsk *(Military logistical systems)*. Warsaw.

Flaga-Gieruszyńska K. (2018). Status danych przestrzennych jako środka dowodowego w postępowaniu cywilnym *(Status of spatial data as a mode of proof in civil litigation).* In: G. Szpor, K. Czaplicki (ed.), *Internet. Informacja przestrzenna (The Internet. Spatial information).* Warsaw, SIP Legalis.

Ganczar M. (2020). Wdrożenie dyrektywy INSPIRE do krajowego porządku prawnego w zakresie budowy infrastruktury informacji przestrzennej *(Implementation of the INSPIRE directive into the legal order in the field of developing spatial information infrastrucutre).* Studia Prawnicze KUL, no. 3, pp. 91–115. https://doi.org/10.31743/sp.7327.

Ganczar M. (2021). The infrastructure of spatial information as an example of opening public sector data in Poland. GIS Odyssey Journal, vol. 1, no. 1, pp. 163–176. https://doi.org/10.57599/gisoj.2021.1.1.163.

Hauser R., Niewiadomski Z., Wróbel A. (2018). Publiczne prawo gospodarcze, System prawa administracyjnego *(Public Economic Law, Administrative Law System)*, vol. 8b. Wydawnictwo C.H. Beck, Warsaw.

Janczak J. (2011). Systemy informatyczne wspomagania zarządzania i dowodzenia *(IT systems assisting in management and leadership)*. Warsaw.

Jankowska M. (2017). Charakter prawny mapy cyfrowej *(The legal character of a digital map)*. Warsaw, SIP Lex.

Kisielnicki J., H. Sroka (2015). Systemy informacyjne biznesu *(Business information systems)*. Warsaw.

Kucyk J. (2013). Nowoczesne technologie w logistyce *(Modern technologies in logistics).* Warsaw.

Kuraś M. (2009). System informacyjny a system informatyczny – co oprócz nazwy różni te dwa obiekty *(An information system and an IT system – what apart of a name differentiates these object)*. Zeszyty Naukowe UEK, issue 770.

Linsenbarth A., Ney B. (1999). Koncepcja Systemu Informacji Przestrzennej w Polsce – stan prac *(The concept of Spatial Information System in Poland – state of works)*. In: Informacja przestrzenna w gospodarce regionalnej *(Spatial information in regional economy)*. Warsaw.

Martysz C., Szpor G., Wojsyk K. (2015). Ustawa o informatyzacji działalności podmiotów realizujących zadania publiczne. Komentarz *(The act on digitization of operations of the entities realizing public tasks. Commentary)*, second edition.

Ministerstwo Gospodarki Morskiej i Żeglugi Śródlądowej *(Ministry of Marine Economy and Inland Navigation)* (2018). https://gospodarkamorska.bip.gov.pl/gospodarka-wodna-legislacja/117358_projekty-rozporzadzen.html [access: 15.11.2022].

Miś R., Strzeliński P., Węgiel A. (2001). Systemy informacji przestrzennej w leśnictwie i ochronie środowiska leśnego *(Spatial information systems in forestry and forest environment protection)*.

Oleński J. (2006). Infrastruktura informacyjna państwa w globalnej gospodarce *(National information infrastructure in global economy)*. Warsaw.

Regulamin korzystania z Hydroportalu *(Regulations of using Hydroportal).* https://www.isok.gov.pl/regulamin.html [access: 15.11.2022].

Stawecki T. (2005). Rejestry publiczne. Funkcje instytucji *(Public registers. Duties of institutions).* Warsaw.

Szpor G. (1998). Informacja w zagospodarowaniu przestrzennym. Zagadnienia administracyjnoprawne *(Information in spatial planning. Admministration and legal issues).* Katowice.

Walasek J. (2015). Projektowanie systemu informacyjnego organizacji *(Designing an information system for an organization)*. Zeszyty Naukowe Politechniki Śląskiej, series: Transport, issue 87.

Zawadzki S.M. (1969). *Podstawy planowania regionalnego (Basics of regional planning)*. Warsaw, p. 118.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.59

Luka Mamić[1], Gordana Kaplan[2], Mateo Gašparović[3]

FUSING MULTIPLE OPEN-SOURCE REMOTE SENSING DATA TO ESTIMATE $PM_{2.5}$ AND PM_{10} MONTHLY CONCENTRATIONS IN CROATIA

Abstract: The objective of this study is to create a methodology for accurately estimating atmospheric concentrations of $PM_{2.5}$ and PM_{10} using Sentinel-5P and other open-source remote sensing data from the Google Earth Engine (GEE) platform on a monthly basis for June, July and August which are considered as months of non-heating season in Croatia, and December, January and February, which, on the other hand, are considered as months of the heating season. Furthermore, machine learning algorithms were employed in this study to build models that can accurately identify air quality. The proposed method uses open-source remote sensing data accessible on the GEE platform, with in-situ data from Croatian National Network for Continuous Air Quality Monitoring as ground truth data. A common thing for all developed monthly models is that the predicted values slightly underestimate the actual ones and appear slightly lower. However, all models have shown the general ability to estimate $PM_{2.5}$ and PM_{10} levels, even in areas without high pollution. All developed models show moderate to high correlation between in-situ and estimated $PM_{2.5}$ and PM_{10} values, with overall better results for $PM_{2.5}$ than for PM_{10} concentrations. Regarding $PM_{2.5}$ models, the model with the highest correlation ($r = 0.78$) is for January. The PM_{10} model with the highest correlation ($r = 0.79$) is for December. All things considered, developed models can effectively detect all $PM_{2.5}$ and PM_{10} hotspots.

Keywords: air quality, TROPOMI, machine learning, $PM_{2.5}$, PM_{10}, remote sensing

Received: 2 November 2022; accepted: 14 December 2022

[1] Sapienza University of Rome, Department of Civil, Building and Environmental Engineering, Rome, Italy, ORCID ID: https://orcid.org/0000-0001-9877-0174, email: luka.mamic@uniroma1.it
[2] Eskisehir Technical University, Institute of Earth and Space Sciences, Eskisehir, Turkey, ORCID ID: https://orcid.org/0000-0001-7522-9924, email: kaplangorde@gmail.com
[3] University of Zagreb, Faculty of Geodesy, Chair of Photogrammetry and Remote Sensing, Zagreb, Croatia, ORCID ID: https://orcid.org/0000-0003-2345-7882, email: mateo.gasparovic@geof.unizg.hr

Introduction

The World Health Organization (WHO) estimates that 99 percent of the world's population breaths air that exceeds their guidelines. The cumulative impacts of air pollution result in over seven million premature deaths annually, making it a serious threat to both human health and the environment (Air pollution, URL 1).

Since it has been shown that particulate matter (PM) is dangerous to human health (Pope III & Dockery, 2006, Anderson et al., 2012; Kim et al., 2015; Kumar et al., 2022), it has received significant attention among air pollutants. Based on their aerodynamic diameter, airborne particles are classified as coarse (i.e., PM_{10}, particles with an aerodynamic diameter less than or equal to 10 μm) or fine (i.e., $PM_{2.5}$, particles with an aerodynamic diameter less than or equal to 2.5 μm).

Even a 10 $g/\mu m^3$ increase in PM_{10} has been shown to increase the chance of hospitalization for myocardial infarction. Furthermore, even a few hours of exposure to high levels of $PM_{2.5}$ increases the risk of myocardial infarction in a high-risk group (Polichetti et al., 2009).

Source and chemical composition of $PM_{2.5}$ and PM_{10} changes in time and space due to various parameters, such as human activity, natural hazards, temperature changes and others (Kelly & Fussell, 2012; Clemente et al., 2022; Gautam et al., 2022; Singh et al., 2022). Therefore, ground stations are commonly used to monitor $PM_{2.5}$ and PM_{10} concentrations but are limited to local areas and are unable to show a broad view (Li et al., 2020). That being said, predicting $PM_{2.5}$ and PM_{10} atmospheric concentrations over larger areas still remains a challenge. However, approaches based on remote sensing have lately been developed. Several studies have been done so far on estimating ambient PM concentrations ($PM_{2.5}$ and PM_{10}) using observations from remote sensing satellites (Li et al., 2021; Wang et al., 2021; Han et al., 2022).

Li et al. (2021) provided a review of the two-step methods for estimating $PM_{2.5}$, which first retrieve the aerosol optical depth (AOD) and then estimate $PM_{2.5}$ from the AOD with other supplemental data containing the temporal or spatial variation impact on $PM_{2.5}$. The new approach for estimating PMs comes with the launch of the first Copernicus mission on monitoring air quality, Sentinel-5P TROPOMI, which offers daily measured ozone (O_3), methane (CH_4), formaldehyde (HCHO), carbon monoxide (CO), nitrogen oxide (NO_2), sulphur dioxide (SO_2), and aerosol index (AI) in the atmosphere. Therefore, Wang et al. (2021) proposed a methodology for $PM_{2.5}$ and PM_{10} estimation over China using TROPOMI and assimilated datasets, and compared it with the traditional approaches which are using AOD data. Their conclusion was that the TROPOMI data have great potential in this topic and fix the issue due to the missing AOD data. More recently, Han et al. (2022) created spatially continuous maps of $PM_{2.5}$ concentrations over Thailand using TROPOMI, elevation, and regulatory grade ground station data.

This research follows a similar approach fusing TROPOMI with multiple open-source remote sensing data from the Google Earth Engine (GEE) platform to create a new method for accurately estimating atmospheric concentrations of $PM_{2.5}$ and PM_{10}

over Croatia for six chosen months. The new approach proposed by this study combines air pollution, meteorological and geographical data to create new parameters in order to answer the questions of $PM_{2.5}$ and PM_{10} composition in Croatia and improve the stability and accuracy of developed models. Due to the variation of air pollutants between the non-heating and heating seasons (Xiao et al., 2015; Cichowicz et al., 2017) modelling was done for June, July, and August which are considered as months of the non-heating seasons in Croatia, and December, January, and February, which, on the other hand, are considered as months of the heating season. Therefore, the objectives of this study are to develop $PM_{2.5}$ and PM_{10} models for months of non-heating and heating season in Croatia.

Furthermore, Random Forest machine learning algorithm, widely used when estimating $PM_{2.5}$ and PM_{10} (Stafoggia et al., 2019; Shao et al., 2020; Zhao et al., 2020; Yang et al., 2020), was employed in this study to build models that can accurately identify air quality. The results showed that new approach developed by this study estimates $PM_{2.5}$ and PM_{10} accurately and, most importantly, can be easily adopted to new study areas.

Materials and methods

In-situ data. There are 71 ground stations in the Croatian National Network for Continuous Air Quality Monitoring (Fig. 1.), but only 31 measure $PM_{2.5}$ and 54 measure PM_{10} in the atmosphere.

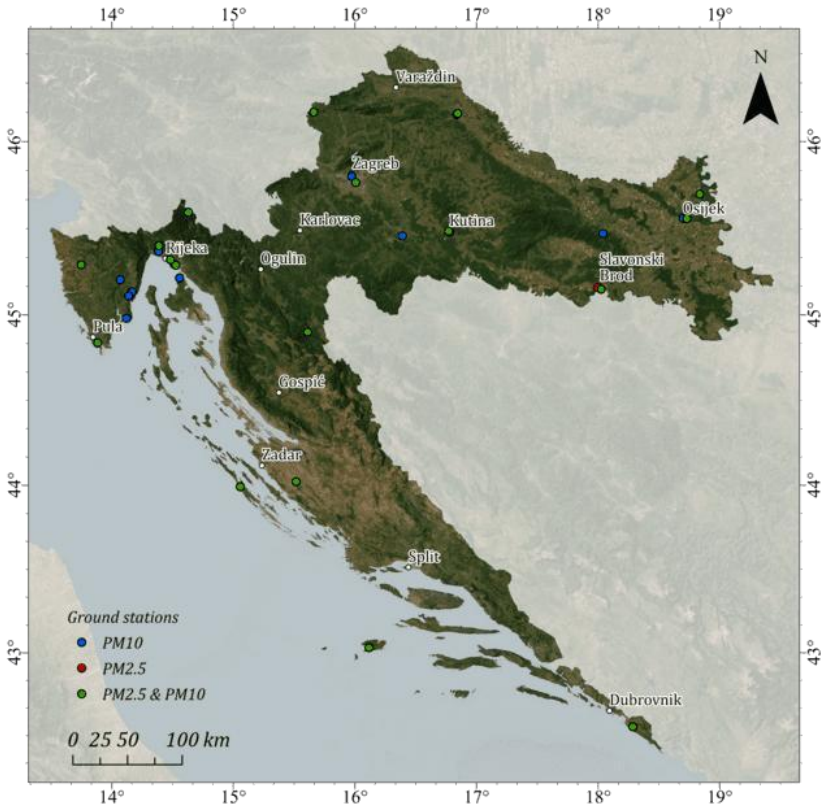


Fig. 1. Croatian National Network for Continuous Air Quality Monitoring
Source: own study

Every hour, automatic stations measure $PM_{2.5}$ and PM_{10} as $\mu g/m^3$. All data is stored and publicly accessible on the Croatian National Network for Continuous Air Quality Monitoring's official website (Kvaliteta zraka u Republici Hrvatskoj, URL 2).

$PM_{2.5}$ and PM_{10} raw hourly data in Excel format (.xls) were downloaded for all stations for June, July, August, and December 2021, as well as for January and February 2022. Furthermore, some data for the observed time range were missing or invalid, so finally data from 20 ground stations were used to estimate $PM_{2.5}$ for all months and PM_{10} from 30 for June, July and August and from 32 for December, January and February. Additionally, ground measurements that were too high or too low compared to the rest of the dataset were removed. Finally, in-situ data was matched to remote sensing data.

Sentinel-5P TROPOMI data. The main data used to estimate the $PM_{2.5}$ and PM_{10} values in this study was TROPOMI data from GEE.

Every day, the Sentinel-5P mission collects data that are used to monitor and forecast air quality, climatic conditions, ozone, and ultraviolet radiation levels. It is the satellite mission launched on October 13, 2017, carrying the Tropospheric Monitoring Instrument (TROPOMI), and it is the first in a series of atmospheric observing systems within Copernicus, the European Union's Earth observation program (Kleipool et al., 2018).

TROPOMI can observe and monitor air pollution from hotspots such as large cities, and industrial areas (Borsdorff et al., 2018; Kaplan & Avdan, 2020). Furthermore, the main topic of this study is to explore the potential of Sentinel-5P data to estimate $PM_{2.5}$ and PM_{10}, both of which are important in determining air quality.

Preprocessed L3 TROPOMI data of AI, CO, HCHO, NO_2, O_3, SO_2 were used for modelling. CH_4 data is missing for all observed periods, and SO_2 data is missing for the winter months (December 2021, January, and February 2022). Furthermore, due to the increased number of cloudy days during the winter months, some CO, HCHO, and NO_2 data are missing. Moreover, due to the reported systematic error for measuring the AI until July 2021, AI data from June was also excluded from the modelling. The unit of TROPOMI measured CO, HCHO, NO_2, O_3, and SO_2 is mol/m^2.

Based on the fact that TROPOMI captures images over Croatia every day between 10:00 AM and 1:00 PM CET, the TROPOMI data were matched with the in-situ data for the precise hour.

Assimilated data. Other meteorological and geographical data from the GEE platform were used to improve the models.

Through its Global Forecast System, the National Oceanic and Atmospheric Administration (NOAA) provides a dataset consisting of selected model outputs as gridded forecast variables (GFS). The 384-hour forecast includes a 3-hour forecast interval and a 6-hour temporal resolution (i.e., updated four times daily). It is a coupled model composed of an atmospheric model, an ocean model, a land/soil model, and a sea ice model, all of which work together to create a realistic representation of meteorological conditions (GFS: Global Forecast System 384-Hour Predicted Atmosphere Data, URL 3).

GFS data used in this study are land surface temperature 2 m above the ground in °C (LST), specific humidity 2 m above ground in kg/kg (kilogram of water per kilogram of air) (HUM), and U and V component of wind 10 m above ground in m/s (U-WIND and V-WIND).

Elevation (DEM) and slope for the ground station locations were extracted from NASA's Shuttle Radar Topography Mission (SRTM) with a spatial resolution of 30 meters (Farr et al., 2007).

Soil pH data at ground level for all stations were extracted from the map made by Hengl in 2018 with a resolution of 250 m.

Parameters. The original TROPOMI parameters and the assimilated datasets are shown in Table 1.

Table 1. Original parameters

Parameter	Description	Source	Unit	Temporal resolution	Spatial resolution
AI	Aerosol index	TROPOMI	/	daily	1113.2 m
CO	Carbon monoxide	TROPOMI	mol/m^2	daily	1113.2 m
HCHO	Formaldehyde	TROPOMI	mol/m^2	daily	1113.2 m
NO_2	Nitrogen dioxide	TROPOMI	mol/m^2	daily	1113.2 m
O_3	Ozone	TROPOMI	mol/m^2	daily	1113.2 m
SO_2	Sulphur dioxide	TROPOMI	mol/m^2	daily	1113.2 m
LST	Land surface temperature	NOAA	°C	6 hours	27 890 m
HUM	Specific humidity	NOAA	kg/kg	6 hours	27 890 m
U-WIND	Eastward wind	NOAA	m/s	6 hours	27 890 m
V-WIND	Northward wind	NOAA	m/s	6 hours	27 890 m
DEM	Elevation	NASA SRTM	m	/	30 m
SLOPE	Slope	NASA SRTM	°	/	30 m
SOIL_pH	Soil pH	Hengl 2018	pH*10	/	250 m

Source: own study

Using the main data (TROPOMI) and the assimilated data, new parameters for the modelling were created to improve the stability of the models (Table 2).

The parameters listed above were created based on the things they have in common (i.e., NO_2 and SO_2 have the same chemical structure, are both inorganic and react similarly). Furthermore, some were created solely as normalized ratios, while others were merged based on their source (i.e., WHT is a parameter composed of wind components, humidity, and temperature).

Table 2. Created parameters

Parameter
$(NO_2+SO_2)/(NO_2-SO_2)$
NO_2/SO_2
HCHO/CO
(CO+HCHO)/CO-HCHO)
$O_3/(NO_2+SO_2+CO)$
$AI*(NO_2/SO_2)$
$O_3/(NO_2/SO_2)$
$O_3/((NO_2+SO_2)/(NO_2-SO_2))$
$SQRT(1/(NO_2+SO_2+O_3))$
(AI+HUM)/(AI-HUM)
(AI+DEM)/(AI-DEM)
$(CO+NO_2)/CO-NO_2)$
$(CO+O_3)/(CO-O_3)$
WIND[1]
WHT[2]
(WHT+AI)/(WHT-AI)
$(WHT+O_3)/(WHT-O_3)$
$(CO+SO_2)/(CO-SO_2)$
S5[3]
(S5+WHT)/(S5-WHT)
(S5+WIND)/(S5-WIND)

[1](U-WIND + V-WIND)/2, [2](((U-WIND + V-WIND)/2)+HUM+LST)/3,
[3](AI+CO+HCHO+NO_2+O_3+SO_2)/6

Source: own study

Modelling with Weka. The Waikato Environment for Knowledge Analysis (Weka) is a large collection of Java class libraries that implement a wide range of state-of-the-art machine learning and data mining algorithms (Witten et al., 1999).

Weka is open-source software with tools for data preprocessing, classification, regression, clustering, association rules, and visualization that is licensed under the GPL (General Public License).

Before modelling, selecting only the best parameters for each model was necessary. This was done using Weka's Classifier subset evaluator tool for the Random Forest algorithm with a percentage split of 70. Once the best parameters were found, all remaining were removed, and the Random Forest classifier was used with data split into training and testing portions of 70% and 30%, respectively.

The Random Forest classifier comprises a group of tree classifiers, each of which is generated using a random vector sampled independently from the input vector. Each tree casts a unit vote for the most popular class to classify an input vector (Pal, 2005).

The basic idea behind Random Forest is a simple but powerful one – the wisdom of crowds. The Random Forest model works so well because a large number of relatively

uncorrelated models (trees) acting as a committee will outperform any of the individual constituent models (Understanding Random Forest, URL 4).

The model was saved once it was developed. All models in this study are created using the same procedure as described above.

The number of instances and parameters used to create each model is shown in Table 3 below.

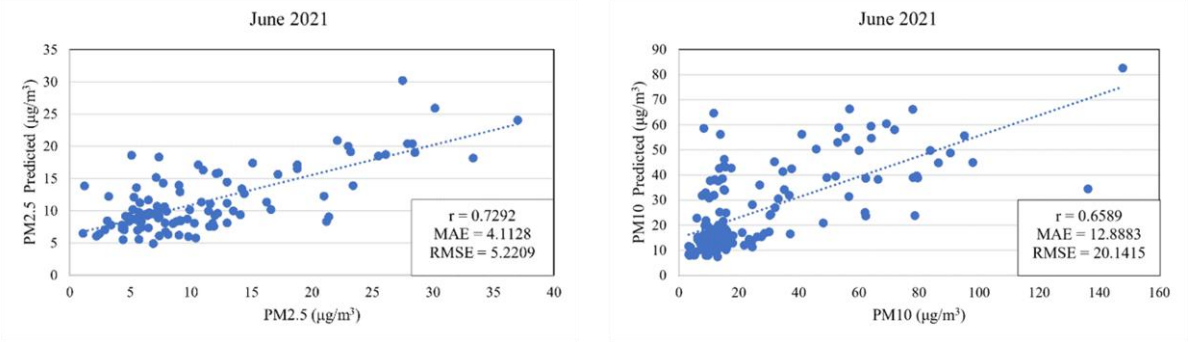
Table 3. Number of instances used to create each model

Model	Pollutant	Number of instances	Number of parameters
June	$PM_{2.5}$	350	12
June	PM_{10}	484	5
July	$PM_{2.5}$	271	4
July	PM_{10}	364	18
August	$PM_{2.5}$	331	11
August	PM_{10}	459	10
December	$PM_{2.5}$	178	6
December	PM_{10}	268	6
January	$PM_{2.5}$	280	7
January	PM_{10}	478	6
February	$PM_{2.5}$	232	10
February	PM_{10}	363	7

Source: own study

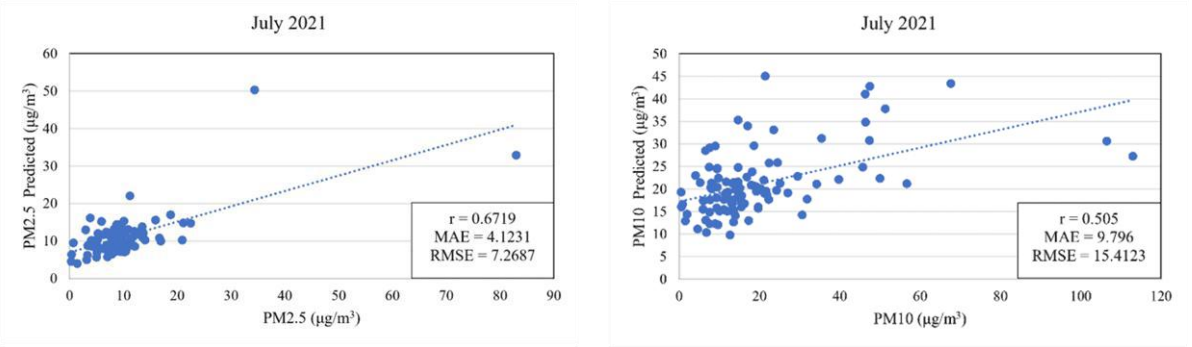
Results and discussion

The monthly $PM_{2.5}$ and PM_{10} models were developed, as noted before, using the Random Forest algorithm with a 70% split, and are shown in Fig. 2.–7. with their correlation coefficient (r), mean absolute error (MAE), and root mean squared error (RMSE).



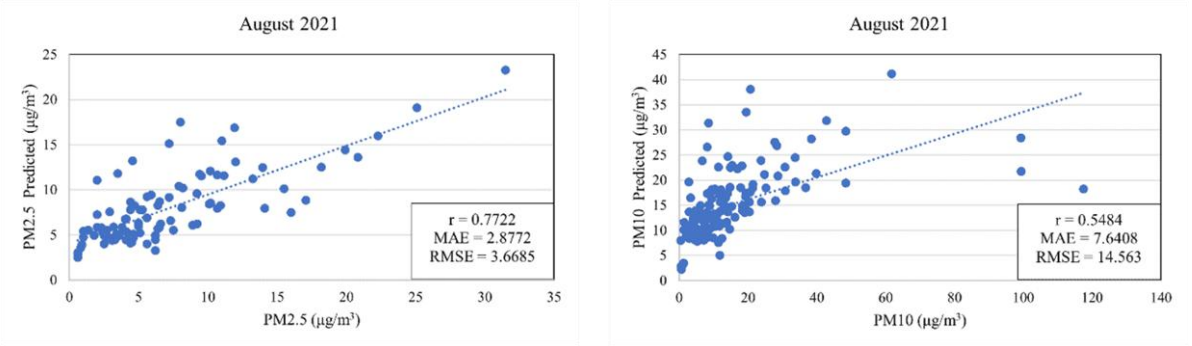
(a) (b)

Fig. 2. June prediction models for: (a) $PM_{2.5}$ (b) PM_{10}
Source: own study



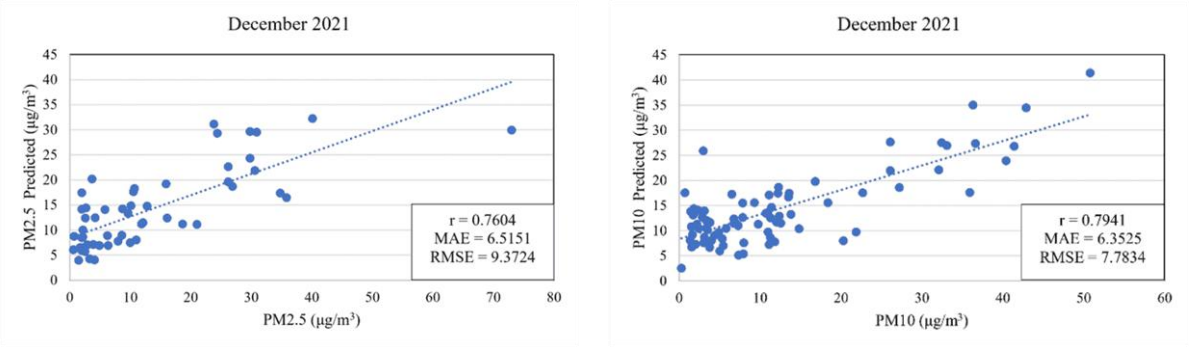
(a) (b)

Fig. 3. July prediction models for: (a) $PM_{2.5}$ (b) PM_{10}
Source: own study



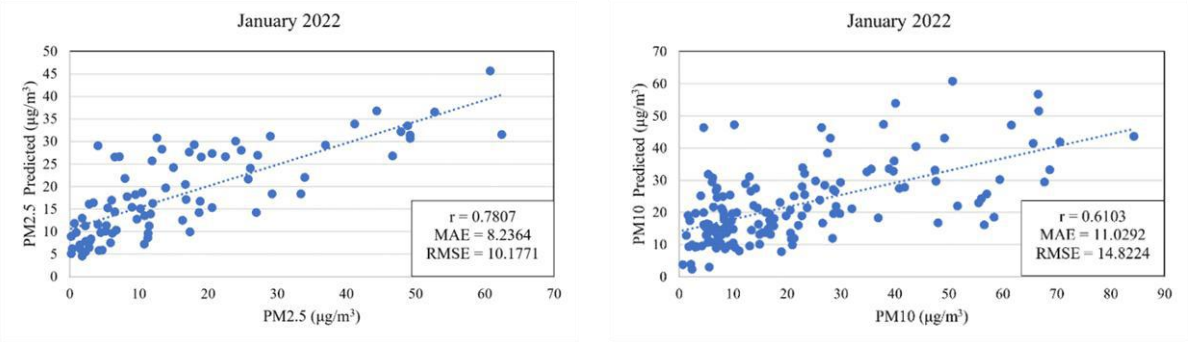
(a) (b)

Fig. 4. August prediction models for: (a) $PM_{2.5}$ (b) PM_{10}
Source: own study



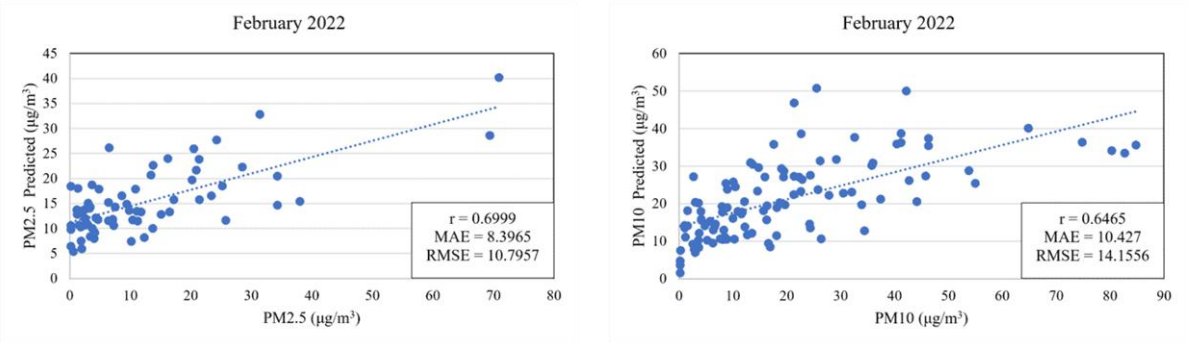
(a) (b)

Fig. 5. December prediction models for: (a) $PM_{2.5}$ (b) PM_{10}
Source: own study



(a) (b)

Fig. 6. January prediction models for: (a) $PM_{2.5}$ (b) PM_{10}
Source: own study



(a) (b)

Fig. 7. February prediction models for: (a) $PM_{2.5}$ (b) PM_{10}
Source: own study

All monthly models give moderate to high correlation, with overall better results for $PM_{2.5}$ than for PM_{10}. Regarding $PM_{2.5}$ models, the one with the lowest correlation is for July with r = 0.67 (MAE = 4.12 µg/m³, RMSE = 7.27 µg/m³), and on the contrary, the one with the highest correlation is for January with r = 0.78 (MAE = 8.24 µg/m³, RMSE = 10.18 µg/m³). On the other hand, the PM_{10} model with the lowest correlation is also the one for July with r = 0.51 (MAE = 9.80 µg/m³, RMSE = 15.41 µg/m³), and the highest for December with r = 0.79 (MAE = 6.35 µg/m³, RMSE = 7.78 µg/m³).

The attributes chosen to build $PM_{2.5}$ and PM_{10} monthly models can give us a better understanding of each exact model. The selected parameters used to develop mentioned models and estimate $PM_{2.5}$ and PM_{10} monthly values are shown in Table 4.

What can be noticed is that the PM_{10} model for July used the highest number of parameters to develop, 18 to be exact, and it came out as the one with the lowest overall correlation. Furthermore, the $PM_{2.5}$ model for July used only four parameters, and even its accuracy is the lowest among $PM_{2.5}$ monthly models, it is still better than most of those for PM_{10}. The most common number of used parameters ranges from five to 12.

Table 4. Parameters used to develop $PM_{2.5}$ and PM_{10} monthly models

Pollutant	Month	Parameters
$PM_{2.5}$	June	O_3, SO_2, HUM, U-WIND, DEM, (CO+HCHO)/(CO-HCHO), O_3/(NO_2+SO_2+CO), O_3/(NO_2/SO_2), SQRT(1/(NO_2+SO_2+O_3)), (CO+O_3)/(CO-O_3), WIND[1], (CO+SO_2)/(CO-SO_2).
PM_{10}	June	HUM, SOIL_pH, DEM, SLOPE, SQRT(1/(NO_2+SO_2+O_3)).
$PM_{2.5}$	July	SO_2, DEM, NO_2/SO_2, O_3/((NO_2+SO_2)/(NO_2-SO_2)).
PM_{10}	July	HUM, U-WIND, SOIL_pH, DEM, SLOPE, (NO_2+SO_2)/(NO_2-SO_2), NO_2/SO_2, AI*(NO_2/SO_2), O_3/(NO_2/SO_2), O_3/((NO_2+SO_2)/(NO_2-SO_2)), (AI+HUM)/(AI-HUM), (AI+DEM)/(AI-DEM), (CO+NO_2)/(CO-NO_2), (CO+O_3)/(CO-O_3), WIND, (WHT[2]+AI)/(WHT-AI), (WHT+O_3)/(WHT-O_3), (S5[3]+WIND)/(S5-WIND).
$PM_{2.5}$	August	O_3, SO_2, LST, DEM, SLOPE, (CO+HCHO)/(CO-HCHO), O_3/(NO_2+SO_2+CO), O_3/((NO_2+SO_2)/(NO_2-SO_2)), (CO+NO_2)/(CO-NO_2), (CO+O_3)/(CO-O_3), WHT, (WHT+AI)/(WHT-AI).
PM_{10}	August	V-WIND, SOIL_pH, DEM, SLOPE, O_3/(NO_2+SO_2+CO), SQRT(1/(NO_2+SO_2+O_3), (CO+NO_2)/CO-NO_2), (WHT+AI)/(WHT-AI), (CO+SO_2)/(CO-SO_2), (S5+WIND)/(S5-WIND).
$PM_{2.5}$	December	O_3, U-WIND, DEM, SLOPE, HCHO/CO, (CO+HCHO)/(CO-HCHO).
PM_{10}	December	NO_2, O_3, DEM, SLOPE, (CO+O_3)/(CO-O_3), (WHT+AI)/(WHT-AI).
$PM_{2.5}$	January	CO, NO_2, HUM, SLOPE, HCHO/CO, (CO+NO_2)/(CO-NO_2), (CO+O_3)/(CO-O_3).
PM_{10}	January	SOIL_pH, DEM, SLOPE, WIND, WHT, (WHT+O_3)/(WHT-O_3).
$PM_{2.5}$	February	CO, NO_2, O_3, LST, HUM, V-WIND, SOIL_pH, (AI+DEM)/(AI-DEM), WHT, (WHT+O_3)/(WHT-O_3).
PM_{10}	February	AI, O_3, HUM, SOIL_pH, DEM, SLOPE, (WHT+AI)/(WHT-AI).
$PM_{2.5}$	June	O_3, SO_2, HUM, U-WIND, DEM, (CO+HCHO)/(CO-HCHO), O_3/(NO_2+SO_2+CO), O_3/(NO_2/SO_2), SQRT(1/(NO_2+SO_2+O_3)), (CO+O_3)/(CO-O_3), WIND[1], (CO+SO_2)/(CO-SO_2).

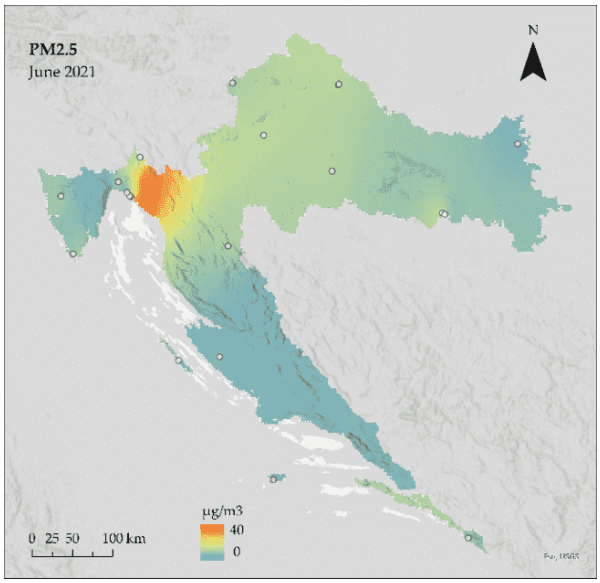
[1](U-WIND + V-WIND)/2, [2](((U-WIND + V-WIND)/2)+HUM+LST)/3, [3](AI+CO+HCHO+NO_2+O_3+SO_2)/6

Source: own study

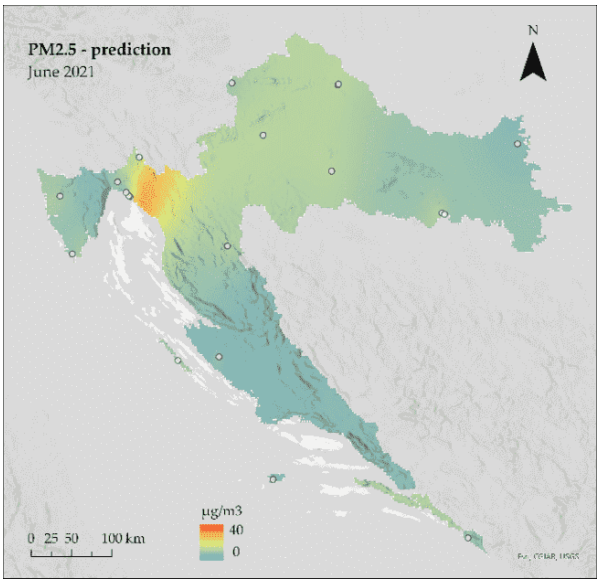
Compared with the study done for China by Wang et al. (2021), our study provides a more straightforward approach and uses fewer parameters, still providing satisfactory results. Wang et al. (2021) used 30 parameters from various sources (TROPOMI, GEOS-FP, MODIS, Open Street Map, and GPW) and showed that SO_2, NO_2, and wind components were the most important parameters. On the other hand, Han et al. (2022) used only TROPOMI and NASA SRTM elevation data in their study for Thailand. Unlike Wang et al. (2021), Han et al. (2022), have shown NO_2 and SO_2 as the most insignificant variables.

To get a visual insight between the in-situ and predicted data, the $PM_{2.5}$ and PM_{10} monthly interpolation maps were made using minimum curvature spline technique

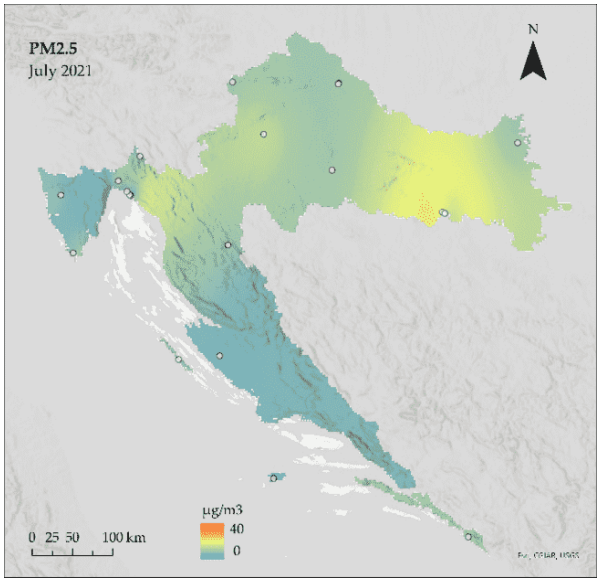
(Fig. 8.–11.). The ground stations used for modelling are indicated as point data on the map.



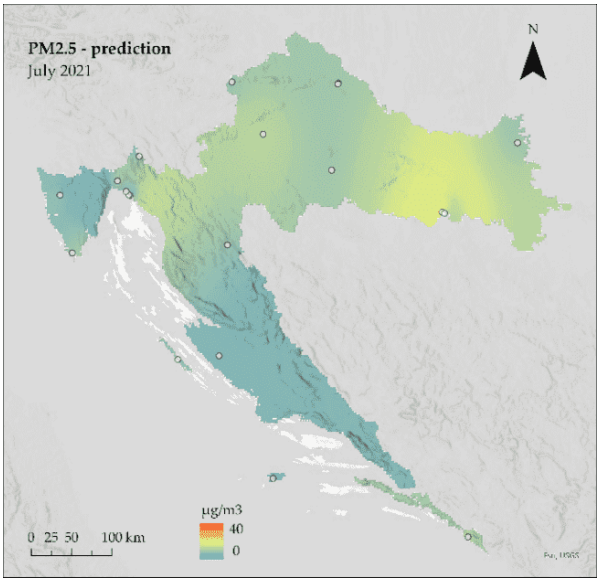
(a)



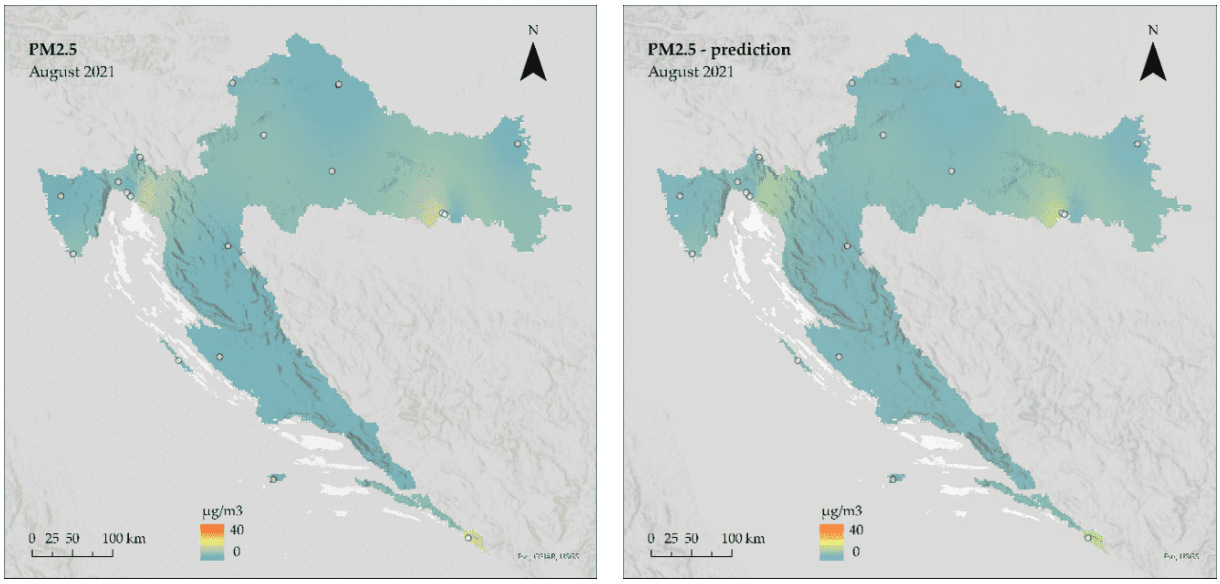
(b)



(c)



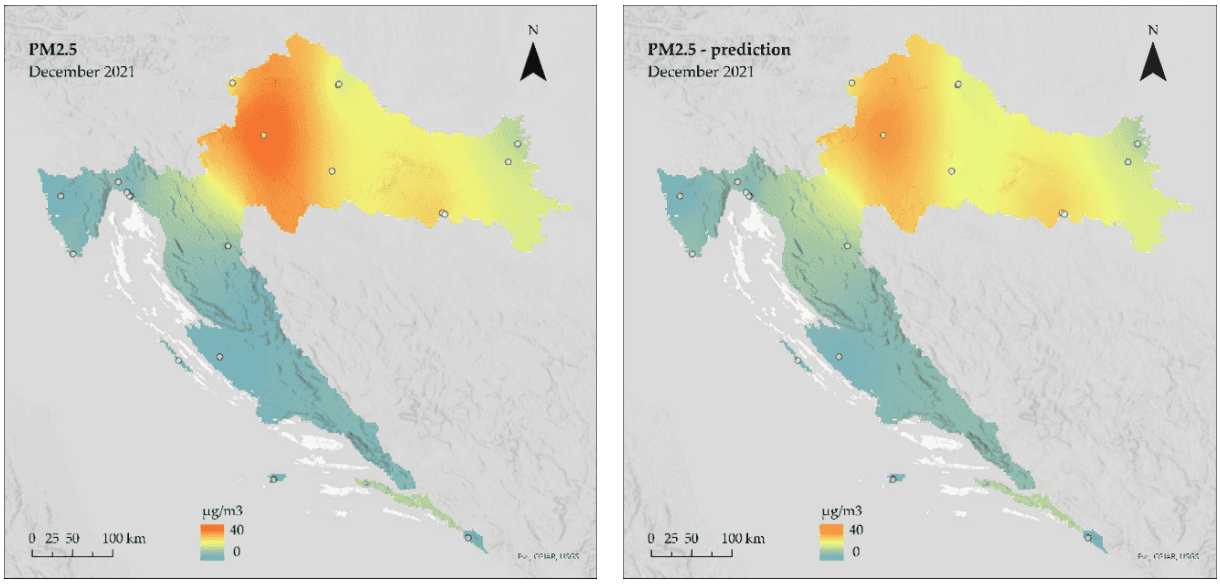
(d)



(e) (f)

Fig. 8. Interpolated monthly $PM_{2.5}$ concentrations: (a) June from in-situ data (b) June from remote sensing data (c) July from in-situ data (d) July from remote sensing data (e) August from in-situ data (f) August from remote sensing data.
Source: own study

We can easily spot two hotspots for the months of the non-heating season for $PM_{2.5}$, especially in June and July. The first one is located by the sea in north-western part of the country, around the urban area of the city Rijeka, and the second one in south-east of continental part of the country close to the border. There are only noticeable differences between the ground and the predicted data, where the predicted values appear to be slightly lower than the actual values (most visible for June).



(a) (b)

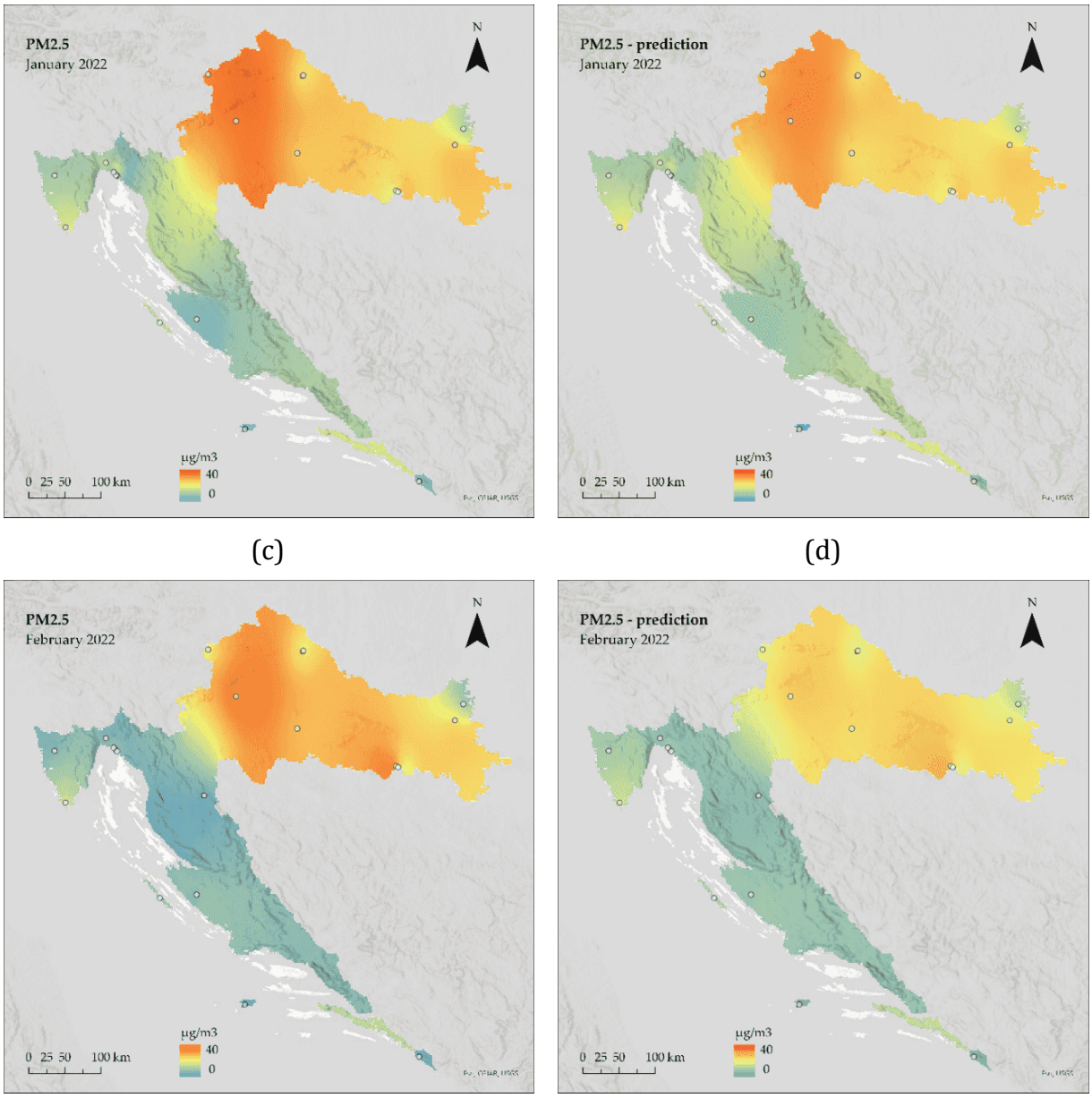
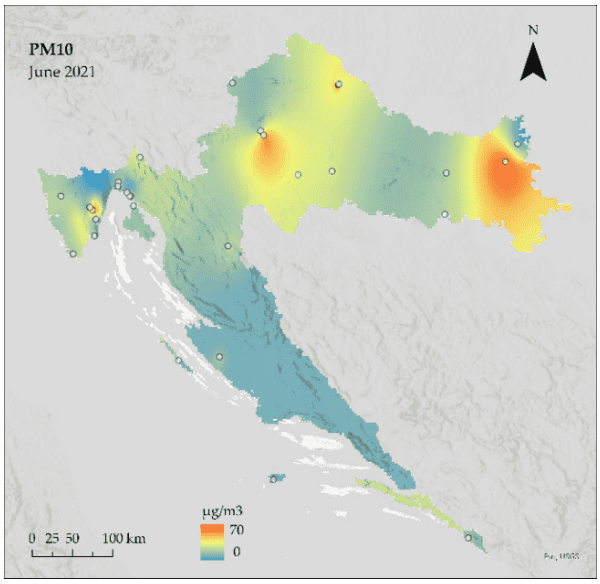
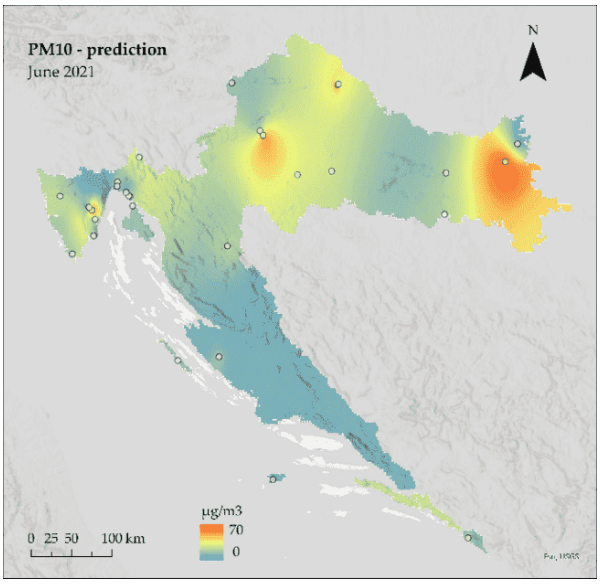


Fig. 9. Interpolated monthly $PM_{2.5}$ concentrations: (a) December from in-situ data (b) December from remote sensing data (c) January from in-situ data (d) January from remote sensing data (e) February from in-situ data (f) February from remote sensing data Source: own study

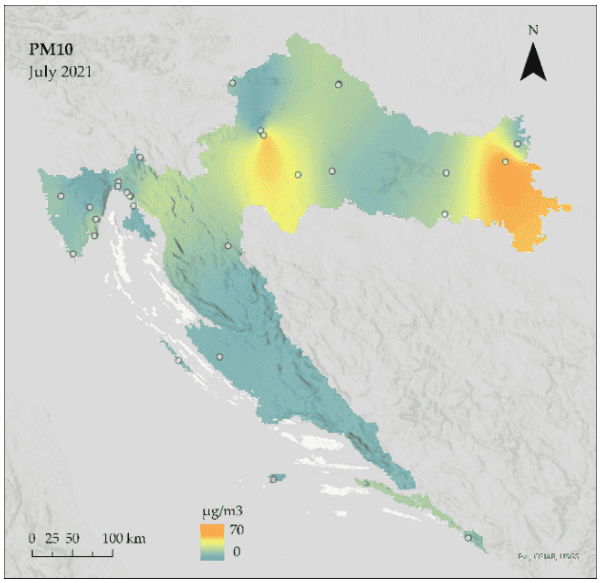
For the months of heating season, it is clearly visible that all the highest $PM_{2.5}$ values are in the east of the country (continental part of Croatia). Wang et al. (2021) observed similar seasonal changes and linked them to heating emissions and diverse meteorological conditions. The predicted values slightly underestimated the actual ones and appeared slightly lower.


PM10
June 2021
N
µg/m3
70
0
0 25 50 100 km

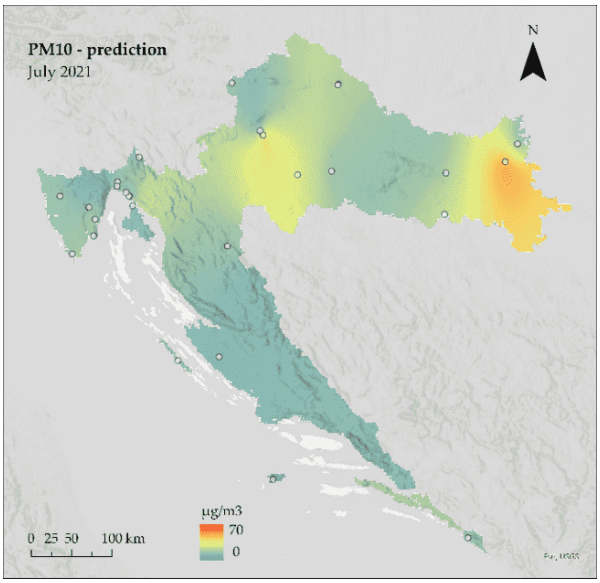
(a)


PM10 - prediction
June 2021
N
µg/m3
70
0
0 25 50 100 km

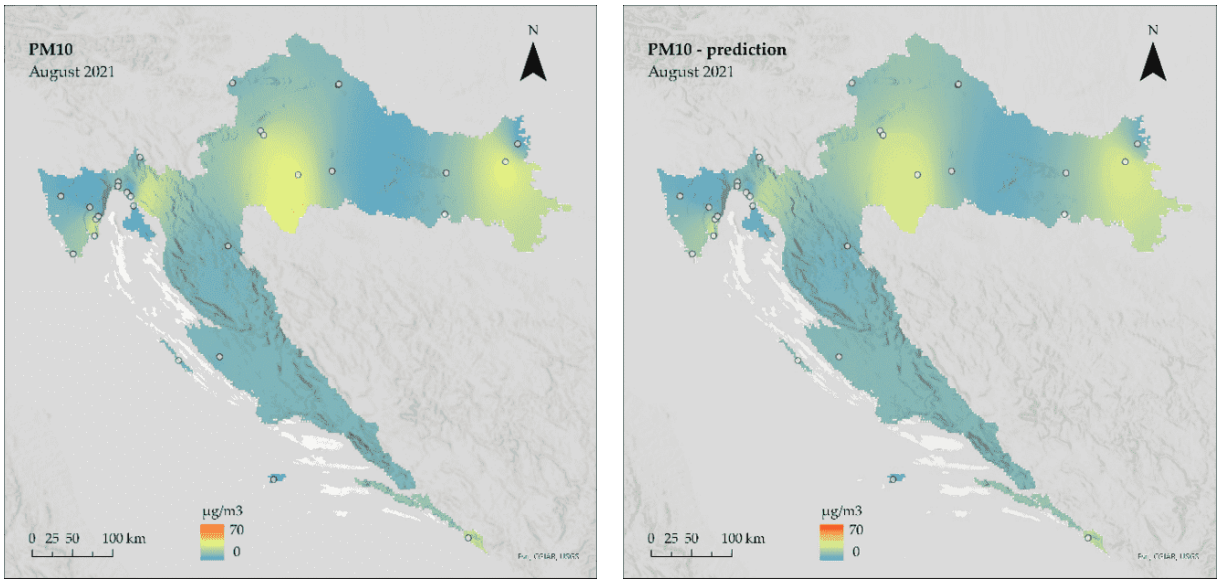
(b)


PM10
July 2021
N
µg/m3
70
0
0 25 50 100 km

(c)


PM10 - prediction
July 2021
N
µg/m3
70
0
0 25 50 100 km

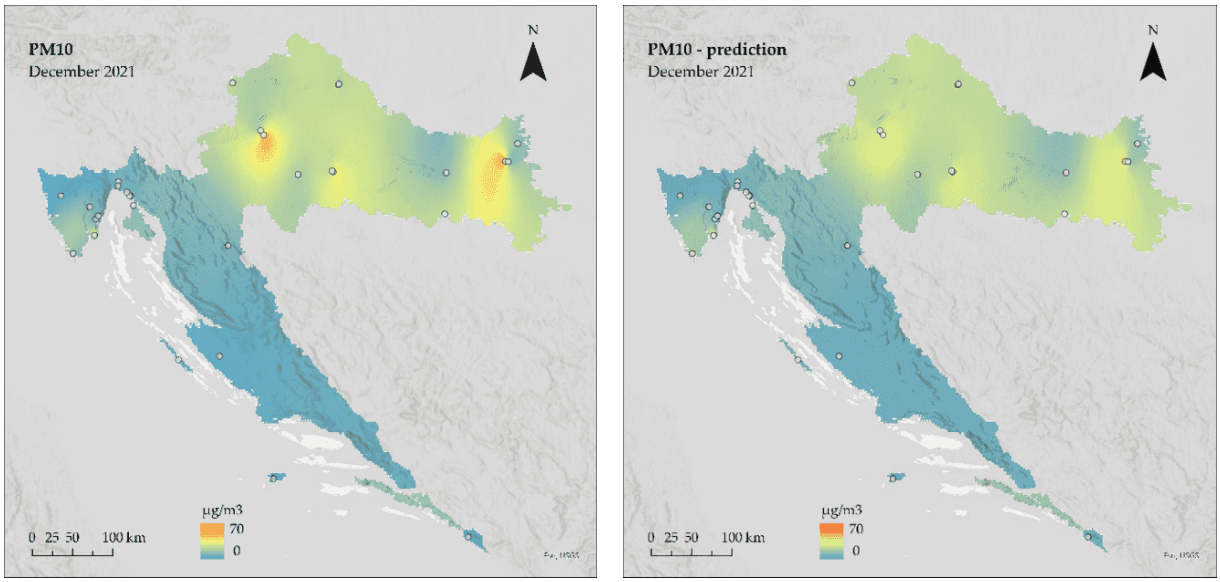
(d)



(e) (f)

Fig. 10. Interpolated monthly PM_{10} concentrations: (a) June from in-situ data (b) June from remote sensing data (c) July from in-situ data (d) July from remote sensing data (e) August from in-situ data (f) August from remote sensing data
Source: own study

The distribution of PM_{10} in months of non-heating season clearly shows us three hotspots (even four for June), all in the northern part of the country, but distributed longitudinally (from west to the east). The central hotspot appears around the urban area of the capital city, Zagreb, and the one in the far east around the urban area of the city of Osijek. Developed models again showed a good performance with ability to find mentioned hotspots.



(a) (b)

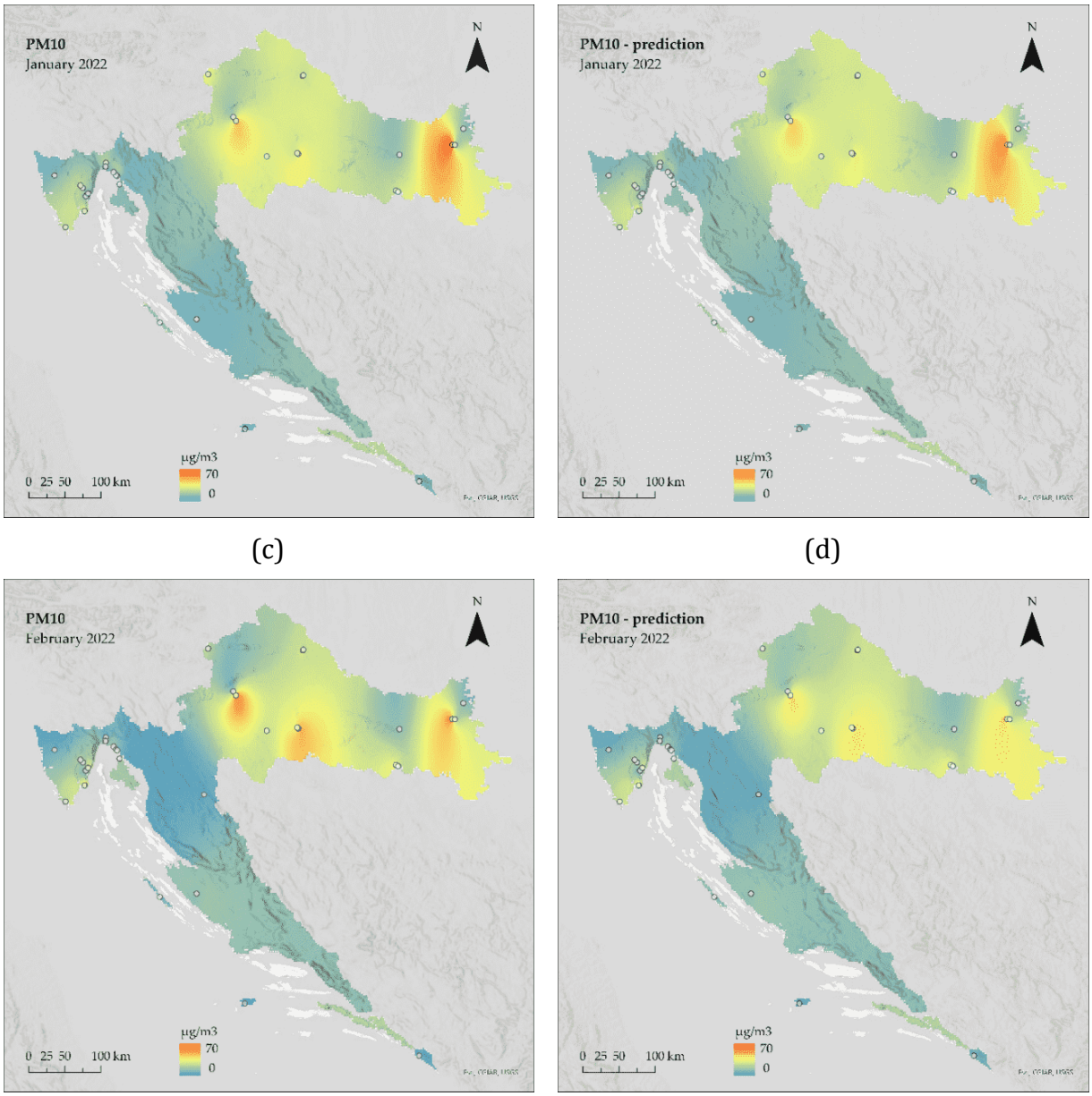


Fig. 11. Interpolated monthly PM_{10} concentrations: (a) December from in-situ data (b) December from remote sensing data (c) January from in-situ data (d) January from remote sensing data (e) February from in-situ data (f) February from remote sensing data Source: own study

When looking at the PM_{10} values in months of the heating season, and those of the non-heating, there is not so much change, even though it was expected that the values during heating season will be much higher. Several studies (Wang et al., 2021; Kumar et al., 2022) connected high PM_{10} emissions to sandstorms and dry climate, neither of which are common in Croatia. There are three hotspots found in the continental part of the country, two of them again located around the urban areas of the cities Zagreb and Osijek, and the third, between, in the town of Kutina.

A common thing for all developed monthly models is that the predicted values slightly underestimate the actual ones and appear slightly lower. However, all models have shown the general ability to estimate $PM_{2.5}$ and PM_{10} levels, even in areas without high pollution. Furthermore, all models can effectively detect all $PM_{2.5}$ and PM_{10} hotspots.

Conclusion

This study proposed a new approach to estimate ambient concentrations of $PM_{2.5}$ and PM_{10} from TROPOMI and other open-source remote sensing data available in GEE.

On a monthly time scale, the Random Forest machine learning method was successfully used to create $PM_{2.5}$ and PM_{10} models for the Republic of Croatia. All monthly models show a moderate to high correlation between in-situ and estimated $PM_{2.5}$ and PM_{10} values, with overall better results for $PM_{2.5}$ than for PM_{10} concentrations. Regarding $PM_{2.5}$ models, the model with the highest correlation ($r = 0.78$) is for January. The PM_{10} model with the highest correlation ($r = 0.79$) is for December.

The spatial distribution of $PM_{2.5}$ concentrations for months during the heating season revealed significant variations in $PM_{2.5}$ pollution in the continental part of Croatia, which motivates the development of regional models and opens a space for new research. Observed seasonal changes could be linked to heating emissions and multiple geographical and meteorological conditions. Furthermore, the next step would be to create seasonal models using the same methodology proposed by this research. The advantage of this approach is that it combines multiple parameters from different sources in order to answer the challenges in the composition of observed air pollutants and that it can be easily adopted in new study areas. Limitations are presented in the form of missing data due to weather conditions.

A common thing for all developed monthly models is that the predicted values underestimate the actual ones and appear slightly lower. However, all models have shown the general ability to estimate $PM_{2.5}$ and PM_{10} levels, even in areas without high pollution. Furthermore, all models can effectively detect all $PM_{2.5}$ and PM_{10} hotspots.

References

Air Pollution, URL 1: https://www.who.int/health-topics/air-pollution#tab=tab_1 [27.10.2022].

Anderson J.O., Thundiyil J.G., Stolbach A. (2012). Clearing the air: a review of the effects of particulate matter air pollution on human health. Journal of medical toxicology, 8(2), 166–175.

Borsdorff T., Hu H., Hasekamp O., Sussmann R., Rettinger M., Hase F., ... & Landgraf, J. (2018). Mapping carbon monoxide pollution from space down to city scales with daily global coverage. Atmospheric Measurement Techniques, vol. 11, no. 10, pp. 5507–5518.

Cichowicz R., Wielgosiński G., Fetter, W. (2017). Dispersion of atmospheric air pollution in summer and winter season. Environmental monitoring and assessment, 189(12), 1–10.

Clemente Á., Yubero E., Nicolás J. F., Caballero S., Crespo J., Galindo N. (2022). Changes in the concentration and composition of urban aerosols during the COVID-19 lockdown. Environmental Research, 203, 111788.

Farr T.G., Rosen P.A., Caro E., Crippen R., Duren R., Hensley S., Kobrick M., Paller M., Rodriguez E., Roth L., Seal D., Shaffer S., Shimada J., Umland J., Werner M., Oskin M., Burbank D., and Alsdorf, D.E. (2007). The shuttle radar topography mission: Reviews of Geophysics, vol. 45, no. 2, RG2004, https://doi.org/10.1029/2005RG000183).

Gautam S., Elizabeth J., Gautam A. S., Singh K., Abhilash P. (2022). Impact Assessment of Aerosol Optical Depth on Rainfall in Indian Rural Areas. Aerosol Science and Engineering, 1–11.

GFS: Global Forecast System 384-Hour Predicted Atmosphere Data, URL 3: https://developers.google.com/earth-engine/datasets/catalog/NOAA_GFS0P25#description [27.10.2022].

Han S., Kundhikanjana W., Towashiraporn P., Stratoulias D. (2022). Interpolation-Based Fusion of Sentinel-5P, SRTM, and Regulatory-Grade Ground Stations Data for Producing Spatially Continuous Maps of PM2. 5 Concentrations Nationwide over Thailand. Atmosphere, 13(2), 161.

Hengl T. (2018). Soil pH in H2O at 6 standard depths (0, 10, 30, 60, 100 and 200 cm) at 250 m resolution (Version v02) [Data set].

Kaplan G., Avdan Z.Y. (2020). Space-borne air pollution observation from sentinel-5p tropomi: Relationship between pollutants, geographical and demographic data. International Journal of Engineering and Geosciences, 5(3), 130–137.

Kelly F.J., Fussell J.C. (2012). Size, source and chemical composition as determinants of toxicity attributable to ambient particulate matter. Atmospheric environment, 60, 504–526.

Kim K.H., Kabir E., Kabir S. (2015). A review on the human health impact of airborne particulate matter. Environment international, 74, 136–143.

Kleipool Q., Ludewig A., Babić L., Bartstra R., Braak R., Dierssen W., ... & Veefkind P. (2018). Pre-launch calibration results of the TROPOMI payload on-board the Sentinel-5 Precursor satellite. Atmospheric Measurement Techniques, vol. 11, no. 12, pp. 6439–6479.

Kumar R.P., Perumpully S.J., Samuel C., Gautam S. (2022). Exposure and health: A progress update by evaluation and scientometric analysis. Stochastic Environmental Research and Risk Assessment, 1–13.

Kumar R.P., Samuel C., Gautam S. (2022). A bibliometric and scientometric: analysis towards global pattern and trends related to aerosol and precipitation studies from 2002 to 2022. Air Quality, Atmosphere & Health, 1–16.

Kvaliteta zraka u Republici Hrvatskoj (*Air quality in the Republic of Croatia*), URL 2: http://iszz.azo.hr/iskzl/index.html [27.10.2022].

Li T., Shen H., Yuan Q., Zhang L. (2020). Geographically and temporally weighted neural networks for satellite-based mapping of ground-level PM2. 5. ISPRS Journal of Photogrammetry and Remote Sensing, 167, 178–188.

Li Y., Yuan S., Fan S., Song Y., Wang Z., Yu Z., ... & Liu Y. (2021). Satellite Remote Sensing for Estimating PM2. 5 and Its Components. Current Pollution Reports, 7(1), 72–87.

Pal M. (2005). Random forest classifier for remote sensing classification. International journal of remote sensing, 26(1), 217–222.

Polichetti G., Cocco S., Spinali A., Trimarco V., & Nunziata A. (2009). Effects of particulate matter (PM10, PM2. 5 and PM1) on the cardiovascular system. Toxicology, 261(1–2), 1–8.

Pope III C.A., Dockery D.W. (2006). Health effects of fine particulate air pollution: lines that connect. Journal of the air & waste management association, 56(6), 709–742.

Shao Y., Ma Z., Wang J., Bi J. (2020). Estimating daily ground-level PM2. 5 in China with random-forest-based spatiotemporal kriging. Science of The Total Environment, 740, 139761.

Singh R., Singh V., Gautam A.S., Gautam S., Sharma M., Soni P. S., ... & Gautam A. (2022). Temporal and Spatial Variations of Satellite-Based Aerosol Optical Depths, Angstrom Exponent, Single Scattering Albedo, and Ultraviolet-Aerosol Index over Five Polluted and Less-Polluted Cities of Northern India: Impact of Urbanization and Climate Change. Aerosol Science and Engineering, 1–19.

Stafoggia M., Bellander T., Bucci S., Davoli M., De Hoogh K., De'Donato F., ... & Schwartz J. (2019). Estimation of daily PM10 and PM2. 5 concentrations in Italy, 2013–2015, using a spatiotemporal land-use random-forest model. Environment international, 124, 170–179.

Understanding Random Forest, URL 4: https://towardsdatascience.com/understanding-random-forest-58381e0602d2 [27.10.2022].

Wang Y., Yuan Q., Li T., Tan S., Zhang, L. (2021). Full-coverage spatiotemporal mapping of ambient PM2.5 and PM10 over China from Sentinel-5P and assimilated datasets: Considering the precursors and chemical compositions. Science of The Total Environment, 793, 148535.

Witten I.H., Frank E., Trigg L.E., Hall M.A., Holmes G., Cunningham S.J. (1999). Weka: Practical machine learning tools and techniques with Java implementations.

Xiao Q., Ma Z., Li S., Liu Y. (2015). The impact of winter heating on air pollution in China. PloS one, 10(1), e0117311.

Yang L., Xu H., Yu S. (2020). Estimating PM2. 5 concentrations in Yangtze River Delta region of China using random forest model and the Top-of-Atmosphere reflectance. Journal of Environmental Management, 272, 111061.

Zhao C., Wang Q., Ban J., Liu Z., Zhang Y., Ma R., ... & Li, T. (2020). Estimating the daily PM2. 5 concentration in the Beijing-Tianjin-Hebei region using a random forest model with a 0.01°× 0.01° spatial resolution. Environment international, 134, 105297.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.79

Jerzy Stanik[1], Maciej Kiedrowicz[2]

STATEMENT OF APPLICABILITY AS A KEY ELEMENT OF THE GIS CERTIFICATION PROCESS IN THE LIGHT OF CYBERSECURITY STANDARDS

Abstract: The Statement of Applicability (SoA) is a mandatory document ISMS that you need to develop, prepare, and submit with your ISO 27001, and it is crucial in obtaining your ISO 27001 Risk Assessment and ISMS certification. According to ISO/IEC 27001, Information Security Management System is a collection of 'that part of the general management system, based on the approach to business risk, to establish, implement, operate, monitor, review, maintain and improve information security. ISO/IEC 27001 specifies the requirements and implementation process for the Information Security Management System. However, implementing this standard without a good SoA document may prove impossible. The article presents a system model for the construction of SoA for ISMS and its certification following the ISO 27001 standard. This model aims to provide instruments for designing and generating an SoA document in relation to ISMS, covering all information processes in GIS. This model allows organizations to evaluate their current state of GIS information asset security implementation according to the best practices defined in ISO/IEC 27001. The proprietary model proposed in this article is assessed from a multi-stage perspective, which confirms that the proposed draft Statement of Use document makes a valuable and innovative contribution to information security management by considering the best practices in this field.

Keywords: spatial data, security, Statement of Applicability (SoA), risk, implementation process

Received: 8 June 2022; accepted: 3 August 2022

[1] Military University of Technology, Faculty of Cybernetics, Institute of Computer and Information Systems, Warsaw, Poland, ORCID ID: 0000-0002-0162-2579, email: jerzy.stanik@wat.edu.pl
[2] Military University of Technology, Faculty of Cybernetics, Institute of Computer and Information Systems, Warsaw, Poland, ORCID ID: 0000-0002-4389-0774, email: maciej.kiedrowicz@wat.edu.pl

Introduction

In the era of constantly increasing amounts of spatial data and geodata, which are the pillar of each GIS class system, it is necessary to ensure appropriate organizational and technical security mechanisms, as it is of key importance for the effectiveness of each system.

Observing the regulatory changes in the European Union and the world in the area of GIS and cybersecurity, one can notice a significant increase in the requirements for the security mechanisms used – legal, organizational and technical safeguards – in information security management systems. This is reflected in the requirements of new standards and regulations, such as standards in the field of information security management – ISO/IEC 27001, the General Data Protection Regulation (GDPR) (EU) 2016/679, or the new cybersecurity directive (EU) 2016/1148. This fact also influences the preparation of the declaration of use and forces the improvement of current solutions in terms of their structure. A well-drafted declaration of use must correctly reflect the selection of safeguards and protects against the potential risk.

In the era of cybersecurity, the design and implementation of adequate security systems concerning information processes in GIS are very important, especially when we want to obtain a security certificate for GIS. Thanks to the flexibility in selecting a set of organizational and technical security measures and their innovative solutions, each GIS-class system can be made professional from the point of view of cybersecurity.

Two types of goals are distinguished in the work: cognitive and practical. The cognitive goal of the presented research is to gain multifaceted knowledge about the currently existing document templates entitled 'SoA' for ISMS certification and for compliance with the ISO/IEC 27001 standard, with particular emphasis on its effectiveness, correctness and conditions. The practical goal is to develop an SoA pattern/project and indications and conclusions for employees of the security department to properly apply this pattern in the construction of the Information Security Management System for compliance with the ISO/IEC 27001 standard. The auxiliary goals are (Al-Mayahi and Mansoor, 2008; Chi-Chun and Wan-Jia, 2012):

1) reviewing the current state of knowledge in Poland on the currently existing templates of the document entitled 'Statement of Use' for the certification of the Information Security Management System for compliance with the ISO/IEC 27001 standard,
2) assessment of its impact on the manner and effectiveness of the certification process,
3) making a comparative analysis of these patterns and presenting own comments, recommendations, suggestions or recommendations for their improvement.

In terms of content, the article addresses the following problems (web pages: www.pcisecuritystandards.org, www.sans.org, nvlpubs.nist.gov):

- Problem 1. The SoA cannot be built without a clearly defined ISMS scope.
- Problem 2. The utility of an SoA depends significantly on the current risk analysis results concerning the established set of information resources to be protected.

- Problem 3. The most desirable SoA is one that should refer to all 18 groups of security application targets listed in Annex A of ISO/IEC 27001. In addition, for each target (114 targets in total), rules, documents, and responsible persons must be specified.

The problems mentioned above constitute the main threads of the final work and determine its framework. This article presented the SoA draft document and the tools and instruments enabling its development were developed based on available literature and own research.

Statement of Applicability and its development process

Statement of Applicability. The Statement of Applicability (SoA) is a central, mandatory part of the ISO 27001 standard for Information Security Management Systems (ISMS). The information security management system focuses on continuous improvement and the declaration of use document helps you to achieve this.

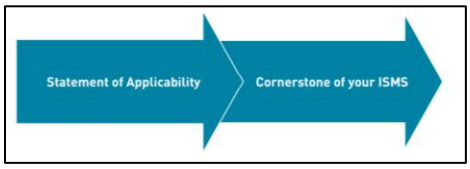


Fig. 1. Linking the SoA to the ISMS
Source: own elaboration

The Statement of Applicability forms the main link between your risk assessment and the information security you have implemented (Fig. 1). The purpose of the Statement of Applicability is to document which controls (security measures) from ISO 27001 Annex A (and thereby the ISO 27002 standard for information security) you will implement and the reason they have been chosen – as well as justify why any controls might be excluded.

It is also good practice to include the following in the Statement of Applicability document (see: www.neupart.com):

- The status of implementation for existing controls
- A link to the control documentation or a brief description of how each control is implemented
- A cross-reference to the sources of other requirements necessitating the controls chosen.

Thus, by preparing a good quality Statement of Applicability, you will have a thorough and complete overview of which controls you need to implement, why they are implemented, how they are implemented, and how well they are implemented.

The Statement of Applicability results from numerous activities defined in the planning phase of an ISO 27001 implementation. The two primary sources for the Statement of Applicability are the risk assessment and Annex A of the standard – in reality, the Table of Contents of the ISO 27002 standard (see: ISO/IEC 27001:2013; ISO

Standard 27001 and ISO Standard 27002). Other sources are the controls in the organization and external security requirements that the organization has to comply with.

The road to the Statement of Applicability. The general scheme [way to] obtain a good Statement of Applicability for a selected organization is shown in Figure 2.

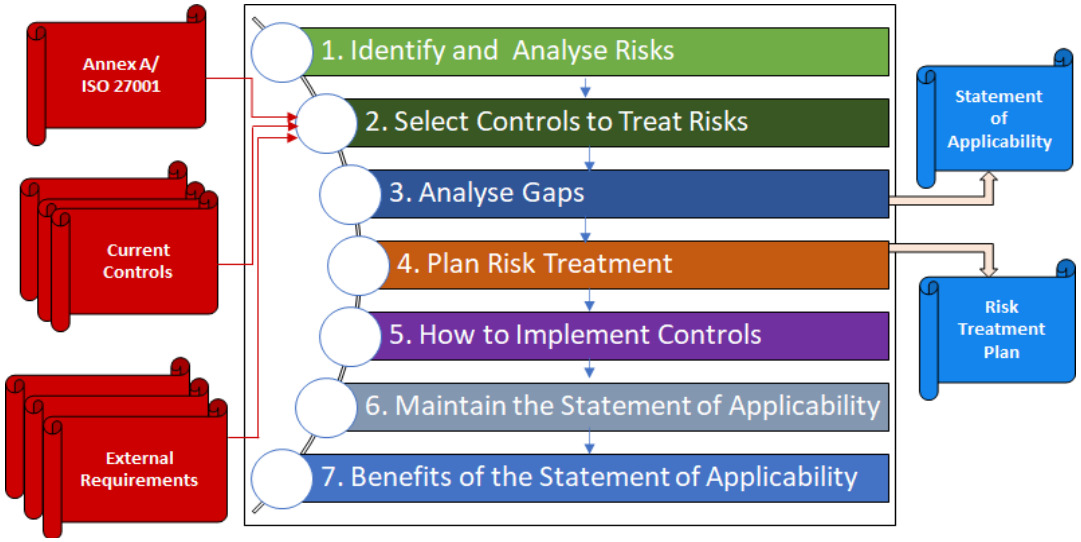


Fig. 2. The road to the Statement of Applicability
Source: own elaboration

Table 1. A step-by-step process for creating an ISO 27001 Statement of Applicability

Name	General description
Identify and Analyse Risks	To ensure that the implemented controls reflect the risk faced by the organization, a risk analysis should be carried out in two phases: the Identification Phase and the Analysis Phase, and the introduction of elements of good practice. Conduct an ISO 27001 risk assessment by listing all information assets and identifying data security risks for each one. Then, prioritize and prioritize the risk based on probability and impact, assign a risk owner, and create a plan to close any vulnerabilities.
Select Controls to Treat Risks	The analysis has determined that the risks are unacceptable, so proper action must be taken. The risk treatment options are typically: a) Applying appropriate controls b) Knowingly and objectively accepting risks c) Avoiding risks, or: d) Sharing the associated business risks with other parties, e.g. insurers or suppliers. Proper controls must be selected for those risks where option a) above is chosen. Fortunately, ISO 27002 provides us with an excellent catalogue of control objectives and controls for treating risks and good guidance on implementing the controls.
Analyses Gaps	While this is not a strict requirement of the ISO 27001 standard, it is recommended that once the required controls have been selected, a gap analysis is performed to establish the current state of the implementation of the controls.

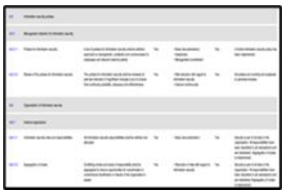
	To ensure the evaluation of the controls is consistent and coherent, it is recommended that a commonly accepted maturity level model be selected. Examples of such maturity scales are: • The COBIT 4.1 Maturity Model • Carnegie Mellon Software Engineering Institute Capability Maturity Model • The Danish Agency for Digitization ISO 27001-benchmark (see: www.digst.dk)
Plan Risk Treatment	As noted in the introduction, the Statement of Applicability is a very central document in the information security management system. After the initial version of the Statement of Applicability has been developed, it will be used both when developing the risk treatment plan and when implementing the controls that have been selected during the 'Select Controls' activity. The risk treatment plan could be said to be the organization's security implementation plan, and the primary goal of the plan is to achieve the organization's security goals.
How to Implement Controls	After the planning of risk management is completed, appropriate protection begins. Depending on how big the difference is between the actual and the necessary levels of security, this can be both a laborious and time-consuming task. Therefore, it is not uncommon for risk management plans to extend over several months or even years. The maturity of the ISMS improves during the implementation of controls and, therefore, the Statement of Use needs to be updated in line with this progress. The Statement of Applicability requires a list of all the controls recommended in Annex A, together with a statement as to whether each control has been applied or not. You must justify each case if you have included or excluded a specific check from Annex A.
Maintain the Statement of Applicability	After selecting the controls and performing a gap analysis of the selected controls, we now have all the information needed to write the Statement of Applicability document. It is recommended to use a structured tool to document the Statement of Applicability. In this way, it will be possible to work with the content of the Statement of Applicability and, for example, sort and filter based on the compliance level, source of requirements and other parameters. Examples of suitable tools to write a Statement of Applicability are spreadsheets, databases and dedicated ISMS tools (www.itgovernance.co.uk, advisera.com).
Benefits of the Statement of Applicability	Here are six reasons why it is an important document to have in your arsenal: 1. Helps you establish eligibility requirements. 2. Provides an overview of crucial information related to the applicant's qualifications. 3. It helps to determine if the applicant meets all the necessary criteria. 4. Document any exceptional circumstances, such as disability-related accommodation. 5. The SoA will be referenced throughout the application process and can sometimes be used as proof of documentation. 6. Finally, it can serve as the basis for some institutions' 'official' letters of good standing.

Source: own elaboration

The Statement of Applicability is one of the first documents an auditor will review as part of the ISO 27001 audit process. The Statement of Applicability helps the auditor understand the organization and what controls have been implemented and assessed as part of that organization's audit.

Comparison table of Statement of Applicability. A schematic illustration of the comparison of selected tools supporting the Statement of Applicability development process is presented in the table below (Table 2).

Table 2. Comparison table of Statement of Applicability

Conformio Conformio	 ZEBSOFT	KB ISO 27001 Implementation Kanban Board	hyperproof Hiperproof
1	2	3	4
Platforms Supported Windows, Mac, Linux SaaS, iPhone, Android	**Platforms Supported** Windows, Mac, Linux SaaS, iPhone, Android	**Platforms Supported** Windows, Mac, Linux SaaS, iPhone, Android	**Platforms Supported** Windows, Mac, Linux SaaS, iPhone, Android
Audience Solutions only for small and medium-sized companies	Audience Organizations that need a Kanban Board that is ISO 27001 compliant	Audience Organizations that need ISO software	Audience Technology companies looking to improve regulatory compliance
Support Work hours 24/7 live support Online	Support Work hours 24/7 live support Online	Support Work hours 24/7 live support Online	Support Work hours 24/7 live support Online
SoA screenshots 	SoA screenshots 	SoA screenshots 	SoA screenshots 
Prices $ 199 a month Free version Free trial version	**Prices** No information available Free version Free trial version	**Prices** No information available Free version Free trial version	**Prices** $ 10,000 per year Free version Free trial version
Training Documentation Webinars Live online Personally	**Training** Documentation Webinars Live online Personally	**Training** Documentation Webinars Live online Personally	**Training** Documentation Webinars Live online Personally
Pieces of information about the company Expert Adviser solutions Established: 2009 Croatia advisera.com	Pieces of information about the company OK Consulting www.okconsultings.com	Pieces of information about the company Established: 2018 Great Britain zebrasoftware.co.uk	Pieces of information about the company Hyper-resistant Established: 2018 United States hyperproof.io

Tool alternatives	Tool alternatives	Tool alternatives	Tool alternatives
Compatibility features Archiving and storage Audit management Compliance Tracking Testing control Compliance with environmental protection requirements FDA compliant HIPAA compliant Incident management ISO compliance OSHA compliant Risk management Polls and opinions Version control Workflow / Automation of processes	**Compatibility features** Archiving and storage Audit management Compliance Tracking Testing control Compliance with environmental protection requirements FDA compliant HIPAA compliant Incident management ISO compliance OSHA compliant Risk management Polls and opinions Version control	**Compatibility features** Archiving and storage Audit management Compliance Tracking Testing control Compliance with environmental protection requirements FDA compliant HIPAA compliant Incident management ISO compliance OSHA compliant Risk management Polls and opinions Version control Workflow / Automation of processes	**Compatibility features** Archiving and storage Audit management Compliance Tracking Testing control Compliance with environmental protection requirements FDA compliant HIPAA compliant Incident management ISO compliance OSHA compliant Risk management Polls and opinions Version control Workflow / Automation of processes

Source: www.itgovernance.co.uk, advisera.com

Research methodology

For this article, it has been assumed that the research methodology boils down to searching for facts and their meaning or implications concerning the method of designing, producing and maintaining a document called an SoA for the certification process and the effectiveness of an ISMS in an organization. The resulting product and research results constitute an authentic, verifiable contribution to knowledge in the field of information security engineering.

The research presented in this article is descriptive and comparative. This determines the lack of a research hypothesis. The research aims to accurately present the features, properties, types, advantages and disadvantages of SoA schemes currently available on the market in information security and then develop a proprietary solution. Comparative research deals with the general problem of focusing on SoA document design and generation methods as techniques and tools, not on methodologies as justification logic. A researcher needs a lot of data to conduct comparative studies – tools

or collection techniques. Tools can vary in complexity, interpretation, design, and administration. Each tool is suitable for gathering a specific type of information.

Select from the available tools those that will provide the data you are looking for to test your hypothesis. It may happen that the existing research tools are not suitable for this purpose in certain situations, so the researcher should modify them or construct their own.

The primary research process led to developing an SoA model – a schema – and then constructing a methodology for its development and generation in paper and/or electronic form. The methodology takes into account such groups of areas (set of columns) in the structure of the table and their attributes, which, according to the members of the problem/research team, allow for a relatively objective and accurate assessment of the quality and/or usefulness of the SoA. Because individual rows in this table may have different values concerning the columns distinguished in the SoA, it is necessary to indicate or assign an appropriate set of techniques and tools enabling the introduction of these data.

Research findings

SoA model concept. The literature analysis on the subject shows that there is no single template [structure/layout or construction] of an SoA document (Goel & Nussbaum, 2021; Miller & Murphy, 2009). Such a situation does not make it easier to understand what an SoA is, and even more so what is meant by its scheme/structure. In the literature on the subject and found on the Internet, you can find many schemes or structures of an SoA document and tools supporting their creation, maintenance and improvement. Software solutions (Goel & Nussbaum, 2021; Walkowski et al., 2019) supporting the process of defining the structure, layout, or scheme of an SoA document and the process of its generation in the form of various solutions/reports can be divided into two groups (www.itgovernance.co.uk, advisera.com):

- Comprehensive solutions or platforms,
- Dedicated toolkits.

In terms of systems theory, the SoA document can be written symbolically as a generalized Cartesian product:

$$f: I \to \bigcup_{i \in I} K_i \text{ or } DS \subseteq \prod_{i \in I} K_i$$

where: $\{K_i : i \in I\}$ - a set family reflecting the features or properties (hereinafter also referred to as attributes) of the SoA.

Each highlighted attribute describes its mandatory or optional element. Using the formal approach, we can assume that an SoA is a relational model based on the mathematical concept of relations. In short, the n-segment relation (n-narn) is any subset of the Cartesian product of certain sets:

$$\text{SoA} \subseteq K_1 \times K_2 \times \cdots \times K_n$$

In the formal scheme/layout approach, SoA we call a non-empty set of attribute names (attributes in short) $\text{SoA} = \{A_1, A_2 \cdots, A_n\}$. Each attribute A_i is assigned a set of

values Dom (A) called the domain (domain, data type, set of values) of the attribute A. It is a named and finite set of values that a given attribute can have. Schema Instance DS is the relation on the set of A_i attribute domains:

$$DS \subseteq Dom(A_1) \times Dom(A_2) \times \cdots \times Dom(A_1)$$

Since each SoA document is inherently related to its SoA relationship schema, it is often possible to find multiple SoA assigned to the same schema. So an SoA is nothing more than a finite set of k tuples with a specific scheme. Consequently, in the relational model, and therefore in the SoA, tuples cannot be repeated. Later in this final paper, the concept of a tuple will be equated with that of a control or SoA control.

The minimum number of domains in SoA is determined by the principle of the need to include the so-called mandatory controls that enable (Fig. 3):

- Identification of which controls (safety measures) will be applied, including recommended or suggested controls from ISO 27001 Annex A and potentially controls from other sources,
- justification for including the applicable controls,
- Determining the implementation status of the applicable controls (i.e. whether they are being implemented or not),
- justification for excluding controls from Annex A, which are not applicable.

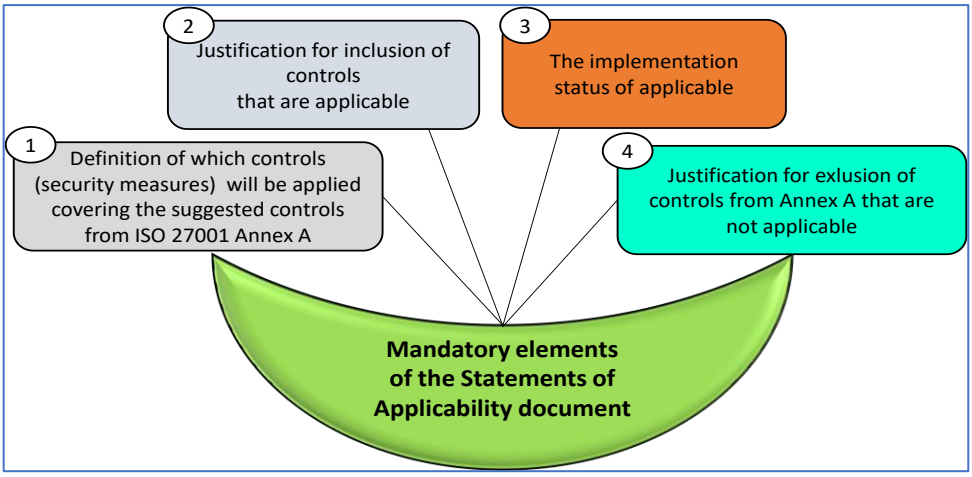


Fig. 3. The minimum number of domains in SoA
Source: Own study

Schematic illustrations of such SoA solutions are shown in Figure 4.

Fig. 4. Illustration of exemplary SoA documents from the point of view of their mandatory elements – example
Source: own elaboration

As shown in the figure above, the number of highlighted elements – (table columns) – in the SoA structure is not very numerous.

As a proprietary solution, we propose the following SoA model:

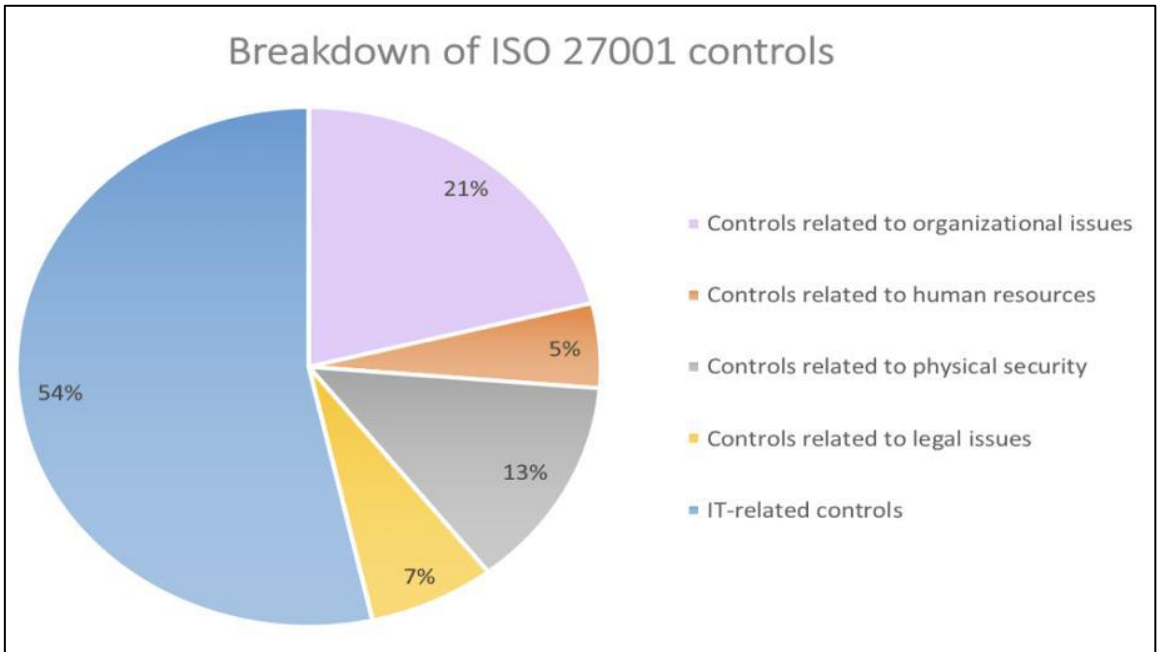
$$SoA \subseteq \mathbb{S} \times \mathbb{E} \times \mathbb{Z} \times \mathbb{U} \times \mathbb{W} \times \mathbb{P} \times \mathbb{D} \times \mathbb{M} \times \mathbb{F}$$

where:
$\mathbb{S}$ – a set of section names per Annex A of ISO 27001,
$\mathbb{E}$ – a set of control or control element names,
$\mathbb{Z}$ – a set of indicators reflecting the application/implementation status in the ISMS,
$\mathbb{U}$ – a set of justifications/objectives for the inclusion of controls that apply,
$\mathbb{W}$ – a set of justifications/objectives for excluding controls,
$\mathbb{P}$ – a set of reasons for selecting or applying security/control,
$\mathbb{D}$ – a set of implementation methods, evidence or comments and details about the control
$\mathbb{M}$ – a set of monitoring methods,
$\mathbb{F}$ – set of indicators reflecting the frequency of monitoring.
The set of section names can be decomposed as follows:

$$\mathbb{S} = \mathbb{S}^{O} \cup \mathbb{S}^{ZL} \cup \mathbb{S}^{IT} \cup \mathbb{S}^{BF} \cup \mathbb{S}^{P},$$

where:
$\mathbb{S}^{O}$ – a set of sections related to organizational issues: A.5, A.6., A.8, A.15,
$\mathbb{S}^{ZL}$ - a collection of sections on human resources: A.7,
$\mathbb{S}^{TI}$ - a set of IT-related sections: A.9, A.10, A.12, A.13. A.14, A.16, A.17
$\mathbb{S}^{BF}$ – a set of physical security sections: A.11
$\mathbb{S}^{P}$ – a set of legal sections: A.18.

The percentage breakdown is as follows:



Looking at the chart above, we can see that over 50% are control points related to your IT infrastructure. This is why cybersecurity specialists strongly rely on the ISO 27001 standard.

Author's proposal of the Statement of Applicability – example. This document aims to define which controls are appropriate to be implemented in the organization, the objectives of these controls, and how they are implemented and approve residual risks and formally approve the implementation of the controls. This document includes all controls listed in Annex A of the ISO 27001 standard. Controls apply to the entire Information Security Management System (ISMS) scope. Users of this document are all employees of an organization who have a role in the ISMS. The first version of the statement applicability will need updating more frequently.

To begin with, during the implementation of ISO 27001 and the new ISMS, the document will need monthly updates until the new systems have all been implemented. A well-prepared Declaration is an excellent audit guide during certification audits! To correctly fill in the SoA template:

- Complete the list of legal, regulatory and other requirements and the risk treatment table – these two documents are the primary input to writing an SoA.
- Based on the data of these two input documents, a decision has to be made as to whether the control is applicable or not, i.e. whether it is needed to meet the requirement or to reduce the risk (Dubois et al., 2010).
- If the control is applicable, it is enough to find the document related to this control, e.g. in the 'List of documents', and specify its name. The SoA template can contain default documents for most of the controls.

A schematic illustration of a fragment of a completed SoA document per the original concept of the solution is presented in the table below:

Creating an SoA demonstrates that the organization has considered a comprehensive set of candidate controls and that the applicability (or otherwise) of each has been duly considered per the requirements of ISO 27001 (see: ISO/IEC 27001:2013; ISO Standard 27001 and ISO Standard 27002). The SoA specifically justifies the inclusion or exclusion of candidate controls (whether sourced from ISO 27001 Annex A, from the ISM, or other sources) as appropriate for your environment and business delivery model. Controls may also be identified and added to the SoA required for other reasons. For example, because of legal or regulatory requirements, specific contractual requirements, or strategic or marketing purposes.

Table 3. A fragment of the SoA from the point of view of the author's solution

Requirements PN-ISO / IEC 27001: 2014 Annex A	Control applied	Selected security features and reasons for using security features	Implementation methods (including related documents, procedures and instructions)	frequency of monitoring

	Model list of security and security targets Type of security	Implemented	Planned implementation	Out of the question	Business requirements	Legal Requirements	Good practices	Risk analysis results		
𝕊	𝔼	ℤ		𝕎	𝕌/ℙ				𝔻	𝕄/𝔽
A.5 Information security policies A.5.1 Information security policies determined by management Purpose: To provide guidance and support by management for information security activities per business requirements and relevant legal standards and regulations.										
A.5.1.1 Policies for information security	**Organizational security:** A set of information security policies should be defined, approved by management, published and communicated to employees and relevant external parties.	**X**			**X**	**X**			The Integrated Management System Policy, the Information Security Policy in the Organization and the Statement of Applicability of the requirements of the PN-ISO / IEC 27001: 20014 standard have been approved by the management and published on the intranet for the attention of all employees. Thus, these documents were communicated to the relevant external parties. The Information Security Policy is supported by thematic policies, standards and principles. All policies referred to in other controls of this Statement of Applicability.	Verification during internal audits of individual processes. / At each internal audit
		Justification of the choice of collateral: Informing employees and other interested parties about information security objectives and commitment to meeting applicable information security requirements in the company and continuous improvement in this area.			**Fulfillment:** Management Policy issued as an attachment to the White Book approved and communicated to employees by placing on the board and the intranet site.					
A.5.1.2 Review of information security policies.	**Safeguard:** Information security policies will be reviewed at scheduled intervals or in the event of significant changes to ensure their continued suitability, adequacy and effectiveness.	**X**			**X**	**X**	**X**	**X**	Each policy has a designated owner who has to review the document at planned intervals. A business strategy, regulations, legislation, contracts, and related security objectives may be threatened by the environment and may change. This results in the need to review policies at planned intervals or any timeframe. This is best practice and reduces information security events in a fast-evolving world. .	Verification of the validity of the Policies during the Management review / Once a year.
		Justification of the choice of collateral: Maintaining the relevance and adequacy of the IMS Policy, ISMS Policy and other system documents.			**Fulfillment:** The suitability assessment is one of the inputs to the management review.					

Source: own elaboration

Conclusions

The organization implementing the Information Security Management System (ISMS) following the requirements of the ISO 27001 standard must analyze each of the sub-items of Annex A and refer them to its own threats and security measures. It is helpful to have a very good SoA in this process. A well-presented and easy-to-understand diagram of the SoA document shows the relationship between the applicable and implemented controls set out in Annex A, taking into account the risks and information assets of the entire organization. This gives the auditor or other stakeholders great confidence that the organization takes information security

management seriously, especially when combined into an overall information security management system. The primary conclusions are:

1. There are no exact rules for developing your SoA as ISO 27001 recognizes that details of cyber security are unique to your business requirements. However, you must include:
   - An explanation of the elements of the security controls you've chosen to mitigate risks, and a justification for why you've included them. These are decided through performing a gap analysis and risk assessment in the starting stages of your ISO/IEC 27001 implementation.
   - If you have excluded any part of ISO/IEC 27001's Annex A, a list of 114 control objectives and explanations of what they are, what they do, and why.
2. The statement of applicability is part of the risk assessment and Information Security Management System (ISMS) component of ISO/IEC 27001. It is a framework of policies surrounding your cyber security systems' legality, physicality, and technicality.
3. Completing the statement of applicability (SoA) is a requirement of the ISO/IEC: a document you must develop, prepare and submit as part of your steps toward best practice regarding your data management systems.
4. The SoA is the roadmap to the efficient and effective implementation and operation of ISO 27001. It is a comprehensive document that identifies and categorizes the elements of information security measures by product and department and many other criteria.
5. In ISO 27001 certifications, the SoA document is critical as it provides physical evidence to the auditor that the necessary steps have been taken to obtain ISO 27001 certification.
6. After considering the diagrams, tables, types, advantages and disadvantages of several SoA solutions under study, it was found that the suitability and/or specificity of each solution depends on general goals, resulting, for example, from the principles of good practice and information security engineering or an individual SoA goal, such as outlined by the authors of this study.

References

Al-Mayahi, Mansoor P. (2008). ISO27001 gap analysis – case study.

Chi-Chun L., Wan-Jia C. (2012). A hybrid information security risk assessment procedure considers interdependences between controls. Expert Systems with Application. 39: 247–257.

Dubois E., Heymans P., Mayer, R. Matulevicius N. (2010). A Systematic Approach to Define the Domain of Information System Security Risk Management. Intentional Perspectives on Information Systems Engineering.

Goel S., Nussbaum B., (2021). Attribution Across Cyber Attack Types: Network Intrusions and Information Operations. IEEE Open Journal of the Communication Society. 2021, 2, 1082–1093. [CrossRef].

How to develop a Statement of Applicability according to ISO 27001:2017, March 2018, Edition 2.0. https://www.neupart.com/ [20.05.2022].

Miller H., Murphy R. (2009). Secure cyberspace: answering the call for intelligent action, IT Professional.

ISO/IEC 27001:2013, Information technology – Security techniques – Information security management systems – Requirements, 2013.

ISO Standard 27001 – Information security management systems – Requirements https://www.bsigroup.com/en-GB/iso-27001-information-security/BS-EN-ISO-IEC-27001-2017/ [20.05.2022].

ISO Standard 27002 – Information technology – Security techniques – Code of practice for information security controls, https://shop.bsigroup.com/ProductDetail/?pid=000000000030347481 [21.05.2022].

Payment Card Industry – Data Security Standard (PCI DSS), https://www.pcisecuritystandards.org/security_standards/index.php [21.05.2022].

SANS Institute – Twenty Critical Security Controls for Effective Cyber Defence http://www.sans.org/critical-security-controls/ [22.05.2022].

NIST Special Publication 800-53 Security and Privacy Controls for Federal Information Systems and Organizations http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-53r4.pdf [22.05.2022].

The Danish Agency for Digitization (Digitaliseringsstyrelsen) ISO 27001-benchmark http://www.digst.dk/Arkitektur-og-standarder/Styring-af-informationssikkerhed-efter-ISO-27001/~/media/Files/Arkitekturogstandarder/[23.05.2022]. InformationssikkerhedefterSO27001/ISO27001_Benchmark.ashx [23.05.2022].

Walkowski M., Biskup M., Szewczyk A., Oko J., Sujecki S. (2019). Container Based Analysis Tool for Vulnerability Prioritization in Cyber Security Systems. In: Proceedings of the 2019 21st International Conference on Transparent Optical Networks (ICTON), Angers, France, 9–13 July 2019; IEEE: Piscataway, NJ, USA. [CrossRef].

Tools and Software Solutions. https://www.itgovernance.co.uk/it-governance-tools [24.05.2022].

Tools and Software Solutions. https://advisera.com/27001academy/product-tour/[24.05.2022].

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.1.93

Artur Kotowski[1]

LEGAL FUTUROLOGY – POTENTIAL OF FORESIGHT RESEARCH IN LEGAL SCIENCES: COULD LEGAL FUTUROLOGY BE TREATED AS AN INDEPENDENT SCIENCE IN JURISPRUDENCE?

Abstract: Forecasting the future in relation to the science of law has not been seriously considered so far. It is not only because the fact that half a century ago futurology was treated as an issue of science fiction. Doubts were raised by the specificity of law as a social science and its susceptibility to cultural factors which are impossible to predict. It was also not very clear what legal futurology was supposed to concern itself with and how to define it. Is it about the area of law in force or about the way of practicing the science of law? The limitations of futurological reflection also result from the fact that the characteristics of the law in force determine the way of conducting jurisprudential research. The former, in turn, as already signaled, operate within a wide spectrum of uncertainty.

The paper aims to answer the research question to what extent legal futurology, understood as a set of issues oriented towards the analysis of the future of law and legal science, can be cultivated as a sub-discipline within the structure of legal sciences.

Keywords: theory of law, methodology of law, legal science, futurology

Received: 21 June 2022; accepted: 26 August 2022

[1] Cardinal Stefan Wyszyński University in Warsaw, Faculty of Law and Administration, Poland, ORCID ID: https://orcid.org/0000-0001-8284-241X, email: a.kotowski@uksw.edu.pl

Introduction

On May 7, 1847, in Berlin, Julius Herman von Kirchman (1802-1884), who has been then a Berlin prosecutor since 1846, delivered a lecture that carried the title "On the lack of value of jurisprudence as a science" (Radbruch, 1924). A year later he published a book under the same title (Kirchman, 1848). Kirchman, who at that time was already quite a recognizable figure of legal practice and science, sharply attacked above all the proponents of the philosophy of law: years later called the "historical school". Kirchman effused on May 7, 1847: *Jurists have become worms that live in the rotten tree, turning away from what is healthy, nestling and spinning their filaments in what is diseased (...) the science of law becomes the handmaiden of chance, error, passion, and misunderstanding, looking only to the past. [...] Where positive law is unambiguous, the science of law should remain silent, for it has nothing to say* (Stelmach, 2012).

In the disciplines of legal studies, both historical and general, Julius Kirchman's speech is regarded as the symbolic beginning of continental legal positivism and the onset of a solid reflection on the methodological status of legal studies. Kirchman was no exception to the doubts raised whether jurisprudence is a science. From the very beginning, representatives of continental legal positivism drew attention to the defects of the hitherto practiced science of law due to the speculativeness of the conclusions and their impermanence. Demonstrating the deficits of the historical school (episodic philosophy of law, treated as a stage of transition between the dominance of Ius naturale and legal positivism), legal scholars such as Kirchman emphasized that the change of the law in force makes obsolete the considerations founded on the paradigm of the "spirit of the nation".

A fundamental methodological postulate of the nineteenth-century positivism was the desire to base the study of law on a naturalistic program of scientific inquiry. In this respect, the difference between the positivism operating within the framework of civil law tradition legal systems and the Anglo-Saxon orders quickly became apparent. In the latter, the issue was not so radically raised. It was rather a matter of analyzing the concepts operating in the legal discourse using semiotic analysis, while "programmatically excluding" axiological issues (Opałek & Wróblewski, 1991).

Meanwhile, the continental positivists quickly set the bar much higher. They wanted to shape the methodological foundations of jurisprudence in such a way that they would be modelled on – in their view – the most efficient in building scientific theories of applied science. On the basis of such assumptions developed, the division into general and detailed disciplines of jurisprudence, which is accepted to this day, developed. The latter, known as dogmatics, were to be oriented, on the basis of the adopted axioms, towards the analysis of the law binding in specific areas of regulation, the differentiation of which was carried out based on a logical division rather than an unspecified typology.

In principle, the contemporary jurisprudence differs little much from the formula formed during the second half of the 19th century. This observation is valid primarily with regard to continental jurisprudence. In relation to common law culture, among other things because of its internal diversity, I would not make such firm conclusions.

Meanwhile, the last two decades have seen a rapid development of sciences related to the acquisition, collection and processing of information. Advances in cyber-electronic technologies have led to transformations of civilization that happen in short time intervals. In some ways, this resembles the situation in the second half of the nineteenth century, when the rapid progress of the relevant sciences affected the social sciences, including law.

In some respects, contemporary jurisprudence is "looking back to the past" as well. Howeverthis fact is not commonly assessed in a pejorative way. For various reasons, both the needs of legal practice and prosaic academic didactics, it is pointed out that proper cognition and understanding of the law in force is facilitated by the knowledge of its genesis.

Forecasting the future in relation to the science of law has not been seriously considered so far. It is not only because the fact that half a century ago futurology was treated as an issue of science fiction (It is said that "Futurology was coined in 1943 by Ossip K. Flechtheim, a German refugee teaching at Atlanta University, to describe the science of predictive probability" – Butler, 2014). Doubts were raised by the specificity of law as a social science and its susceptibility to cultural factors which are impossible to predict (Beebe, 2013). It was also not very clear what legal futurology was supposed to concern itself with and how to define it (Ashby Pate, 2010). Is it about the area of law in force or about the way of practicing the science of law? The limitations of futurological reflection also result from the fact that the characteristics of the law in force determine the way of conducting jurisprudential research. The former, in turn, as already signaled, operate within a wide spectrum of uncertainty.

The progress of futurological studies in other social sciences (predictive research became an academic focus in the 1960s. – Butler, 2014), such as management, security sciences, political studies, has partially eliminated these doubts (Peerenboom, 2011). Also, improvement of information technology tools, both through the availability of hardware and software to conduct futures studies, are offsetting what was previously thought to be the impossibility of conducting futures research (Zacher, 1971). Ultimately, the challenges of the future in the form of climate change, economic transformation, social migration or the development of technology (including biotechnology) require that legal reflection includes an attempt to work out solutions not in the moment of need, but in order to have the means or legal constructs for the future, if necessary (Muller et al., 2012).

This paper aims to answer the research question to what extent legal futurology, understood as a set of issues oriented towards the analysis of the future of law and legal science, can be cultivated as a sub-discipline within the structure of legal sciences. Alternatively, could it be treated as an independent science within jurisprudence?

This issue also extends to the specific issues of legal studies and perhaps especially to interdisciplinary projects, which are geographic information systems (GIS) related projects. The use of new technologies, cooperation with experts from other sciences opens up the need for legal studies to develop methodological standards for undertaking research related to – generally speaking – futures studies.

The structure of legal sciences – some remarks in methodological and praxeological aspects

Looking from of the position of the general methodology of sciences, one can doubt the legitimacy of treating jurisprudence as a conglomerate of various normative disciplines, unless the notion of "science" in relation to jurisprudence is not treated as such, which must each time meet the postulates of a separate object of research and an independent (or recapitulated) research method.

Nowadays, the structure of jurisprudence, which is unquestionably accepted, as a group of general (theory, philosophy and not always independently distinguished methodology of legal sciences), dogmatic (detailed sciences of jurisprudence), historical and empirical disciplines, which was developed in the second half of the 19th century under the influence of the positivist paradigm of practicing science. Such a division, with minor differences, is common in countries belonging to the culture of the statutory law.

The general acceptance of such an accepted structure of jurisprudence as a scientific discipline (excluding the common law culture) does not exclude the formulation of polemical remarks. Doubts can be formulated from the praxeological (utility) and methodological perspective. These are, of course, exemplary directions of critical reflection, but as one may think, they are fundamental for the theory (and philosophy) of law, bearing in mind that each theoretical thesis may be supported or inferred on the basis of a particular philosophical in accordance to legal thesis (Wróblewski, 1966).

Let us first address the praxeological issue. The aforementioned division makes jurisprudence a science of high internal heterogeneity. However, it stands in opposition to the convergence and unification processes observed for at least half a century. Both of them occur in the science and practice of law. The former are connected with the internationalisation of the issues of legal science and practice between the culture of the state law and the common law systems, in which there is no such strict division on the location of problems in specific sub-disciplines of legal studies. The unifying tendencies, on the other hand, concern the direction of development of the whole modern science, in which one tries to combine research problems and build theories that do not abstract the explanations from each other, but take into account the factors located in different sciences. It seems that the heterogeneous structure of jurisprudence hinders rather than facilitates the realization of itsexternal integration , if only due to the generation of numerous methodological problems on the part of the science of law itself. Legal practice, on the other hand, faces completely different problems. Of course, the traditional division into branches of law remains valid and doubting its correctness seems to be an aberration. Especially that the division into civil, criminal and administrative law fulfils the conditions of logical differentiation because of the precisely specified criteria: the subject of regulation, the method of regulation, the type of legal relationship shaped by this regulation. All of them make it possible to divide the denotative scope of legal regulation into three scopes. For all three names exhaust the range of designations of the name: "legal regulation". The problem is, however, that it is the representatives of legal practice who observe that certain legal problems are located

in the area of different aspects of regulation. Also in the science of law itself the division into flagship dogmatics is increasingly perceived as insufficient, in view of the emergence of new sub-disciplines in their areas, which are characterised by far-reaching specialisation. We have observed it before, basically, mainly in the area of administrative law, but in the face of deepening specialisation also in the area of private law and even in the area of penal-material law the previously mentioned criteria of dividing dogmatics become too general, and a "penalist" from the area of penal- fiscal law sees qualitatively significant differences in relation to general penal law. All this, to put it succinctly, results from the increase in the number of legal regulations and the legislator's embracing of more and more new subjects of regulation.

While the praxeological aspect can be accepted or not, the polemic from the methodological perspective is more serious. It is about principals of the foundations of jurisprudence as a science. It should be noted that, as it has already been pointed out, the division into general, dogmatic, historical and empirical disciplines of jurisprudence does not meet the criterion of logical differentiation. It is a typology, and in addition, such, which does not always allow to precisely qualify research problems to a particular discipline. Difficulties of this kind are observed at the level of general science of jurisprudence. The literature indicates that in the statutory law legal culture the boundary between the theory and philosophy of law is not precisely defined and, in fact, it does not seem possible to define it. This gives rise to justified doubts as to the methodological correctness of the division of jurisprudential disciplines, since it does not allow for an answer to the question which of them should formulate theories concerning a given research problem. It is also worth noting that the division of general jurisprudential disciplines is itself "general" and does not take into account those subdisciplines which became independent especially after the Second World War. I mean here legal ethics (located within the philosophy of law), but also logic and legal argumentation. All of them are most often situated in the area of legal theory, but the latter – also following its genesis in the period of legal positivism – is most often divided into the theory of norms, interpretation and application of law. There is not enough space for logic and legal argumentation. The point is that important legal disciplines, which have been intensively developed during the last several decades and which are responsible for significant reformulation of thinking about law, are not included as such in the structure of jurisprudence. Logic has brought to the study of law the great importance of semiotic analysis and a pragmatic view of legal language. This made it possible to reject or at least reduce the significance of the naturalistic methodological postulate in relation to the phenomenon of law, which as social following the pattern of Anglo-Saxon analytical jurisprudence began to be analyzed in the form of conceptual studies. The division of the general sciences of jurisprudence does not take into account the transformations that took place as a result of the anti-naturalistic turn in the social sciences after World War II and the shift of attention to the discursive-argumentative aspect of law, the linking of theoretical issues with constitutional law, and legal reasoning being shaped by argumentative, "Perelmanian" logic. By necessity of the limited volume of the text, it is only possible to marshal these problems.

Meanwhile, the general sciences of jurisprudence still function according to the 19th century scale of issues and problems. The second aspect of methodological polemics with the existing structure of jurisprudence is connected with the already signaled requirement of distinguishing an independent object of research and an autonomous or recapitulated research method. These requirements result from the general methodology of sciences. The postulate of the methodological autonomy of jurisprudence was the fundamental problem, the solution of which ensured jurisprudence the status of a science. The reception of conceptual analysis to the specifics of normative reasoning allowed jurists, through the whole theory of exegesis, to construct a methodological apparatus that could meet these requirements. However, it is worth recalling that while it works in the field of analytical jurisprudence, on which the theory of law and dogmatic disciplines are based, it does not apply at all in the other disciplines classified as legal sciences. This is because the exegesis of a normative act – or more broadly – the theory of interpretation of law is not a basic research method in the historical and empirical disciplines of legal studies. The former use the historical method, although the interpretation of no longer binding sources of law takes place in the formula of exegetical or free hermeneutics, which is necessary due to the requirement to take into account the historical realities of their creation. Reading the meaning of the non-binding sources of law, or more broadly, of historical normative texts (which, after all, not all of them have the status of currently defined normative acts) in a limited way is carried out by using contemporary theories of interpretation, or general rules of exegesis. Another thing is that - as noted in the literature – the theory of legal interpretation is a "relatively young" discipline (Waśkowski, 1936), since it was developed at the end of the 19th century, and the directives of interpretation are not directly applicable to earlier historical sources. They are used by historians of law in an auxiliary way. The empirical sciences of jurisprudence form a conglomerate of disciplines with such a variety of subjects and methods recycled from other sciences that the methodological autonomy of jurisprudence does not apply to them at all. Thus, including the sociology of law, criminology, not to mention criminalistics or forensic psychology into the group of empirical legal sciences is an artificial typology within the framework of the division of disciplines, but it does not meet the requirements of autonomy of a given science, set out in the general methodology of sciences. Of course, it can be assumed (and so it is) that the name "science" within the concept of "legal science" is characterized by different attributes than "science" within the general methodology of sciences. In any case, it results in the current postulate of the still nineteenth-century positivism that the boundaries of jurisprudence are determined only by its autonomous research method, and all other disciplines, except for roman studies, should be excluded from jurisprudence and placed within the framework of other sciences proper to them. In this convention the sociology of law, like the philosophy of law, should be placed, respectively, as a subdiscipline of sociology and philosophy. The status of empirical disciplines of penal sciences would be unclear, however, taking into account the research area of, for example, victimology or criminalistics, the research

questions need to be answered from the perspective of their respective sciences, such as psychology or a given applied science.

Of course, there are other proposals for defining the structure of legal studies. For example, in 1990 Robert Alexy and Ralf Dreier pointed out the possibility of distinguishing the general juristic theory of law as a subject discipline and the theory of legal science as a metatheory of the general theory of law (Alexy & Dreier, 1990). This proposal, however, has not been widely adopted by the theoretical-legal discourse, and the division into scientific units within institutes or faculties of law in the entire legal culture reflects its structure outlined above.

The above in itself does not raise major problems, apart from still defining the methodological status of certain disciplines within the legal sciences. On the other hand, if we consider the possibility of incorporating into this structure innovative research areas which could be given the status of sub-disciplines, such as the issue of studying the future of law, then the question of the validity and usefulness of the existing typology of legal sciences is most justified.

Legal futurology – science or fantasy?

Stanislaw Lem in his famous science-fiction novel "Solaris", accurately summarizes in the words of its main character Kris Kelvin, that in the history of science there have been situations when "every science is always accompanied by some pseudoscience, its bizarre twisting [...] astronomy has its caricaturist in astrology, chemistry once had it in alchemy..." (Lem, 2012). Wondering about the possibility of integrating into the structure of legal sciences its sub-discipline in the form of legal futurology, the question arises whether we are dealing with such a pseudo-scientific "freak" (Lem, 2012) or could it be a real, new subdiscipline of jurisprudence, as it seems – classified as an empirical science and placed next to sociology of law, criminology, or legal psychology, which is rarely mentioned but has already gained its rightful place in this group?

Before we consider the answer to the question posed in this way, we should first consider whether the analysis of the development trends of certain research subjects in the science of law entitles us to assume that we are dealing with futurology (Andersson, 2018). Futurology is defined as, generally speaking, the study of the future, but one which, by means of empirical methods of analysis, is supposed to lead to conclusions which are considered to be true (Butler, 2014). Of course, we do not mean actual findings of what and how will happen. It is rather a question of making certain prospective assumptions which, on the basis of replicable procedures of empirical analysis, would have the same content if only different researchers had implemented a given method in the same way and procedurally applied it in the same way. We cannot predict all future factors. This is understandable, but what is involved is the ability to reach a rational conclusion about a particular phenomenon in the future on the basis of evaluation criteria currently accepted as true. Although logical categorical sentences do not apply to prospective sentences, this is true, of course, by analogy, of making

statements about the future in a manner similar to that of syllogistics, assuming other factors unchanged (the *ceteris paribus* clause).

It can be assumed that the veracity of the observation that modern science has the tools to conduct research on the development trend of certain phenomena will not be contested. Analyses of this kind should fit into the above, very generally outlined formula and, together with technological progress, should be part of the automation of at least some of the research processes (Barton & Bibas, 2017). The methods used to conduct futurological analysis are various. Taking into account the specificity and needs of legal sciences, the empirical prediction of development trends on the basis of the Delphi technique, or other surveys or questionnaire studies of experts may be applied in order to determine the direction of development of a given phenomenon, classified as one that falls within the area of interest of legal studies. Due to the characteristics of the legal phenomenon, it seems that various computer modeling techniques can be used in a limited way within the framework of legal futurology. Analyses of development trends using computer software may be applicable to the analysis of so-called hard indicators within individual sub-disciplines. However, they must not be confused with the focus of legal futurology itself. Thisis important as well. The fact that we analyze, for example, trends in the development of crime on the basis of data from previous years concerning the number of recorded crimes of a given type is in itself an example of studies on the future, but in itself does not entitle to qualify such analyses to the area of a possible new discipline of jurisprudence, which would be legal futurology. This type of research has already been conducted for many years – also because of the needs of practice – in existing disciplines, in this case within criminology. In order not to expose ourselves to the accusation of lack of precise distinction of the object of research for legal futurology, we should only define it by including previous research that has been successfully conducted in disciplines listed so far.

Let us remember that the basis for the evaluation of the legitimacy of the separation of a new sub-discipline in the structure of legal sciences is to obtain an answer not to the question whether it is possible to find already now single issues corresponding to the formula – in the scope of our interest – of the studies on the future, but whether it is possible to isolate the area, that is, the range of issues so far not analyzed or studied residually – fragmentarily and qualify them to the discipline of jurisprudence so far unknown. The second condition, formulated by the general methodology of sciences, concerns the possibility of defining an independent research method. In the case of legal futurology, this requirement is fulfilled by the reception of research methods for conducting studies on the future and incorporating them into the needs of legal sciences.

In order to clarify the complexity of the methodological problem outlined above, it should first be pointed out that obviously exegesis of a normative act is not applicable to futurological analyses. By contrast, it can itself be one of interest to legal futurology. Leaving aside the assessment of the effectiveness of such analyses and the possibility of endowing their results with the value of credibility, in this respect there is a difference between individual research issues which can already be qualified as formulas of futurological studies and the actual area of legal futurology as a sub-discipline of

jurisprudence. Only additionally, in passing, it may be noted that the analyses of analytical problems – such as the one signalled above, concerning the directions of development of the theory of exegesis, is precisely an example of the application of research techniques combined with the so-called foresight studies (including the Delphic analysis, which will be discussed in a moment).

Let us refer to the doubts which immediately arise from such requirements concerning the methodological correctness of distinguishing legal futurology in the structure of legal sciences. Predicting the directions of development of legal phenomena is difficult due to their interaction with factors from the extra-normative environment. Thus, studying – for example – the law-making process in some individual context (e.g., the development trends of criminal law guarantees), a large uncertainty immediately appears, which is due to a significant number of socio-political factors. In other words, in the case of legal phenomena, the difficulty of conducting studies on the future is due to the significant influence of unchanged factors that remain in relation to the studied phenomenon, which makes it difficult - as already mentioned – to endow these results with credibility, since they are worked out in conditions of considerable uncertainty. At the same time, the factors around the normative are also burdened with the same conditions. Thus, a whole spectrum of interactions appears, which, while allowing for some analysis of their developmental trends, are highly uncertain, so that futurological analyses of this kind, conducted in these contexts, are not treated as ones that generate scientifically certain conclusions.

The problems of legal futurology are also sometimes seen as studies on the evolution of specific legal institutions (Marano & Noussia, 2020). Such a research approach seems to be wishful thinking and results from a misunderstanding of futurology itself. It is difficult to predict what changes in positive law will occur in a certain period of time. Indeed, the aim of futurology is to conduct studies on the developmental tendencies of certain phenomena, and not in the context of legal sciences – on the development of particular legal institutions. Reflection of the latter kind can be undertaken at the level of individual legal dogmatics. Regardless of the assessment of the legitimacy and effectiveness of conducting such studies.

Legal futurology, meanwhile, should be associated with analyses of the legal science problems, and, as it seems, to a limited extent with the sphere of legal practice, due to the difficulty of conducting studies of this kind. Thus, legal futurology may cover – for example – not particular problems of law application or interpretation, but evolution of these legal phenomena based on current and assumed as future developmental tendencies of these aspects of law. Therefore, the subject of legal futurology is the study of the future of particular legal science disciplines or problems functioning in them as general research directions, and not particular dogmatic or theoretical-legal issues.

At the end of this part of the discussion, we should briefly refer to the signaled research methods that can be used within the legal futurology. The first catalog of such methods consists of survey or questionnaire-based expert research with a wide range in the formula of Delphi analysis. This type of research consists of a multi-stage questioning of experts in a given field (in the case of legal sciences, e.g. theorists dealing

with the theory of legal interpretation) to indicate the current conditions and future directions of development of a phenomenon within their area of competence. The next stage consists in revealing the aggregated results given by all the experts with a request to evaluate the conclusions reached and formulate further predictions about the development trends. The number of inquiry stages depends on the individual study, its specificity and the scope of analysis. This formula is characterized by the flexibility of the research methodology and allows it to be adapted to the requirements of a specific project. As it has already been mentioned, computer modeling techniques and specialized software enabling the determination of development trends of specific phenomena are of limited use in the case of legal futurology, due to the necessity to operate on quantitative variables, which would necessitate the operationalization of qualitative variables, characteristic of legal sciences in the studied scope, into quantitative variables. This does not always seem possible, and even if it is, it does not solve the difficulties of using such operationalized variables in computer modeling. In general, legal futurology would rely on sociological research methodology in formulating forecasts of the development of the science of law. The whole range of methods of this kind enters here, from the already mentioned questionnaire and survey research, to interviews, and even observations (external and participatory) and simulations (e.g. of different procedures of applying, making, interpreting the law, adapting new technical or organizational solutions to carry out such legal procedures). However, one cannot escape the doubt whether the above catalog of methods entitles legal futurology to the status of an independent sub-discipline in the structure of legal sciences, or whether it should be placed in one of the already existing disciplines of jurisprudence.

An attempt to summarize the potential of future studies in legal sciences

We have established that there is a potential in the area of legal sciences to undertake research classified in the general methodology of sciences as future studies. Thus, we have verified the first requirement for distinguishing legal futurology as a sub-discipline of legal science. We have also determined that the reflection on the evolution of legal science, rather than on specific institutions of positive law or problems of legal practice (therefore, the consideration of the evolution of, e.g., contract law should be qualified as the subject of civil law dogmatics and not legal futurology as a separate science in the structure of legal studies, cf – Borselli, 2020), should be the subject of its interest for praxeological reasons. The former, however difficult to analyse from a futurological perspective, are already nowadays – albeit rarely – undertaken by dogmatic disciplines and should be placed there, analysing the matter from the perspective of the methodology of legal sciences.

It is problematic, however, to meet the second requirement – to define a research method unique to legal futurology. To be more precise, these are methods used in the sociology of law, recycled for the purposes of studying the future. This also applies to the Delphi technique, which, although most often associated with futurological analyses, is also used as an instrument for improving decision-making processes in large

organizational units, analyzing their current status, etc. In other words, the Delphi technique is not unique to futurology per se. This raises methodological implications for legal futurology that this method, too, although considered effective, is not unique within futurology studies.

To summarize, there are fundamental methodological limitations to determining whether legal futurology deserves to be treated as an independent discipline within the structure of legal sciences and, if so, in which group of sciences it should be placed. In fact, the answer to this question depends on the accepted boundaries of legal studies itself. If we were to apply the currently rather unacceptable criteria of legal positivism, based on methodological naturalism, legal futurology could not be qualified as a science of law, just as all other empirical disciplines, because they do not use the formal-dogmatic method. However, nowadays, such rigorous postulates are rejected, and disciplines that recapitulate the methods of other sciences are included among legal sciences.

However, I have fundamental doubts whether legal futurology can be treated as an independent discipline among empirical sciences of jurisprudence. Understood as a reflection on the directions of legal science development , it seems more appropriate as a part of legal theory. The theory of law is usually divided into three basic sections: the theory of legal norms, the theory of law application and the theory of law interpretation. On the other hand, there are new groups of issues that do not fit into this traditional division of legal theory, such as jurisprudence or legisprudence (and also interdisciplinary issues, such as transhumanism, e.g. – Maj, 2019). Also legal cognitive science is located as a multidisciplinary issue in the area of legal theory. The fact that legal futurology is not treated as an independent discipline of legal studies does not depreciate its role or the importance of the analysed problems. It does, however, give rise to a reformulation of the division of legal theory itself, which is still based on typology and cognitive limits formulated for general jurisprudence, shaped during the domination of legal positivism. In this context, it may be worthwhile to separate the levels of legal theory, in a way referring to the already signalled proposal of Alexey and Dreier that the theory of law should be divided into two levels: a general theory of law and a detailed theory of legal sciences. The latter would take over the traditional, nowadays specified, divisions of the theory of law, which, after all, constitute a metadiscipline above the detailed sciences of jurisprudence. On the other hand, the general theory of law, which is divided into general analytical and empirical jurisprudence, could encompass all new research directions, which so far have been difficult to assign, and which also require an answer by the science of law to the postulate of theoretical unification of conducted analyses. This is combined with interdisciplinary research, which is not always the same thing (Bruhn, 2000; Bunge, 1983; Grobler, 2006). Then, legal futurology as a part of general, empirical theory of law could interact with legal cognitive science, jurisprudence (or cognitive jurisprudence) and try to shape empirical reflection on law, reducing all accusations of having no of methodological basis.

Reference

Alexy R., Dreier R. (1990). The Concept of Jurisprudence. Ratio Juris, vol. 3, no. 1, pp. 1–13. https://doi.org/10.1111/j.1467-9337.1990.tb00047.x

Andersson J. (2018). The Future of the World. Oxford.

Pate R.A. (2010). The future of harmonization: soft law instruments and the principled advance of International Lawmaking. Toronto International Law Review, vol. 13, no. 2, 23 pp.

Barton B.H., Bibas S. (2017). Rebooting justice. More technology, fewer lawyers, and the future of law. London.

Beebe B. (2013). Fair Use and Legal Futurism. Law & Literature, vol. 25, no. 1, pp. 10–19.

Borselli A. (2020). Smart Contracts in Insurance: A Law and Futurology Perspective. In: P. Marano, K. Noussia (ed.), InsurTech: A Legal and Regulatory View. AIDA Europe Research Series on Insurance Law and Regulation, vol 1. Springer, Cham. https://doi.org/10.1007/978-3-030-27386-6_5

Bruhn J.G. (2000). Interdisciplinary research: a philosophy, art form, artifact or antidote? Integrative Physiological Behavioral Science, vol. 35(1), p. 58–66.

Bunge M. (1983). Treatise on Basic Philosophy, vol. 6, Epistemology & Methodology II: Understanding the World, Reidel, Dordrecht, p. 219–221.

Butler A.M. (2014). Futurology. The Oxford Handbook of Science Fiction. DOI: 10.1093/oxfordhb/9780199838844.013.0040

Grobler A. (2006). Metodology of Sciences. Wydawnictwo Aureus-Znak, Cracow.

Kirchman J. (1848, reprint 1990). Die Wertlosigkeit der Jurisprudenz als Wissenschaft (*The worthlessness of jurisprudence as a body of knowledge*).

Lem S. (2012). Solaris. Wyd. Literackie, Warsaw.

Maj M. (2019). Artificial intelligence and robots as a challenge for law. https://doi.org/10.34616/23.19.064

Marano P., Noussia K. (ed.) (2020). InsurTech: A Legal and Regulatory View, vol. 1, Springer.

Muller S., Frishman S.Z.M., Kistemaker L. (ed.) (2012). The Law of the Future and the Future of Law: Volume II. Hague.

Opałek K., Wróblewski J. (1991). Law: methodology, philosophy, theory of law. Warsaw.

Peerenboom R. (2011). The future of Law in a Multi-Polar Wolrd: Toward a Global New Deal. In: S. Muller, S.Z.M. Frishman, L. Kistemaker (ed.), The Law of the Future and the Future of Law. Oslo.

Radbruch G. (1924). Introduction to jurisprudence. Warsaw.

Stelmach J. (2012). Positivist myths of legal method. Legal Forum, no. 3 (11).

Waśkowski E. (1936). Theory of interpretation of civil law. Warsaw.

Wróblewski J. (1966). The philosophical and afilosophical attitude in the contemporary theory of law. Studia Prawnicze, no. 13.

Zacher L.W. (1971). Technical change and structural and social transformation – futurological remarks. Humanization of Labour, no. 5–6.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.105

Krzysztof Świtała[1]

A IMPACT OF ADMINISTRATIVE LAW REGULATION ON MODELS OF USING SPATIAL DATA TO PROMOTE TOURISM ASSETS OF POLAND AND ITS CULTURAL AND NATURAL HERITAGE

Abstract: The purpose of the article is to analyze the impact of legal regulations on the use of spatial data related to Poland's tourism assets and its cultural and natural heritage through spatial information services used as part of spatial information systems, both in the public and private sectors. The conducted considerations are to allow for the formulation of de lege lata remarks and de lege ferenda postulates regarding the existing legal basis for the functioning of the spatial information infrastructure. The proposed solutions should have a positive impact on improving the efficiency of using the data collected in this infrastructure for purposes related to the promotion of Poland's cultural and natural heritage.

Keywords: spatial data for tourists, cultural heritage, natural heritage, open data, interoperability

Received: 16 December 2022; accepted: 20 December 2022

[1] Cardinal Stefan Wyszyński University, Law and Administration Faculty, Department of Informatics Law, Warsaw, Poland, ORCID ID: https://orcid.org/0000-0003-0426-5383, email: k.switala@uksw.edu.pl

Introduction

Spatial data in the area of processing information on natural and cultural heritage has significant potential for promoting tourism assets. The article analyses the legal aspects of the issue in question. The purpose of this article is to present the importance of normative instruments in regulating processes related to the processing of spatial data for tourism activities. The role of GIS systems and spatial information infrastructure in the dissemination of information on natural and cultural heritage is considered, in particular in relation to monuments and forms of nature conservation. The importance of open data and the interoperability of the related collections and services is also relevant to this issue. The growth of GIS in tourism is linked to the development of user-oriented web services and their specific needs in this area (Jovanović, 2007). By providing secure and efficient access to such resources, it is possible to disseminate them freely and automatically on geoportals and websites aimed at promoting the tourism assets of EU regions.

Material and Methods

The article uses 2 legal research methods: dogmatic and empirical. The first one consists in a multifaceted analysis of the content, structure and mutual relations of legal acts relating to the processing of spatial data for tourism-related purposes. The second method, on the other hand, refers to the study of the actual effects of the application of the legal norm. The paper presents examples of electronic services that in their daily operation use data that are part of the infrastructure of spatial information based structurally and procedurally on national regulations that implement the INSPIRE Directive. The application of the discussed methods allowed a discussion and formulation of conclusions concerning the most effective solutions of using spatial data to promote tourist attractions.

GIS and data on natural and cultural heritage

Geographical information systems are a solution consisting of databases, hardware, software and users for processing spatial data, one of the functions of which is to support decision-making and disseminate information about specific objects and phenomena. In the context of tourism, there is a need for various forms of information on spatial relationships, of which cartographic studies are the most prominent (Leszczyńska, 2003). Spatial information systems are used not only for data visualization, but above all for spatial analysis resulting in the acquisition of new knowledge (Białousz, 2013). Such solutions also play an important role in areas related to tourism management (Chang, 2011). Information systems offering services to geographic research and decision-making could play roles in tourism management, which are indicated below:

- Conducting Tourism Information Management – from the traveler perspective, GIS has important information storage features and could provide travel information

inquiry service for tourists. Furthermore, from the travel management service sector perspective, it could make tourism management more easily.

- Being Able to Produce a Comprehensive Thematic Map – in comparison with traditional paper tourist map, the advantages of GIS drawing tourism plans are clear visible, because of its tiered storage capabilities, travelers could output a map including all tourism elements, such as terrain, road transport, services, facilities, tourist attractions and choose their own set of elements.
- Providing References for the Tourism Development – from a large amounts of GIS stored data about human and natural landscape, transportation, climate, topography, soil, vegetation, animals and plants, tourism management department could obtain the information that is useful for business operations and improving competitiveness by the use of data mining technology (Wei, 2012).

Through the use of GIS, the implementation of public policies can be based on evidence relating to the current state of specific objects and phenomena on the ground. In the context of tourism, this is important for tourists able to benefit from a better quality of public services adapted to the current needs of their audience.

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) indicates in Annex I that the Infrastructure for Spatial Information shall include data concerning protected areas designated or managed under international, Community or Member State law to achieve specific conservation objectives. We can include information on cultural and natural heritage in this category. Annex III of the INSPIRE Directive also covers buildings and habitats and natural homogeneous areas.

Nature conservation

Nature conservation is considered as a set of activities aimed at preserving animate and inanimate nature and the landscape in an unchanged or optimal condition. The primary objective of nature conservation is to maintain the stability of ecosystems and ecological processes and to conserve biodiversity (Habuda, 2017). One of the most important principles resulting from the Act of 27 April 2001. Environmental Protection Law is the preservation of sustainable development, understood, according to Article 3, point 50, as such social and economic development in which a process of integrating political, economic and social activities takes place, maintaining natural balance and sustainability of basic natural processes in order to ensure the possibility of satisfying the basic needs of particular communities or citizens of both the present and future generations.

Catalog of capacities necessary for sustainable development implementation includes:

- measure progress,
- promote equity,
- adapt to shocks,
- to transform development pathways,

- link knowledge with action,
- govern cooperatively.

This standard is derived from the United Nations standards developed as part of the work on the Brundtland Report in 1987 relating to keeping the Earth's environment in the best possible condition for the future (Clark, 2020).

The principle of sustainable development presupposes the application of effective legal mechanisms guaranteeing the preservation of natural heritage for future generations. On the basis of Article 6 of the Act of 16 April 2004 on nature protection, forms of nature protection in Poland include:

- national parks,
- nature reserves,
- landscape parks,
- areas of protected landscape,
- Natura 2000 areas,
- nature monuments,
- documentation sites,
- ecological sites,
- nature and landscape complexes,
- species protection of plants, animals and fungi.

The most important data on these objects are collected in a central register of forms of nature protection maintained in electronic form by the General Director of Environmental Protection. The technical details of the operation of this collection result from the Regulation of the Minister of the Environment of 11 September 2012 on the central register of forms of nature protection. Access to this resource is possible online through the domain crfop.gdos.gov.pl. The aforementioned service makes it possible to search for an object on the basis of the criterion of its own name, type of nature conservation form or location in units of the country's basic territorial division. In addition to this graphical user interface, this collection can be used as an interoperable service for browsing (Web Map Service – https://sdi.gdos.gov.pl/wms) or downloading spatial data (Web Feature Service – https://sdi.gdos.gov.pl/wfs). The General Directorate for Environmental Protection also provides a thematic geoportal (https://geoserwis.gdos.gov.pl/mapy/). As emphasized in the literature, one of the primary goals related to the establishment of the INSPIRE directive in the EU area was to organize the data obtained from the member states on environmental protection and thus guarantee better consistency and efficiency of the environmental management processes (Rusztecka, 2012). From the point of view of promoting the tourist values of the regions, data on protected areas and their characteristic habitats of flora and fauna can be a useful source of information for tourists looking for naturally attractive holiday destinations.

Protection of monuments

Pursuant to the definition of Article 3(1) of the Act of 23 July 2003 on the protection and care of historical monuments, a monument is understood to be an immovable or movable object, parts or complexes thereof, being a work of man or related to his activity and being a testimony of a past epoch or event, the preservation of which is in the public interest due to its historical, artistic or scientific value. The content of art. 3 item 1 of the discussed act distinguishes additionally an archaeological monument which is an immovable monument, being a surface, underground or underwater remnant of human existence and activity, consisting of cultural stratification and products or their traces, or a movable monument, being such a product. The collection of data concerning the objects in question is the register of monuments maintained in the voivodeship on the basis of Article 8 by the voivodeship conservator of monuments. On the basis of art. 9 paragraph 1 an immovable monument is entered in the said register on the basis of a decision issued by the voivodeship conservator of monuments ex officio or on application of the owner of the immovable monument or the perpetual usufructuary of the land on which the immovable monument is located. Additionally, on the basis of Article 21 et seq. a register of monuments was created, which includes the following subcategories:

- The General Conservator of Monuments maintains a national register of monuments in the form of a set of registration cards of monuments located in provincial registers of monuments.
- Provincial conservator of monuments maintains a provincial register of monuments in the form of register cards of monuments located in the province.
- The head of the commune (mayor, town president) maintains a communal register of monuments in the form of a collection of address cards of immovable monuments from the communal area.

The detailed rules concerning the keeping of the aforementioned collections are established in the Regulation of the Minister of Culture and National Heritage of 26 May 2011 on keeping a register of monuments, national, provincial and communal records of monuments, and a national list of monuments stolen or illegally exported abroad. The fact that these provisions do not provide for electronic form as the primary means of keeping these collections deserves criticism. This reduces the efficiency with which public authorities can perform their tasks related to this category of data. It also limits the potential for their re-use, for example in electronic services for tourists seeking objects of particular historical or artistic value in a particular area.

Due to the requirements resulting from the Act of 4 March 2010 on spatial information infrastructure, which is the implementation in the national legal order of the previously discussed INSPIRE directive, the basic data concerning monuments have the form of electronic spatial data and are made available through national and regional geoportals. One such solution is the map portal of the National Heritage Institute (mapa.zabytek.gov.pl) – an entity established by the Minister of Culture and National Heritage based on the order of 23 December 2010 on the change of the name and scope

of activities of the National Heritage Research and Documentation Centre, issued in accordance with Article 11 and Article 13(1) of the Act of 25 October 1991 on the organization and management of cultural activities. The said ICT system also includes WMS, WFS and CSW spatial data services.

Open data

Issues relating to open data, the principles and modalities for sharing and transferring public sector information for re-use are set out in the Act of 11 August 2021 on open data and re-use of public sector information implementing Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and re-use of public sector information. This act addresses the situation of transfer to external parties of public sector information, comprising open data characterized by electronic form, completeness, timeliness, referentiality, processed in an open and non-proprietary machine-readable format, which is intended to be reused free of charge on the same basis for any user, without the user having to prove his or her identity. Re-use of these resources means such use that goes beyond their intended public tasks. In the 2011 European Commission Communication. Open data - an engine for innovation, growth and transparent governance (COM (2011) 882) identified the following key challenges that can be overcome through effective mechanisms for the re-use of these resources:

- Untapped business and economic opportunities – public data are an essential raw material for a wide range of new information products and services that build on new possibilities to analyze and visualize data from different sources.
- Addressing societal challenges – public data could for example be used to enhance the sustainability of national health care systems or essential factor for tackling environmental challenges, such as unsatisfactory energy efficiency level or increasing emissions because of inefficient traffic management systems.
- Accelerating scientific progress – scientific activities are increasingly undertaken through global collaboration on the internet, using very large data collections, huge computing resources and high-performance visualization for e-science (research enabled by e-infrastructure/ICT).
- Need to act at all levels: local, regional national and EU level – data users do not want their mobile service to stop at the border, and Europe-wide business information services with gaps for one or more countries will lose much of their interest.

Public data exploitation holds important potential for the EU economy and consumer welfare.

Public sector resources, and in particular spatial data, can be used for purposes related to promoting Poland's tourism assets and cultural heritage beyond the original purpose of processing these resources in connection with inventorying and securing objects of natural or cultural value. Examples of commercial solutions using such data include services such as Czech Mapy.cz or Polish Mapa-turystyczna.pl. They are available via a web browser or mobile application, enabling users not only to view data on natural

and cultural sites, attractions and tourist infrastructure, but also to enter their own spatial data (e.g. from a GPS receiver) related to their activities in the area and share them via social media. As the statistical reports commissioned by the EU indicate, the level of maturity of the Member States' policies for opening up public data resources is steadily increasing (Open Data Maturity Report 2021, p. 24). The aim is to achieve a level of data sharing that is as automated and free as possible, using APIs that are easily adaptable to specific applications.

Spatial data interoperability

The concept of interoperability of spatial data is defined in the INSPIRE Directive. Article 3(7) of this act states that it means the possibility for spatial data sets to be combined, and for spatial data services to interact, without repetitive manual intervention, in such a way that the result is coherent and the added value of the spatial data sets and services is enhanced.

The issue of improving the level of interoperability between information systems in the EU Member States is addressed in the European Commission Communication European Interoperability Framework - Implementation Strategy (COM (2017) 134). This document formulates the following most relevant problems related to the insufficient degree of cooperation between electronic services and datasets:

- legal issues, e.g. by ensuring that legislation does not impose unjustified barriers to the reuse of data in different policy areas;
- organizational aspects, e.g. by requesting formal agreements on the conditions applicable to cross-organizational interactions;
- data/semantic concerns, e.g. by ensuring the use of common descriptions of exchanged data;
- technical challenges, e.g. by setting up the necessary information systems environment to allow an uninterrupted flow of bits and bytes.

In the context of this issue, the EU institutions place an important emphasis on supporting the processes of managing and developing the European interoperability reference architecture and European interoperability cartography. The primary objective of EIF implementation is to inspire European public administrations in their efforts to design and deliver seamless European public services to other public administrations, citizens and businesses which are to the degree possible, digital-by-default (i.e. providing services and data preferably via digital channels), cross-border-by-default (i.e. accessible for all citizens in the EU) and open-by-default (i.e. enabling reuse, participation/access and transparency).

The EIF has formulated the following catalogue of principles relating to fundamental behavioral aspects to drive interoperability actions:

- Subsidiarity and proportionality;
- Openness;
- Transparency;
- Reusability;

- Technological neutrality and data portability;
- User-centricity;
- Inclusion and accessibility;
- Security and privacy;
- Multilingualism.

Data openness and the use of data formats that enable the processing of public sector information resources in an automated way are closely linked to the achievement of semantic and technical levels of interoperability. The organizational level, on the other hand, is characterized by important links to legal procedures related to spatial data management.

Results and discussion

Spatial information plays an important role in electronic services for promoting the tourism assets of EU regions. A main objective of the article was to analyze the relationship of legal instruments regulated by the Act of 4 March 2010 on spatial information infrastructure based on Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), in relation to normative solutions proposed in Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information. In this article, particular emphasis is placed on identifying potential added values resulting from ensuring the interoperability of electronic services and data sets, as well as possible legal barriers related to the subject matter of ongoing research.

An important element of the considerations is the description of the registers established in the Act of July 23, 2003 on the protection of monuments and the care of monuments and the Act of April 16, 2004 on the protection of nature. In this field, it is also important to assess the possibilities of their further improvement using information and communication technologies, open spatial data formats and GIS tools.

The analyses made in the article allowed conclusions to be drawn on the ways, conditions and benefits of using spatial data as a resource relevant to the dissemination of comprehensive and up-to-date tourism information.

Conclusion

Increasing the interoperability and openness of spatial data in the area of processing natural and cultural heritage information is a beneficial process that improves the performance of public tasks and the reuse of such resources. This makes it possible to ensure more effective promotion of the tourist assets of regions based on comprehensive and up-to-date spatial data on natural or culturally significant sites. It is also important to use the potential of big data and virtual reality, which will make it possible to forecast and model tourist traffic effectively. This will allow cultural and natural assets to be used in a more sustainable way.

References

Białousz S. (2013). Rozważania metodyczne o informacji przestrzennej In: S. Białousz (ed.), Informacja przestrzenna dla samorządów terytorialnych (*Spatial information for local governments*). Warszawa, p. 21.

Chang G., Caneday L. (2011). Web-based GIS in tourism information search: Perceptions, tasks, and trip attributes, Tourism Management 32, p. 1436.

Clark W., Harley A. (2020). Sustainability Science: Toward a Synthesis. Annual Review of Environment and Resources, no. 45, pp. 369–370.

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European Interoperability Framework – Implementation Strategy (COM (2017) 134).

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Open data – an engine for innovation, growth and transparent governance (COM (2011) 882).

Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information.

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).

Habuda A., Radecki W. (2017). Ochrona przyrody w systemach prawnych ochrony środowiska Polski, Czech i Słowacji (*Nature protection in legal systems of environmental protection in Poland, the Czech Republic and Slovakia*). Warszawa, p. 141.

Jovanović J., Njeguš A. (2007). The Application of GIS in Tourism and Its Components. Yugoslav Journal of Operations Research, vol 18, no. 2, p. 262.

Leszczyńska M. (2003). Role of GIS in region tourist promotion. Archiwum Fotogrametrii, Kartografii i Teledetekcji, vol. 13A, p. 132.

Rusztecka M., Sudra P., Ślepowrońska K., Wołoszyńska E. (2012). Dane dotyczące środowiska (*Environmental data*). In: S. Białousz, E. Bielecka (ed.), INSPIRE i krajowa infrastruktura informacji przestrzennej (*INSPIRE and the national spatial information infrastructure*). Warszawa, p. 178.

Wei W. (2012). Research on the Application of Geographic Information System in Tourism Management. Procedia Environmental Sciences, no. 12, p. 1106.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.115

Paweł Hajduk[1]

DIVERGENCE BETWEEN AUTHORITIES ON PUBLICLY AVAILABLE SPATIAL DATA IN POLAND

Abstract: The article aims to outline the divergence between authorities on publicly available spatial data in Poland, using the example of a dispute between the Polish Data Protection Authority and the Surveyor General of Poland concerning the publication of the numbers of land and mortgage register on the Polish spatial information website Geoportal. The issues of whether the number of the land and mortgage register is personal data and grounds for processing land register numbers from the DPA's and Surveyor General's perspectives are analyzed. Then, the reasons for this conflict and, more broadly, for disputes between authorities are examined. It is hypothesized that the main reason for this dispute is that the different aims drive different authorities empowered in the regulation of processing publicly available data.

Keywords: spatial data, personal data, dispute, authorities

Received: 11 December 2022; accepted: 23 December 2022

[1] Cardinal Stefan Wyszyński University in Warsaw, Faculty of Law and Administration, Department of Informatics Law, Doctoral School, ORCID ID: https://orcid.org/0000-0001-5583-2267, email: p.hajduk@outlook.com

Introduction

As a result of the digital transformation, the use (processing) of personal data in all aspects of social reality has become widespread. Data is a critical concern in social, political, and economic life in this environment (Obendiek, 2022). It includes spatial information. The legislator's response at the EU and national (Polish) level is to introduce legal acts to respond to the threats posed by this new reality. The critical act is Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (OJ L 119, 4.5.2016, p. 1-88) (GDPR).

The consequence is that situations arise where it is necessary to balance the obligations under the norms of data protection law and the implementation of statutory obligations under sectoral regulations. The problem originated in an extensive network of legal acts, the application of which is not coordinated.

The article aims to outline the divergence between authorities on publicly available spatial data in Poland, using the example of a dispute between the Polish Data Protection Authority and the Surveyor General of Poland concerning the publication of the numbers of land and mortgage register on the Polish spatial information website Geoportal. To meet this objective, it is necessary to analyze whether the land and mortgage register is personal data and grounds for processing land register numbers from the DPA's and Surveyor General's legal perspectives. Furthermore, to position this problem in a more comprehensive perspective, the article also analyzes the reasons for this conflict and disputes between authorities in general.

Considering the extensive normative grid at the EU and national levels and the complexity of the presented issue, it needs to be emphasized that this article should be treated as an introduction to the discussion on the authorities' competence in spatial data processing in the context of intersection between regulations, in particular, data protection law.

Materials and methods

The article was prepared based on the legal-dogmatic research method, using the analysis of legal acts at the level of EU and Polish law, analysis of case law, and views of legal literature.

It is necessary to make a caveat concerning the scope of conducted analysis. From a procedural perspective, the dispute between the Polish Data Protection Authority (also: DPA) and the Surveyor General of Poland is multi-layered. However, for the purposes of this article, i.e., the divergence between authorities on publicly available spatial data in Poland, the analysis is limited to two fundamental issues: whether land register numbers constitute personal data and whether there is a basis for processing land register numbers in the Polish spatial information portal. These two issues have been decided in the Polish Data Protection Authority's decision of 24 August 2022, reference DKN.5112.13.2020, and, subsequently, in the judgment of the Voivodship

Administrative Court in Warsaw of 5 May 2022, reference II SA/Wa 2222/20. Hence, the legal analysis in the article is limited to these issues.

Dispute between the Polish DPA and the Surveyor General of Poland

The Polish DPA, in the decision of 24 August 2022, reference DKN.5112.13.2020, imposed the highest possible fine (100,000 Polish zlotys) on the Surveyor General of Poland. It concluded that the Surveyor General of Poland had violated Article 5(1)(a) of the GDPR, i.e., the principle of the lawfulness of personal data processing, and Article 6(1) of the GDPR, by making personal data available on the Geoportal without a legal basis in the scope of land and building register numbers. As indicated in the decision, the scope of data disclosed in the land and mortgage register is broad and includes first names, surnames, parents' first names, the individual's PESEL identification number, and property address (following Article 25 of the Act on Land Registers and Mortgages (Journal of Laws of 2022, item 1728)). Information on this number allows feasible access to data disclosed in the register because gaining access does not require having any specified permission. Furthermore, the Polish DPA stressed the scale and severity of the threat to individuals, pointing out that making land registry numbers public allows any person to view the personal data in the land registries, which exposes a significant number of people to identity theft.

In its decision, the DPA indicated a breach of the principle of lawfulness which means that personal data was intentionally made available on Geoportal to any Internet user without a legal basis. Furthermore, the DPA argued that the scope of disclosed data covers a wide range of data, the publication of which allows for establishing detailed information about owners of properties in Poland. On the other hand, the Surveyor General of Poland argued, as a line of defense, that such a number is not personal data and that the processing was lawful because it had legal grounds in Polish Geodetic and Cartographic Law and sector-specific regulations. The arguments of both sides will be analyzed further in this article.

The Surveyor General of Poland has filed an appeal against this decision with the Voivodship Administrative Court in Warsaw. However, in the judgment of 5 May 2022, reference II SA/Wa 2222/20, the Voivodship Administrative Court in Warsaw upheld the decision of the Polish Data Protection Authority and endorsed the reasoning presented in the decision.

For the broad procedural context of this case, the Polish Data Protection Authority issued yet another decision of 6 July 2022, reference DKN.5131.27.2022, where it found a violation by the General Surveyor of Poland of provisions related to the failure to report a personal data breach (Article 33(1) of the GDPR) and on the failure to notify data subjects of a personal data breach without undue delay (Article 34(1) of the GDPR).

Additionally, the Surveyor General of Poland was fined for the highest maximum amount for procedural violations during an inspection conducted by the Polish DPA. The Voivodship Administrative Court in Warsaw, in a judgment of 23 February 2021, reference II SA/Wa 1746/20, upheld the decision of the Polish DPA, pointing to

violations of Articles 31 and 58(1)(e) and (f) of the GDPR for failing to ensure, during the inspection of compliance with data protection regulations, access to premises, equipment and means for processing personal data and access to personal data and information necessary for the performance of tasks, as well as failure to cooperate during the inspection.

To the best knowledge, both judgments of the Voivodship Administrative Court in Warsaw are not final. The Surveyor General of Poland has filed a cassation appeal against both judgments, which is waiting to be heard.

The number of the land and mortgage register as personal data

The Surveyor General of Poland argued that the personal data protection law could not apply to the disclosure of land and mortgage register numbers, as these numbers do not constitute personal data. However, in the first instance judgment of 5 May 2021 (reference II SA/Wa 2222/20), the Voivodship Administrative Court in Warsaw unequivocally ruled that land and mortgage register numbers in the current normative form in Poland constitute personal data.

The ruling of the Voivodship Administrative Court ought to be accepted since the land and mortgage register numbers meet the definition of personal data provided for in Article 4(1) of GDPR, according to which "'personal data' means (1) any information relating to (2) an identified or identifiable (3) natural person ('data subject'). Further, the GDPR stipulates that "an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person."

While the Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data (OJ L 281, 23.11.1995, p. 31–50) (Directive) was still in force, the Article 29 Working Party published its Opinion 4/2007 on the concept of personal data of 20 June 2007, where part three considers the meaning of a critical element of the definition of the term "personal data," i.e., information about an identified or identifiable (natural) persons (Opinion 4/2007 on the concept of personal data, 2007). In the opinion, it is indicated that personal data are also those pieces of information that make it possible to identify a natural person, even in a non-direct way (for example, through a telephone number, a car registration number, or an insurance number). However, it is not all information, but the only information that can be acquired by all means reasonably likely to be used. The subject of assessment remains what these measures in a particular situation are.

Concerning the notion of personal data, a discussion, even before the entry into force of the GDPR arose, as to whether data should be identifiable objectively or subjectively. The essence of this discussion was whether identifiability should be assessed in the context of a given entity's technical and organizational capabilities or

whether it should be made from an objective standpoint. The issue was, to some extent, considered by the Court of Justice of the European Union (CJEU) in the Patrick Breyer case. That case concerned whether a dynamic IP address could be considered personal data. The CJEU took the view adopted by the Advocate General that the means are not likely reasonably to be used to identify the data subject if (1) "the identification of the data subject was prohibited by law or (2) practically impossible since it requires a disproportionate effort in terms of time, cost and man-power, so that the risk of identification appears, in reality, to be insignificant" (Court of Justice of the European Union judgment of 19 October 2016, Breyer v. Bundesrepublik Deutschland, reference C-582/14, ECLI: EU:C:2016:779). It leads to the conclusion that the CJEU was more inclined towards a more objective theory that protects data subjects to a greater extent.

However, bearing in mind the facts of this case, the land and mortgage register numbers constitute personal data, as based on the number alone obtained in the spatial information portal (Geoportal), any person can, through an Internet search engine and the Electronic Land Register portal, determine the owner of the property and the information on its financial situation that is disclosed.

It is worthwhile to underline that the legal literature has pointed out the problem (Drobek, 2015). Moreover, this stance is aligned with the established case law of the administrative courts in Poland (referred to in the judgment in the analyzed case: judgment of the Voivodship Administrative Court in Kraków of 14 May 2014, reference II SA/Kr 126/14; judgment of the Voivodship Administrative Court in Wrocław of 2 December 2010, reference II SA/Wr 546/10; judgment of the Supreme Administrative Court of 18 February 2014, reference I OSK 1839/12).

In practice, this means that land register numbers are covered by the personal data protection regime (Drobek, 2015), including the standards under Article 8 of the Charter of Fundamental Rights of the European Union (2000/C 364/01) and Article 51 of the Constitution of the Republic of Poland (Journal of Laws of 1997, No. 78, item 483, with amendments).

Moreover, it could be argued that making the land and mortgage register number public poses a significant threat to individuals' rights. For example, information from the register might be used in the civil proceedings for payment in Poland. Based on information about pending enforcement proceedings or the size of mortgage obligations disclosed in the register, the parties of the civil proceedings for payment may attempt to demonstrate the merits of granting interim measures (for example, by seizure of the movables) before initiating proceedings by proving that an economic situation of the other party is so unsatisfactory as to require the granting of interim measure. Therefore, it constitutes an integral part of proving the premise of the so-called "legal interest," which, according to Article 730(1)(1) of the Polish Civil Procedure Code, is one of the two prerequisites, in addition to the assertion of a credible claim, for the court to grant interim measure.

Grounds for processing the land and mortgage register numbers – analysis of the Polish Data Protection Authority and the Surveyor General of Poland

This subsection is divided into three parts; it addresses the arguments about the legal basis for data processing by the General Surveyor of Poland. The first subsection presents arguments of the Polish DPA, the second provides information on the position of the Surveyor General of Poland, and the third one shows the reasoning provided in the judgment of the Voivodship Administrative Court in Warsaw of 5 May 2021, reference II SA/Wa 2222/20 (first instance), rendered in this case.

The Polish DPA's arguments.

The Polish DPA ruled that the Surveyor breached Article 5(1) letter (a) of the GDPR and Article 6(1) of the GDPR by "making available on the Geoportal without a legal basis personal data in the scope of land and building register numbers obtained from the land and building register (maintained by starosts)."

Following Article 5(1) letter (a) of the GDPR, data shall be processed lawfully, fairly and in a transparent manner in relation to the data subject ("lawfulness, fairness and transparency"). Subsequently, Article 6(1) of the GDPR provides legal grounds for processing data. The Polish DPA decided that the Surveyor General of Poland had no basis for processing this personal data, i.e., publishing land registry numbers in the Geoportal. DPA pointed out the sector-specific regulations that the Surveyor General of Poland had breached.

The first is Article 13(1) letter (f) of the Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (OJ L 108, 25.4.2007, p. 1–14) (the INSPIRE Directive), in according to which "Member States may limit public access to spatial data sets and service, where such access would adversely affect the confidentiality of personal data and/or files relating to a natural person where that person has not consented to the disclosure of the information to the public, where such confidentiality is provided for by national or Community law." Moreover, the INSPIRE Directive in the recital 24 expresses that "the provision of network services should be carried out in full compliance with the principles relating to the protection of personal data."

Next, Article 5a section 4 of the Polish Geodetic and Cartographic Law imposes an obligation on the General Surveyor of Poland to apply safeguards to prevent misuse or unlawful access to or transfer of processed personal data.

Furthermore, Article 11, section 2 point 5 of the Act 4 March 2010 on spatial information infrastructure (Journal of Laws of 2021, item 214) (the Polish Spatial Information Infrastructure Act) indicates that access to spatial data sets and services shall be restricted based on provisions for personal data protection.

Finally, the Polish DPA stressed that Article 36, with the mark of 4 section 16 of the Law of 6 July 1982 on Land Registers and Mortgages, applies to the General Surveyor of Poland. This provision stipulates that it is prohibited to provide third parties with access to the data contained in sections one and two of the land and mortgage registers, which

are made available free of charge to the authorities in charge of the real estate cadastre to verify the compatibility of the data of the land and building register with the data contained in the land and mortgage registers.

The Surveyor General of Poland's arguments.

The Surveyor General of Poland, during the proceedings in the Voivodship Administrative Court in Warsaw, raised a number of substantive arguments concerning legal grounds for processing that need to be analyzed.

The Surveyor General of Poland argued that it is legally obliged to make the numbers of the land and mortgage register publicly available. It raised that this is its statutory task which could be derived from at least two regulations.

First, the General Surveyor of Poland referred to Chapter 6 of Annex II of Commission Regulation (EU) No 1089/2010 of 23 November 2010, implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services (OJ L 323 8.12.2010, p. 11) (Commission Regulation 1089/2010). It argued that it is obliged to publish land registry numbers on the Geoportal, implying that the processing of personal data would be legally performed under Article 6(1)(c) of the GDPR.

The purpose of the Commission Regulation 1089/2010 is to lay down requirements for technical arrangements for the interoperability and harmonization of spatial data sets and services. Annex II covers requirements for spatial data themes, and Chapter VI refers directly to the cadastral parcels, including spatial object types. However, it seems that in indicated Chapter, there is no direct link to any relevant obligation to provide public information on the land register numbers or owners' identity.

The second regulation on which the General Surveyor of Poland based its argument is the Polish Geodetic and Cartographic Law in connection with the Polish Spatial Information Infrastructure Act. The General Surveyor of Poland argued that the limitation of data processing stipulated in Article 11 of the Polish Spatial Information Infrastructure Act could not cover the land register number itself. Instead, access to the information should be limited directly by Article 24 section 5 of the Polish Geodetic and Cartographic Law, which scope is by reference defined in Article 20 section 2 point 1 of the Polish Geodetic and Cartographic Law. However, the information on a land and mortgage register number is not covered directly by the referred section yet only by another section (Article 20 section 1). Since the scope of the limitation does not cover the land and mortgage register number, the Surveyor General of Poland, as it argued, is not only allowed to publish the numbers but is even obliged to do so under Article 24 section 5 of the Polish Geodetic and Cartographic Law. Consequently, it argues that it cannot be fined for performing statutory tasks.

The Voivodship Administrative Court in Warsaw's reasoning.

The Voivodship Administrative Court in Warsaw, in the judgment of 5 May 2021, reference II SA/Wa 2222/20, upheld DPA's decision and argumentation.

First, as presented above, the court ruled that the land register numbers constitute personal data. According to the court, the subjects affected by the respective rights and obligations disclosed in the land records are also natural persons. Moreover, the scope

of the data of natural persons disclosed in the land register is extensive. The public land register numbers allow the identification of natural persons whose data are included in the land register. The court referred to a well-established line of case law in this regard.

Similarly, concerning the issue of the legal basis for processing, the court ruled that the General Surveyor of Poland did not have any applicable basis for processing. The court's reasoning suggests that, in its view, all sectoral regulations, which are complementary, should be considered when determining the legal basis for publishing land registry numbers in the Geoportal. Following the Polish DPA, the court stressed that Article 36, with the designation of 4 section 16 of the Law of 6 July 1982 on Land Registers and Mortgages, applies to the General Surveyor of Poland. It means that the court found, based on the sector-specific regulations, that there is a prohibition on disclosing this information to the public, which also binds the General Surveyor of Poland.

As stated, The Surveyor General of Poland has filed a cassation appeal against the judgment, which is waiting to be heard by the Supreme Administrative Court.

Analysis of reasons for disputes between authorities

The matter of legal arguments regarding the nature of the land and mortgage register numbers as personal data and the legal basis for publishing these numbers in the Geoportal highlights another, more profound issue. Due to the ubiquitous processing of personal data discussed in the introduction, there emerges a situation in which data protection regulations, such as the GDPR, permeate all industries with sector-specific regulations. As in this case, the relationship between sector-specific regulations and the GDPR is often ambiguous. It means that the scope of competence of the authorities in the public administration system overlaps. The current provisions of Polish administrative law do not provide practical tools to resolve potential inconsistencies between authorities in a model where there is uncertainty on the part of supervised entities in the market regarding the correct interpretation of the law.

For this problem to be addressed, it is first necessary to establish what reasons may cause disputes between authorities in the regulated fields. Following the article by Aagaard (2011), three primary sources of overlapping regulations and potential disputes between authorities may be distinguished. The first reason would be unintended broad regulations implemented by the legislature in the context of uncertainty about outcomes of the legislative process or because of compromises during such process. It is argued that the legislative bodies are incentivized to assign broad competencies to regulators so that they have the flexibility to respond either to threats or to a change in the underlying problem they were initially intended to tackle. The second one is an organic tendency of authorities to expand their competencies to achieve pragmatic objectives, for example, increasing the scope of authority up to the limits of competencies or as part of an argument to enhance the budget. Therefore, the risk of dispute emerges through the application of general clauses in the law, where there is scope for interpretation and a debate over how a particular clause should be

understood. However, these appear to be relatively rare cases, and their use should be determined by compelling reasons for adopting such a solution, for example, justified by the severe risk of violation of fundamental rights (Aagaard, 2011).

It needs to be agreed that these reasons may arise in relation to different normative contexts. The degree to which these general reasons apply to the case examined in this article will be reviewed below.

Analysis of the reasons for the dispute between the Polish Data Protection Authority and the Surveyor General of Poland

There could be different purposes for processing the same set of data. For example, it could be used for the public interest (security or transparency of the payment system) or be treated as a tradable item for marketing purposes. Considering the complexity of these processes, the GDPR stipulates one of the principles for processing personal data, the minimization principle. Under Article 5(1) letter (c) of the GDPR, "personal data shall be collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes; further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, following Article 89(1), not be considered to be incompatible with the initial purposes ("purpose limitation")." It means that the processing of personal data is lawful if it is limited to the extent necessary to fulfill the given purpose, based on the grounds in Article 6 of the GDPR, one of which is that processing is necessary for compliance with a legal obligation to which the controller is subject (Article 6(1)(c).

However, in practice, it is difficult to draw the line between the scope of data necessary to fulfill the purpose and those exceeding the purpose, as it is necessary to balance between the fulfillment of the obligation and the determination of the necessary scope of data. In general, from the perspective of the ability to fulfill the obligation, it is more prudent to have a broader range of data than a narrower one.

It is even more complicated for the authorities because they are bound by the principle of legalism, according to which public authorities act on the basis and within the limits of the law (Article 7 of the Constitution of the Republic of Poland). Processing data to a greater extent than necessary violates the principle of legalism, but it can be argued that failure to perform an obligation provided by a legal provision also violates this principle.

There is a risk that on the part of the authority (which is at the same time the controller of personal data) at the stage of performing the statutory obligation, a perception will arise in which the processing of personal data to the extent objectively exceeding the principle of minimalism is not only not prohibited, but it is necessary to perform the statutory obligation. It seems that it can be cautiously hypothesized that this type of situation might have arisen in this case. However, a similar tension between privacy and the use of spatial data is also described in the US literature, so it could be argued that it is not specific only to European jurisdictions (Rissman et al., 2017).

The question of what purpose motivated the actions of the Polish Data Protection Authority and the Chief Geodesist of Poland should be considered. It seems to be a relevant consideration from the perspective of purposive interpretation, according to which the understanding of a provision should be derived from the purpose of its enactment in conjunction with other provisions in the given act and supporting legal acts (Zieliński, 2008).

The concept of a purpose should be distinguished from that of a task, even though they remain related. A purpose (in Polish: "cel") is defined in the Polish Polish Scientific Publishers (PWN, 2022) as "a direction to which one is aiming". In this sense, a goal is the long-term outcome of the entity's activities that has been set. The definition of the goal provides a framework for the activities of a given entity, providing interpretative directives on which actions should be carried out and to what extent. It is an accepted position in the legal literature according to which tasks should be understood as activities carried out at a given time to maintain or bring about a particular order of things, as opposed to purposes that set long-term objectives (Szyrski, 2015).

From this perspective, the purpose of the Polish Data Protection Authority seems unambiguous. From the perspective of this authority, the processing of personal data of an extensive range of persons (property owners in Poland) took place without legal basis, in violation of the principle of minimalism, and this process threatened to violate the rights and freedoms of these persons. Therefore, the President of the Office for the Protection of Personal Data (the name of the Polish DPA) was obliged to do so as the competent authority for the protection of personal data, according to Article 34(1) of the Act of 10 May 2018 on the Protection of Personal Data (Journal of Laws of 2019, item 1781).

On the other hand, it seems more difficult to reconstruct the purposes of the actions taken from the perspective of the Surveyor General of Poland. The Surveyor General of Poland has a legal position that is obliged to publish land registry numbers in the Geoportal, and that process is lawful because it serves statutory tasks. According to Article 6(1) of the Polish Geodetic and Cartographic Law, the Surveyor General of Poland is the government administration's central authority, competent in geodesy and cartography. Suppose one were to argue in favor of disclosing information on land and mortgage register numbers in the Geoportal. In that case, it could be raised that this serves to increase the security of legal transactions in real estate and ensures that potential real estate purchasers have full and flexible access to the legal status of the property, which allows for more streamlined real estate transactions. However, when analyzed from the perspective of the regulation, such arguments cannot stand, and the administrative courts' position should be agreed with.

Conclusions

Protecting data privacy is not just about compliance. Ultimately, it is about pursuing statutory aims and values. Applying them is difficult because following one may lead to the impairment of the other. Different statutory aims and values drive various

authorities empowered in processing data. There will be more situations like this, especially in publicly available data, like spatial data, because this is an intersection of different aims and regulatory areas.

The overlapping (intersection) of regulations is not limited to spatial data but relates to other areas of regulation, such as financial markets, anti-money laundering (Kindylidi, 2022), and competition (Costa-Cabral & Lynskey, 2017). Meanwhile, the issue of vague regulations, together with a failure to consider the data protection perspective by the actors, is crucial for the development of enforceable personal data law. The question of how it is possible to delimit the powers of different authorities arises.

In the legal literature, anticipating the situation referred to in this article, regarding the problem of extensive access to the data disclosed in the land and mortgage registers, it has been proposed to change the model of access to the land and mortgage registers in such a way that unrestricted access to the land and mortgage registers as such is preserved, while the scope of data disclosed for the unrestricted access is limited on a subject-based manner (Gryszczyńska, 2020).

As an ancillary note considering the definition of personal data presented above, also other spatial data (depending on the extent to which they are collected) than land register numbers may constitute personal data to the extent that they allow for the identification of an individual natural person (for example when aggregated with other information). Furthermore, spatial data is considered to play an essential role in environmental protection and proper planning of the use of space, as well as spending of public funds and tax incentives, as well as accountability of such pre-settlements (Rissman et al., 2017). Hence, solutions are proposed to introduce anonymization of spatial information with as negligible loss of data quality as possible, such as that provided by Hasanzadeh et al. (2020).

The seriousness of this issue from a fundamental rights perspective is demonstrated by the fact that this situation has become of interest to the Polish Commissioner for Human Rights (Marcin Wiącek met with the General Surveyor of Poland, 2022). The debate on whether land register numbers meet the definition of personal data and if such processing is legal is a debate on where the line between the right to privacy and the need to use personal data and to what extent lies.

References

Aagaard, T.S. (2011). Regulatory overlap, overlapping legal fields, and statutory discontinuities. Virginia Environmental Law Journal, vol. 29, no. 3, pp. 273–285.

Act of 17 May 1989 – Geodetic and Cartographic law (Journal of Laws of 2021, item 1990).

Act on Land Registers and Mortgages (Journal of Laws of 2022, item 1728).

Act 4 March 2010 on spatial information infrastructure (Journal of Laws of 2021, item 214).

Act of 10 May 2018 on the Protection of Personal Data (Journal of Laws of 2019, item 1781).

Charter of Fundamental Rights of the European Union (2000/C 364/01).

Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services (OJ L 323 8.12.2010, p. 11).

Constitution of the Republic of Poland (Journal of Laws of 1997, No. 78, item 483, with amendments).

Costa-Cabral F. and Lynskey O. (2017). The Internal and External Constraints of Data Protection on Competition Law in the EU. Common Market Law Review, vol. 54, no. 1, 2017, pp. 11–13. https://doi.org/10.54648/cola2017002.

Court of Justice of the European Union judgment of 19 October 2016, Breyer v. Bundesrepublik Deutschland, reference C-582/14, ECLI: EU:C:2016:779).

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) OJ L 108, 25.4.2007, p. 1–14.

Drobek P. (2015). Accessibility of the spatial data in the context of the personal data protection. In: G. Szpor, A. Gryszczyńska (ed.), access to spatial data and its limitations. Legal aspects. GIS Odyssey 2015, Zagreb, Croatian Information Technology Society – GIS Forum, Centre of Law & Informatics, pp. 83–84, 87–88. http://www.gis.us.edu.pl/index.php?option=com_mtree&task=att_download&link_id=553&cf_id=24 [access: 25.11.2022].

Polish Data Protection Authority's decision of 24 August 2022, reference DKN.5112.13.2020. https://uodo.gov.pl/decyzje/DKN.5112.13.2020 [access: 25.11. 2022].

Polish Data Protection Authority's decision of 6 July 2022, reference DKN.5131.27.2022. https://uodo.gov.pl/pl/343/2410 [access: 25.11.2022].

Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data (OJ L 281, 23.11.1995, p. 31–50).

Hasanzadeh K., Kajosaari A., Häggman D., Kyttä M. (2020). A context sensitive approach to anonymizing public participation GIS data: From development to the assessment of anonymization effects on data quality. Computers, Environment and Urban Systems, 83, pp. 3, 10. https://doi.org/10.1016/j.compenvurbsys.2020.101513.

Gryszczyńska A. (2020). How to shape access to spatial data from public registers. In: J. Bydłosz, A. Zwirowicz-Rutkowska, M. Gajos-Gržetić, W. Federczyk (ed.). 27th Geographic Information Systems Conference and Exhibition GIS Odyssey 2020. Book of Abstracts, pp. 28–29. http://www.gis.us.edu.pl/index.php?option=com_mtree&task=att_download&link_id=1148&cf_id=24 [access: 25.11.2022].

Kindylidi I. (2022). The Data Protection Implications of the EU AML Framework: A Critical Overview & the Case of AI. In: A. Gryszczyńska, P. Polański, N. Gruschka, K. Rannenberg, M. Adamczyk (ed.). Privacy Technologies and Policy. APF 2022. Lecture Notes in Computer Science, vol 13279, p. 47. https://doi.org/10.1007/978-3-031-07315-1_3.

Marcin Wiącek spotkał się z Głównym Geodetą Kraju (*Marcin Wiącek met with the General Surveyor of Poland*). https://bip.brpo.gov.pl/pl/content/rpo-spotkanie-glowny-geodeta-kraju [access: 25.11.2022].

Obendiek A.S. (2022). What We Actually Talking About? Conceptualizing Data as a Governable Object in Overlapping Jurisdictions. International Studies Quarterly, vol. 66, no. 1, pp. 1–13. https://doi.org/10.1093/isq/sqab080.

Opinion 4/2007 on the concept of personal data. 01248/07/EN WP 136. Article 29 Data Protection Working Party, pp. 13–16. https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2007/wp136_en.pdf [access: 25.11.2022].

Purpose (in Polish: Cel). https://sjp.pwn.pl/sjp/cel;2447324.html [access: 25.11.2022].

Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (OJ L 119, 4.5.2016, p. 1–88).

Rissman A.R., Owley J., L'Roe A.W., Wilson Morris A., Wardropper C.B. (2017). Public Access to Spatial Data on Private-Land Conservation. Ecology and Society, vol. 22, no. 2, p. 1. https://doi.org/10.5751/ES-09330-220224.

Szyrski M. (2015). § 1. Teoretyczne zasady podziału zadań i kompetencji organów właściwych w sprawach jawności i jej ograniczeń, II. Znaczenie podstawowych teoretycznych pojęć – zadanie i cel, kompetencja, właściwość i zakres działania. Zastosowanie pojęć teoretycznych w ustawach o dostępie do informacji publicznej oraz o ochronie informacji niejawnych, 3. Kompetencja (*§ 1. Theoretical principles of the division of tasks and competencies of authorities competent in matters of openness and its limitations, II. Meaning of basic theoretical concepts – task and purpose, competence, jurisdiction, and scope of action. Application of theoretical notions in the Acts on access to public information and protection of classified information, 2. Task and Purpose*). In: G. Szpor, B. Szmulik (ed.). Jawność i jej ograniczenia. Zadania i kompetencje. Tom IX (*Openness and its limitations. Tasks and competencies. Volume IX*) [access 25 November 2022: Legal Information System Legalis].

Voivodship Administrative Court in Warsaw judgment of 23 February 2021, reference II SA/Wa 1746/20. https://orzeczenia.nsa.gov.pl/doc/5EE3FB1B60 [access: 25.11.2022].

Voivodship Administrative Court in Warsaw judgment of 5 May 2021, reference II SA/Wa 2222/20. https://orzeczenia.nsa.gov.pl/doc/4A792B19E5 [access: 25.11.2022].

Zieliński M (2008). Wykładnia prawa. Zasady, reguły, wskazówki (*Interpretation of the law. Principles, rules, guidelines*), p. 79.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.129

Piotr Drobek[1]

THE ROLE OF CODES OF CONDUCT IN THE EU DATA PROTECTION FRAMEWORK

Abstract: The paper presents the legal nature and functions of codes of conduct in EU data protection law. The General Data Protection Regulation (GDPR) contains much more extensive provisions on codes of conduct than previous Directive 95/46/EC, giving them a potentially much more significant role in the EU data protection regime. The GDPR specifies codes of conduct as co-regulatory instruments whose compliance by controllers and processors has significant legal consequences. They are primarily intended to facilitate compliance with the GDPR by controllers and processors from a specific sector or to perform similar processing operations. It is, therefore, essential to identify the legal nature of the codes of conduct, the legal consequences of adhering to them, and their function in the EU data protection model. The theoretical analysis of EU data protection codes of conduct considers legal and regulatory theory perspectives.

Keywords: accountability, data protection, GDPR, code of conduct, co-regulation

Received: 30 November 2022; accepted: 16 December 2022

[1] Cardinal Stefan Wyszyński University in Warsaw, Faculty of Law and Administration, Department of Informatics Law, ORCID ID: https://orcid.org/0000-0002-0178-851Xe, mail: p.drobek@uksw.edu.pl

Introduction

The General Data Protection Regulation (GDPR) was adopted in 2016 after four years of intensive legislative work. As an EU regulation, this legal act has been directly applicable in all EU member states since May 25, 2018. The reform of the personal data protection framework in the EU was carried out under the slogan of strengthening basic principles regarding data processing, strengthening the rights of data subjects, and adapting specific legislative solutions to the fast-moving environment of data processing. The purpose of the reform was to ensure the effectiveness of personal data protection law. The new regulations moved away from a descriptive specification of obligations favouring principle-based regulation. The accountability principle has become central to this new model of data protection. According to it, controllers must operationalise general data protection principles. The second key element is the risk-based approach permeating the GDPR. The regulatory model adopted by the EU justifies reaching out to regulatory theory scholarship. Often the process of adoption of the GDPR is framed as at least partly shifting from a traditional command-and-control model of regulation to meta-regulation (e.g. Gellert 2020). Meta-regulation approach can be understood as a situation in which regulators do not specify how the regulated organisations have to comply with standards but require them to create their own system of ensuring compliance and demonstrate it to regulators (Black, 2012). Meta-regulation expects that regulated organisations will identify risks, put in place an internal control system, and continuously evaluate the effectiveness of implemented solutions and improve them (Gilad, 2010). Karen Yeung and Lee A. Bygrave (2022) presented a more nuanced view of GDPR. According to them, the GDPR contains both legal norms specified in a traditional way (as a command and control), design regulation and meta-regulatory elements exemplified by codes of conduct. GDPR gives codes of conduct a potentially much more significant role in the EU data protection regime. It is, therefore, necessary to examine the legal nature of the codes of conduct and their function in the EU data protection model in light of the evolution of the legislation in this field.

Material and Methods

This paper presents the results of the research carried out using the desk research method involving analysis of EU and national legal acts, policy documents, including documents of the European Commission, reports on the implementation of the EU data protection legislation and opinions and Guidelines adopted by the Article 29 Working Party on data protection and European Data Protection Board. The available scientific literature on law and regulation relevant to analysing data protection codes of conduct was also examined.

Regulatory theory perspective

The codes of conduct under EU data protection law are often categorised as self-regulation (Góral & Makowski, 2018; Fajgielski, 2018) or enhanced self-regulation tools (Medzini, 2021). The regulation is generally understood as "any public means of control over an activity that is essentially lawful but which the state wishes to be undertaken subject to certain constraints" (Hodges, 2015). According to paragraph 3.2 of the Opinion of the European Economic and Social Committee on Self-regulation and co-regulation in the Community legislative framework, self-regulation "broadly denotes the adoption by economic operators of certain rules of conduct among themselves or in relation to third parties in the market and in society, adherence to which is agreed among themselves, without any external coercive mechanisms". Such voluntary and flexible rules are based on the identical interests of the actors in the given sector rather than on state coercion (Csink & Mayer, 2014). Examples of such regulations initiated and undertaken by those whose behaviour is to be regulated are unilateral codes of conduct, customer charter, negotiated code, and unilateral sector codes (Hodges, 2015).

European Economic and Social Committee, under paragraph 3.4 of its opinion mentioned above, indicated that the term co-regulation means "a form of regulation of stakeholders that is promoted, guided or controlled by a third party which is either an official body or an independent regulatory authority, normally with oversight and monitoring powers and in some cases with the power to impose sanctions" (2015). Unlike self-regulation, co-regulation involves some degree of direct government involvement (Hodges, 2015). However, even when regulation is required by law, it is usually enforced by the industry itself. Nonetheless, professional or state regulators accept codes of conduct as a result of cooperation (Csink & Mayer, 2014). Cooperation understood in this way does not mean that the data protection code of conduct is a kind of "contract" between its owners and DPA (Drobek, 2019).

Considering how codes of conduct are addressed in EU legislation, it should be noted that they are a co-regulation that aims to facilitate the application of laws. The same is true concerning the protection of personal data.

Evolution of the legal landscape

The General Data Protection Regulation (GDPR) introduces broader and more extensive provisions on codes of conduct than those previously provided in Directive 95/46/EC. They are in line with the European Commission's announcement of further support for self-regulatory initiatives and, in particular, the promotion of codes of conduct. As European Commission pointed out, such initiatives "can contribute to a better enforcement of data protection rules"(European Commission 2010). Directive 95/46/EC referred to codes of conduct in Article 27 in general terms. The Member States and the Commission were primarily to encourage trade associations and other bodies representing other categories of controllers to develop codes of conduct (Article 27(1)). These instruments were intended to contribute to properly implementing the data protection legislation taking into account the specific features of the various

sectors. Directive 95/46/EC referred separately to national and Community codes without indicating criteria to distinguish the two types from each other. A draft national code of conduct or a draft amendment or an extension to an existing code of conduct was to be submitted for an opinion to the national supervisory authority, which could assess whether the draft code complied with national data protection legislation implementing Directive 95/46/EC (Article 27(2)). With regard to the Community code of conduct, at the EU-level opinion was issued by the Article 29 Working Party on data protection (Article 29 Working Party), an independent advisory body composed of representatives of national supervisory authorities (Data Protection Authorities or DPAs) from the EU Member States, the European Data Protection Supervisor and the European Commission. In addition, a role was also envisioned for the European Commission in ensuring that approved Community codes were properly publicised (Article 27(3)).

According to the European Commission, the provisions mentioned above of Directive 95/46/EC "have rarely been used so far and are not considered satisfactory by private stakeholders" (European Commission 2010). Indeed, only a few community codes have been approved. In 2003 the Article 29 Working Party positively assessed the Community code of conduct on direct marketing submitted by the Federation of European Direct and Interactive Marketing (FEDMA) (WP 29 2003), and later in 2010, the On-line marketing Annex to this code (WP 29 2010). The Article 29 Working Party issued a working document on Recommended Practice 1774 – Protection for privacy and transborder data flows of personnel used in international air transport of passengers and of cargo submitted by the International Air Transportation Association (IATA), recognising that this is not a Community code of conduct in the meaning of art. 27 of Directive 95/46/EC (WP 29 2001). In other cases, the Article 29 Working Party did not approve the submitted codes (WP 29 2008, WP 29 2009, WP 29 2015, WP 29 2018).

In its first report on the implementation of Directive 95/46/EC in 2003, the European Commission expressed disappointment that so few organisations had submitted sectoral codes of conduct for approval at the community level (European Commission 2003). The industries, however, drew attention to the slowness of the proceedings and the minuteness of the Article 29 Working Party's analysis of the submitted Community codes (Kantar, 2010). Another problem was related to Article 27(3) of Directive 95/26/EC, which requires that Community Codes ensure compliance with national data protection laws. As a result, more than mere compliance with Directive 95/46/EC, due to differences in its implementation, was needed, and additional adaptation to the legal requirements of each member state was required. Christopher Kuner, addressing this problem, postulated that the Article 29 Working Party, in such a situation, "should not insist on the continued application of every provision of national law in addition to the code" (2007).

An interesting potential problem regarding the paragraph mentioned above of Article 27 was raised by Carl Vander Maelen (2020). He argued that this paragraph makes the submission of a Community code for review by the 29 Working Party optional. Consequently, given the risk of a negative opinion on the code, the provision

creates a free-rider scenario in which organisations that have not submitted their codes for opinion may be in a better position than organisations that have submitted their codes in good faith to the 29 Working Party.

There were many more codes of conduct in operation at the national level. However, researchers stressed the wide variation in national regulations on codes of conduct, their application in practice, and, consequently, the varying popularity of such tools in different countries (Robins et al., 2009). The nature and role of codes of conduct and their possible legal effects in data protection systems have been understood differently. For instance, in the Netherlands, "approval" of a code by a supervisory authority was not binding on the courts, while in Ireland or Greece, codes could be more formally incorporated into the legal system and become legally binding (LRDP KANTOR Ltd, 2010; Vander Maelen, 2022; Korff, 2003). In Poland, the Act 1997 did not directly refer to codes of conduct and thus did not provide any procedure for their approval. Despite this, the Polish supervisory authority took steps to initiate the preparation of codes of best practices and informally accepted them after early and often intensive consultations within its general competence. Such codes did not introduce any mechanisms for enforcing compliance with their provisions by those who adhered to them. It should be added that they had no binding force.

Remarkable that, according to industry representatives, supervisory authorities seemed less interested in reaching a consensus on data protection practices with the industry and more interested in unilaterally imposing their own set of rules. There was also pointed to insufficient resources devoted to promoting and assessing codes of conduct for some supervisory authorities (Robins et al., 2009). There has also been tension between organisations and supervisory authorities (Korff, 2003) related to tense expectations and, to some extent, mistrust.

GDPR, as previously announced by the European Commission, seeks to increase the role of codes of conduct in the new EU data protection architecture and also respond to the failure of the regulations contained in Directive 95/46/EC. The codes of conduct are regulated in Articles 40 and 41 of the GDPR. Other provisions of the regulation also refer to them. The personal scope of the codes has been expanded to include not only controllers but also processors. Their material scope has been tightened by indicating examples of areas of possible regulation, the roles of all actors involved have been clearly defined, and procedural issues have been provided for to the extent necessary. The EU legislator has placed a firm emphasis on ensuring the operation of effective compliance monitoring mechanisms, including the existence of accredited monitoring bodies. At the same time, the attempt to counteract the fragmentation of regulation through mechanisms for the approval of transnational codes and to ensure consistency with the requirements for accreditation of monitoring bodies should be emphasised.

According to Article 40 (1) GDPR, a wide range of actors like the EU Member States, the supervisory authorities, the EDPB and the European Commission are required to encourage the drawing up of codes of conduct intended to contribute to the proper application of GDPR, "taking account of the specific features of the various processing sectors and the specific needs of micro, small and medium-sized enterprises". Codes of

conduct, amendments or extensions to such codes may be prepared by associations and other bodies representing categories of controllers or processors. The purpose of the codes was defined as specifying the application of GDPR. Among the examples listed of possible areas to be covered by the codes are the following, such as with regard to:

- "fair and transparent processing;
- the legitimate interests pursued by controllers in specific contexts;
- the collection of personal data;
- the pseudonymisation of personal data;
- the information provided to the public and to data subjects;
- the exercise of the rights of data subjects;
- the information provided to, and the protection of, children, and the manner in which the consent of the holders of parental responsibility over children is to be obtained;
- the measures and procedures referred to in Articles 24 and 25 and the measures to ensure security of processing referred to in Article 32;
- the notification of personal data breaches to supervisory authorities and the communication of such personal data breaches to data subjects;
- the transfer of personal data to third countries or international organisations; or
- out-of-court proceedings and other dispute resolution procedures for resolving disputes between controllers and data subjects with regard to processing, without prejudice to the rights of data subjects pursuant to Articles 77 and 79".

The draft code, amendment or extension must be submitted to the competent supervisory authority under Article 55 GDPR. The supervisory authority shall provide an opinion on whether the draft code, amendment or extension complies with and shall approve it if it finds that it provides sufficient appropriate safeguards (Article 40 (5)). Where a draft code of conduct relates to processing activities in several Member States, the competent supervisory authority shall, before approving the draft code, amendment or extension, submit it in the procedure referred to in Article 63 to the EDPB, which shall provide an opinion on whether the draft code, amendment or extension complies with GDPR or, where the is a tool for international transfers provides appropriate safeguards. Where the EDPB's opinion confirms that the draft code, amendment or extension complies with this GDPR or provides appropriate safeguards for international transfers, the EDPB shall submit its opinion to the Commission. According to Article 40 (9) GDPR, the European Commission may, by implementing acts, decide that such approved code of conduct, amendment or extension has general validity within the EU under the examination procedure set out in Article 93(2). The European Commission shall ensure appropriate publicity for the approved codes which have been decided as having general validity (Paragraph 9). Approved transnational codes of conduct having general validity may also be adhered to by controllers or processors that are not subject to GDPR in order to provide appropriate safeguards for personal data transfers to third countries or international organisations under the terms referred to in Article 46(2)(e). Such controllers or processors shall make binding and enforceable commitments, via contractual or other legally binding instruments, to apply those appropriate safeguards,

including with regard to the rights of data subjects (Paragraph 3). Except for codes covering the public sector, accredited monitoring bodies must monitor controllers' or processors' compliance with approved codes of conduct under Article 41 GDPR. The Monitoring bodies' competencies are without prejudice to the tasks and powers of the competent supervisory authorities.

In order to clarify the provisions in question, the European Data Protection Board adopted Guidelines 1/2019 on Codes of Conduct and Monitoring Bodies under Regulation 2016/679 Version 2.0. The guidelines clarify procedures and rules related to the submission, approval and publication of codes of conduct at national and European levels. They also specify the conditions that must be taken into account by supervisory authorities when assessing whether a submitted draft code of conduct is correct and whether it contributes to the effective application of the GDPR. At the same time, the guidelines clarify the conditions that must be met by monitoring bodies. In addition, the EDPB clarified that all previously approved codes of conduct must be reviewed and approved again under the GDPR. The EDPB adopted several opinions on the draft accreditation requirements for monitoring bodies submitted by national supervisory authorities (see more at: https://edpb.europa.eu). The primary role of the EDPB is to ensure consistent application of the GDPR. Therefore, these opinions contribute to a harmonised approach concerning drafting national accreditation requirements for monitoring bodies. As a result, at the national level, supervisory authorities have already approved various codes of conduct or are still in the evaluation process. Significantly, the EDPB has already given a positive opinion on two transnational codes on cloud services (2001a, 2001b). In this regard, it was hoped that this approval of the two codes could set the path for faster adoption of future codes in various fields, keeping in mind that a positive opinion is only the beginning of the path for the actual operation of these codes in real life (Vander Maelen, 2021). After more work, the EDPB adopted the European Data Protection Board Guidelines 04/2021 on Codes of Conduct as tools for transfers Version 2.0. These guidelines complement the previously mentioned EDPB guidelines on Codes of Conduct and Monitoring Bodies. They clarify the actors' roles in drawing codes of conduct intended to serve as a tool for data transfers to third countries. Such codes of conduct under Article 46 GDPR should address the core principles, rights and obligations under the GDPR and specific safeguards required in the data transfer context. The guidelines provide a checklist of elements to be included in a code of conduct intended for data transfers. The EDPB also indicated that depending on the original scope and content of the code of conduct, it may need to be amended to cover all of the above issues necessary for data transfers to third countries.

The codes of conduct were also referred to in the first evaluation of the application of the GDPR on the EU level. Multistakeholder Expert Group established by the European Commission confirmed that micro, small and medium-sized enterprises recognise the value of codes of conduct in helping them comply with the GDPR and recommended drawing up a test to assess whether the codes take into account the needs of SMEs (2019). The European Commission, in its Communication, among other things, focused on supporting the establishment of code(s) of conduct that would contribute to a more

consistent approach, especially in health scientific research area and make the cross-border processing of personal data easier in this field (2020).

The Concept of a Data Protection Code of Conduct

The EU law recognises codes of conduct in different areas (Kamara, 2020). The relatively large number of 7149 documents containing the phrase "code of conduct" in the EUR-lex search results might prove this view's accuracy. Still, such a quantitative analysis may lead to erroneous conclusions since even a cursory examination of the documents retrieved shows that the term is used inconsistently in very different contexts and has a distinct legal character. Furthermore, how codes of conduct are regulated varies from one piece of EU legislation to another. In most cases, these legal acts do not define the concept itself, of which the GDPR is just one example.

In contrast, Directive 2005/29/EC concerning unfair business-to-consumer commercial practices in the internal market contains a code of conduct definition. According to Article 2(f), it is "an agreement or set of rules not imposed by law, regulation or administrative provision of a Member State which defines the behaviour of traders who undertake to be bound by the code concerning one or more particular commercial practices or business sectors". As we can see, the definition is embedded in the specifics of consumer protection law and can be helpful for this paper only to a limited extent, as data protection codes of conduct go beyond commercial practices or business sector activities. Nonetheless, the broader implication of this definition is that a code of conduct is a set of rules of behaviour that members who voluntarily join it undertake to follow.

It may also be helpful to refer to the existing body of academic work, bearing in mind that scholars do not understand this concept uniformly. However, we can identify some common definitional elements of the concept. The Black's Law Dictionary defines this term as "a written set of rules governing the behaviour of specified groups, such as lawyers, government employees, or corporate employees" (1999). Similarly, codes of conduct embody "a set of rules for employees, members, or member organisations to follow" (Bennet & Raab, 2006). Carl Vander Maelen proposed a more comprehensive operational definition reads as follows: "codes of conduct aim to stipulate the desirability of a certain conduct by States, international or non-governmental organisations or private associations and persons, with codes aimed at corporations specifically seeking to enhance the accountability of such corporate actors in the (international) marketplace by defining voluntary standards and principles to steer the behaviour of similar types of enterprises (i.e., a certain sector)" (2020).

Based on the previous findings, we can identify the following conceptual elements according to which a code of conduct:

(1) sets out expected rules of behaviour for its adherents, who undertake to be bound by them;

(2) targets a homogeneous group of businesses, other organisations, or specific sectors;

(3) is voluntary;

(4) can be adopted by different organisations or bodies as owners of the code;

(5) serves to increase the accountability of adherents and influence their behaviour.

The privacy and data protection literature broadly divides codes of conduct by their scope into five categories: organisational, sectoral, functional, technological, and professional (Bennet & Raab, 2006).

The organisational code is an instrument implemented within the structure of a given private or public organisation, especially in more complex organisations. Such a code will not be a code of conduct in the sense of Article 40 GDPR but rather as a type of data protection policy referred to in Article 24 GDPR or binding corporate rules. For clarity, let us refer to the definition of binding corporate rules provided in Article 4(20) GDPR. According to it, these are "personal data protection policies which are adhered to by a controller or processor established on the territory of a Member State for transfers or a set of transfers of personal data to a controller or processor in one or more third countries within a group of undertakings, or group of enterprises engaged in a joint economic activity."

On the other hand, sectoral codes will undoubtedly be codes of conduct within the meaning of Article 40 GDPR. The EU data protection law will mainly consider such codes as codes of conduct. It is worth emphasising that the distinguishing feature of sectoral codes is "that there is a broad consonance of economic interest and function among organisations in the sector, and by extension, a similarity in the kinds of personal information processed (Bennett & Raab, 2006). The concept of codes of conduct under Article 40 of GDPR will also include another category of codes mentioned by both authors, namely functional codes, the scope of which covers homogeneous data processing practices without being limited to one sector (EDPB 2019). For example, such codes may focus on various sectors' marketing activities, HR, or children's data processing (EDPB 2022). Another category relates to technology. As Bennet and Raab pointed out, technology codes deal with privacy and data protection issues associated with using new technologies. In practice, such codes, while often referring to a specific technology, cover homogeneous data processing operations. Therefore, they may be difficult to distinguish from functional codes, and the scope of Article 40 GDPR may also cover such. The last category refers to codes developed by professional societies or associations for professionals directly involved in data processing operations, such as market researchers (Bennett & Raab, 2006). This category, under certain conditions, could also qualify as a code of conduct under Article 40 of the GDPR.

Based on an analysis of the GDPR provisions on codes of conduct in terms of their scope of application and function, we can provide the following typology of data protection codes of conduct:

- National codes applicable in one Member State;
- Transnational codes;
- Transnational codes having general validity;
- Transnational Codes have general validity applicable to international transfers.

Nevertheless, first and foremost, we should divide codes into national and transnational. The EDPB has clarified that a transnational code refers to data processing activities in more than one Member State (2019) in contrast to a national code, which relates to processing activities in only one Member State. One should emphasise that cross-border processing under Article 4(23) is unnecessary for a code to be considered transnational (EDPB 2019). It will be sufficient for such a code to cover processing operations carried out by entities in the separate Member States.

The European Commission may make a transnational code universally valid within the EU through an implementing act. Adopting such an implementing act by the European Commission is a prerequisite for the code of conduct to be used for data transfers to third countries under Article 46 of the GDPR.

Although codes of conduct are often equated exclusively with the private sector, the GDPR does not limit the application of codes of conduct to that sector. However, Article 41 GDPR distinguishes public sector codes of conduct from private sector codes by excluding, in the former case, provisions for monitoring bodies of codes of conduct. This exclusion does not in any way weaken the requirement to implement effective monitoring mechanisms for such kinds of codes. However, it raises the problem of ensuring effective compliance monitoring mechanisms. According to the EDPB, effective monitoring can be achieved by adapting existing audit requirements to include code monitoring (2019). Mixed codes covering controllers and processors from the public and private sectors should also be mentioned.

Functions of codes of conduct. In relating the above features to data protection codes of conduct, it is worth referring to Peter Hustinx. He distinguished four purposes for developing data protection codes of conduct in different countries: to avoid legislation, anticipate legislation, implement legislation, and supplement it (Hustinx, 1991). In light of the GDPR, data protection codes of conduct are primarily developed for the third purpose mentioned above and much less for the fourth purpose. For these reasons, Urszula Góral and Paweł Makowski rightly argued that codes of conduct are sets of guidelines and instructions aimed at clarifying provisions of the GDPR (2018). According to Article 40 of GDPR, the primary purpose of codes of conduct is to facilitate compliance with the GDPR. To this end, the codes should concretise and operationalise the general principles of personal data protection for a specific industry or a particular type of processing operation. A data protection code of conduct is "a detailed description of what is the most appropriate, legal and ethical set of behaviors of a sector." Therefore it can "operate as a rulebook for controllers and processors who design and implement GDPR compliant data processing activities which give operational meaning to the principles of data protection set out in European and national law" (EDPB 2019). In this sense, we should view data protection codes of conduct as implementation or compliance tools that in no way replace or modify the provisions of the GDPR (Drobek, 2019). In particular, such codes can tailor the general obligations of controllers and processors to the risk of violation of the rights or freedoms of natural persons that sector-specific processing may entail.

Codes of conduct can provide controllers and processors with a greater degree of autonomy to establish standards and best practices for protecting personal data in the sector covered by the code, as well as increase legal certainty regarding solutions to problems identified in the sector. Codes of conduct also serve to build trust among data subjects.

In addition, codes of conduct may provide adequate safeguards in relation to data transfers to importers in third countries under Article 46(2)(e).

Codes of conduct may also serve as a means to facilitate the demonstration of compliance with the provisions of GDPR, as explicitly indicated by Article 24(3). In particular, this concerns under Article 32(3) GDPR, the demonstration of compliance with data security obligations or under Article 28(5) GDPR, the demonstration of sufficient guarantees by the processor. According to Article 35(8) GDPR, controllers or processors, in assessing the impact of the processing operations, in particular for a data protection impact assessment, must consider approved codes of conduct.

Pursuant to Article 83(2)(j) GDPR, when deciding whether to impose an administrative, financial penalty and determining the amount of the penalty, the supervisory authority will pay attention to the application of approved codes of conduct. It should be noted that, depending on the circumstances and behaviour of the controller or processor, this may reduce or increase their liability in this respect.

Functions of codes of conduct

In relating the above features to data protection codes of conduct, it is worth referring to Peter Hustinx. He distinguished four purposes of developing data protection codes of conduct in different countries: to avoid legislation, anticipate legislation, implement legislation, and supplement it (Hustinx, 1991). In light of the GDPR, data protection codes of conduct are primarily developed for the third purpose mentioned above and much less for the fourth purpose. For these reasons, Urszula Góral and Paweł Makowski rightly argued that codes of conduct are sets of guidelines and instructions aimed at clarifying provisions of the GDPR (2018). According to Article 40 GDPR, the primary purpose of codes of conduct is to facilitate compliance with the GDPR. To this end, the codes should concretize and operationalize the general principles of personal data protection to a specific industry or a particular type of processing operation. A data protection code of conduct is “a detailed description of what is the most appropriate, legal and ethical set of behaviors of a sector. "Therefore it can "operate as a rulebook for controllers and processors who design and implement GDPR compliant data processing activities which give operational meaning to the principles of data protection set out in European and national law" (EDPB 2019). In this sense, we should view data protection codes of conduct as implementation or compliance tools that in no way replace or modify the provisions of the GDPR (Drobek, 2019). In particular, such codes can tailor the general obligations of controllers and processors to the risk of violation of the rights or freedoms of natural persons that sector-specific processing may entail.

Codes of conduct can provide controllers and processors with a greater degree of autonomy to establish standards and best practices for the protection of personal data in the sector covered by the code, as well as increase legal certainty with regard to solutions to problems identified in the sector. Codes of conduct also serve to build trust among data subjects.

In addition, codes of conduct may serve to provide adequate safeguards in relation to transfers of data to importers in third countries under Article 46(2)(e).

Codes of conduct may also serve as a means to facilitate the demonstration of compliance with the provisions of GDPR, as explicitly indicated by its Article 24(3). In particular, this concerns under Article 32(3) GDPR the demonstration of compliance with data security obligations or under Article 28(5) GDPR the demonstration of sufficient guarantees by the processor. According to Article 35(8) GDPR, controllers or processors in assessing the impact of the processing operations, in particular for the purposes of a data protection impact assessment, must take into due account approved codes of conduct.

Pursuant to Article 83(2)(j) GDPR, when deciding whether to impose an administrative financial penalty and determining the amount of the penalty, the supervisory authority will pay attention to the application of approved codes of conduct. It should be noted that, depending on the circumstances and behaviour of the controller or processor, this may reduce or increase their liability in this respect.

Legal nature of the codes of conduct

Data protection codes of conduct are often included in the broad category of soft law as opposed to hard law (Fischer, 2018; Góral & Makowski, 2018; Gaeta, 2019). It should be stressed that soft law is intensively developed and plays an important role in the EU regulatory framework (Stefan, 2012). This progressive development of EU soft law does not diminish all concerns regarding, among other things, the legitimacy, nature and legal effect of such acts. It has recently been particularly demonstrated by the actions undertaken at the EU level concerning the Covid-19 pandemic (e.g. Stefan, 2020). It should be added that the legal nature of soft law within the EU law system does not mean it has no legal effect. Moreover, in fact, the codes of conduct created under the GDPR produce the legal effects provided for in this regulation and the obligations imposed in them can be legally enforced.

However, soft law is not a sufficiently precise term to describe the codes of conduct. First of all, it is questionable whether they should be regarded as law. It is assumed that codes of conduct do not generally constitute binding acts of law (Fajgielski, 2018). They are only self-binding for entities that have voluntarily agreed to apply them directly or indirectly, and they could even be considered so-called "tools of self-discipline" (Gaeta, 2019). One can say that codes of conduct can constitute a source of civil law obligations imposed on their adherents, as they can be regarded as an advanced form of contract between the signatories (stakeholders) creating them.

Consequently, codes of conduct shall be binding in the first instance on those who have subscribed to the code voluntarily (Drobek, 2019). Codes of conduct may also indirectly affect the understanding of the content of the obligations imposed on controllers or processors by the GDPR in the industry concerned, but who have not adhered to such a code. They also bind the supervisory authorities that have approved these codes. Supranational codes that require an opinion from the European Data Protection Board bind this body and its members (national supervisory authorities). Doubts have been raised about the legal force of supranational codes, for which, according to Article 40(9) GDPR, the European Commission may decide that they have general validity within the Union.

As a rule, codes of conduct are not sources of generally applicable law but constitute a source of civil law obligations imposed on their signatories, as they can be regarded as an advanced form of contract between the signatories (members of the code) (European Economic and Social Committee 2015). Consequently, a breach of the obligations imposed on the signatories to a code of conduct will give rise to liability under the terms of the code, which should provide for appropriate sanctions in the event of non-compliance with its provisions. Codes of conduct are intended to facilitate compliance with the provisions of GDPR by clarifying them and considering the specificities of a particular sector. In such a situation, a breach of the code of conduct may be treated as a breach of GDPR and give rise to administrative liability under the general rules. However, if the code of conduct introduces a higher standard of personal data protection than that provided in generally applicable data protection legislation, its breach will give rise to liability on the principles set out in the code.

As indicated earlier, codes of conduct are, by their very nature, voluntary. However, this does not exclude a situation where the code becomes de facto mandatory as an indirect result of belonging to a professional or industry organisation that has adopted the code as binding on its members.

Conclusions

The GDPR gives a more significant role to codes of conduct than in the previous EU data protection regime. The GDPR explicitly identifies codes of conduct as co-regulatory instruments. Their compliance with which controllers and processors have significant legal consequences but also provides an essential layer of cooperation between controllers, processors and supervisory authorities. However, the codes of conduct must not lower the level of protection from what is guaranteed by the data protection legislation, including GDPR and sector-specific laws.

At this still preliminary stage of application of the GDPR, it can be said that there is already an adequate formal framework for the preparation and approval of codes of conduct, as well as for the accreditation of monitoring bodies; there are also already the first approved codes on the EU and national level. However, it is too early to comprehensively assess their functioning, as there needs to be more experience with their practical operation.

References

Act (1997). Act of 29 August 1997 on the Protection of Personal Data, unified text: Journal of Laws of 2014, item 1182 with amendments.

Bennet C., Raab C. (2006). The Governance of Privacy. Policy Instruments in Global Perspective. The MIT Press, Cambridge, London, pp. 155–158.

Black J. (2012). Paradoxes and Failures: New Governance, Technics and the Financial Crisis. Modern Law Review, vol. 76, no. 4., pp. 1037–1063.

Black's Law Dictionary (1999). West Group, St. Paul, p. 250.

Csink L., Mayer A. (2014). How to Regulate: The Role of Self-Regulation and Co-Regulation. Hungarian Yearbook of International Law and European Law, vol. 3, pp. 403–420.

Opinion of the European Economic and Social Committee on Self-regulation and co-regulation in the Community legislative framework (2015/C 291/05).

Directive 95/46/EC, 1995. Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Official Journal L 281/31.

Directive 2005/29/EC, 2005. Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council ('Unfair Commercial Practices Directive'), Official Journal L 149/22.

Drobek P. (2019). Opracowywanie i zatwierdzanie kodeksów postępowania oraz warunki i tryb akredytacji podmiotu monitorującego jego przestrzeganie (*Drawing up and approving codes of conduct, as well as the conditions and procedure for accreditation of monitoring bodies*). In: D. Lubasz (ed.), Ustawa o ochronie danych Osobowych. Komentarz (*Personal Data Protection Act. A Commentary*). Wolters Kluwer, Warszawa, pp. 179–204.

EUR-Lex. https://eur-lex.europa.eu/homepage.html [access: 24.11.2022].

European Commission (2003). Report from the Commission. First report on the implementation of the Data Protection Directive (95/46/EC) COM(2003) 265 final. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52003DC0265&qid=1669466237911&from=PL [access: 24.11.2022].

European Commission (2010). Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. A comprehensive approach on personal data protection in the European Union (COM/2010/0609 final) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52010DC0609&qid=1669720186919 [access: 24.11.2022].

European Commission (2020). Communication from the Commission to the European Parliament and the Council. Data protection as a pillar of citizens' empowerment and the EU's approach to the digital transition - two years of application of the General Data Protection Regulation (COM/2020/264 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1669720562137&uri=CELEX%3A52020DC0264 [access: 24.11.2022].

EDPB (2019). Guidelines 1/2019 on Codes of Conduct and Monitoring Bodies under Regulation 2016/679 Version 2.0 https://edpb.europa.eu/sites/default/files/files/file1/edpb_guidelines_201901_v2.0_codesofconduct_en.pdf [access: 24.11.2022].

EDPB (2021a). European Data Protection Board Opinion 16/2021 on the draft decision of the Belgian Supervisory Authority regarding the "EU Data Protection Code of Conduct for Cloud Service Providers" submitted by Scope Europe. https://edpb.europa.eu/system/files/202105/edpb_opinion_202116_eucloudcode_en.pdf [access: 24.11.2022].

EDPB (2021b). European Data Protection Board Opinion 17/2021 on the draft decision of the French Supervisory Authority regarding the European code of conduct submitted by the Cloud Infrastructure Service Providers (CISPE). https://edpb.europa.eu/system/files/202105/edpb_opinion_202117_cispecode_en_0.pdf [access: 24.11.2022].

EDPB (2022). European Data Protection Board Guidelines 04/2021 on Codes of Conduct as tools for transfers Version 2.0. https://edpb.europa.eu/system/files/2022-03/edpb_guidelines_codes_conduct_transfers_after_public_consultation_en_1.pdf [access: 24.11.2022].

European Economic and Social Committee (2015). Opinion on Self-regulation and co-regulation in the Community legislative framework, Official Journal C 291/05.

Fajgielski P. (2018). Art. 40 Kodeksy postępowania (*Article 40 Codes of conduct*). In: P. Fajgielski. Ogólne rozporządzenie o ochronie danych. Ustawa o ochronie danych osobowych. Komentarz (*General Data Protection Regulation. Personal Data Protection Act. A Commentary)*. Wolters Kluwer, Warszawa, p. 250.

Fischer B. (2018). Art. 40 Kodeksy postępowania (*Article 40 Codes of conduct*). In: M. Sakowska-Baryła (ed.), Ogólne rozporządzenie o ochronie danych osobowych. Komentarz (*General Data Protection Regulation. A Commentary*). C.H. Beck, Warszawa.

Gaeta M. (2019). Hard Law and Soft Law on Data Protection: What a DPO Should Know to Better Perform His Or Her Tasks. European Journal of Privacy Law & Technologies, vol. 2019, no. 2, pp. 61–78.

GDPR, 2016. Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation. Official Journal L 119/1.

Gellert R. (2020). The risk-based approach to data protection. Oxford University Press, Oxford.

Gilad S. (2010). It runs in the family: Meta-regulation and its siblings. Regulation & Governance, vol. 4., no.4, pp. 485–506.

Góral U., Makowski P. (2018). Art. 40. In: E. Bielak-Jomaa, D. Lubasz (ed.), RODO. Ogólne Rozporządzenie o ochronie danych. Komentarz *(GDPR. General Data Protection Regulation. A Commentary)*. Wolters Kluwer, Warszawa, pp. 819–820.

Hodges C. (2015). Law and Corporate Behaviour. Integrating Theories of Regulation, Enforcement, Compliance and Ethics. Hart Publishing, Oxford and Portland, pp. 1–2 and 466.

Hustinx P. (1991). The Role of Self-Regulation in the Scheme of Data Protection. Paper presented to the 13th Conference of Data Protection Commissioners, Strasbourg, cited by Bennet C. Raab C. (2006). The Governance of Privacy. Policy Instruments in Global Perspective. The MIT Press, Cambridge, London, p. 152.

Kamara I. (2020). Article 40 Codes of conduct. In: C. Kuner, L.A. Bygrave, C. Docksey (ed.), The EU General Data Protection Regulation (GDPR). A Commentary. Oxford University Press, Oxford, pp. 718–723.

Korff D.(2003). EC Study on Implementation of Data Protection Directive 95/46/EC (2002). Available at SSRN: https://ssrn.com/abstract=1287667 or http://dx.doi.org/10.2139/ssrn.1287667 [access: 24.11.2022], pp. 185–188.

Kuner C. (2007). European Data Protection Law. Corporate Compliance and Regulation. Oxford University Press, Oxford, pp. 46–48.

LRDP KANTOR Ltd (2010). Comparative study on different approaches to new privacy challenges, in particular in the light of technological developments. Final Report. https://op.europa.eu/en/publication-detail/-/publication/9c7a02b9-ecba-405e-8d93-a1a8989f128b [access: 24.11.2022], p. 52.

Medzini R. (2021). Governing the shadow of hierarchy: enhanced self-regulation in European data protection codes and certifications. Internet Policy Review, vol. 10, no. 3. https://doi.org/10.14763/2021.3.1577.

Multistakeholder Expert Group (2019). Contribution from the Multistakeholder Expert Group to the stock-taking exercise of june 2019 on one year of GDPR application. https://ec.europa.eu/info/sites/default/files/report_from_multistakeholder_expert_group_on_gdpr_application.pdf, p. 4.

Robinson N., Graux H., Botterman M.,Valeri L. (2009). Review of the European Data Protection Directive. Sponsored by the Information Commissioner's Office. RAND Corporation, Santa Monica, p. 37. https://www.rand.org/pubs/technical_reports/TR710.html [access: 24.11.2022].

Stefan O. (2012). European Union Soft Law: New Developments concerning the Divide between Legally Binding Force and Legal Effects. Modern Law Review, vol. 75, no. 5, pp. 879–893.

Stefan O. (2020). The Future of EU Soft Law: Research and Policy Agenda for the Aftermath of Covid-19. Journal of International and Comparative Law, vol. 7, no. 2, pp. 329–350.

Vander Malen C. (2020). Codes of (Mis)Conduct? An Appraisal of Articles 40–41 GDPR in View of the 1995 Data Protection Directive and Its Shortcomings. European Data Protection Law Review, vol. 6, no. 2, pp. 231–242.

Vander Malen C. (2021). First or Many? First GDPR Transnational Code of Conduct Officially Approved After EDPB Opinions 16/2021 and 17/2021. European Data Protection Law Review, vol. 7, no. 2, pp. 228–231.

WP 29 (1998), Article 29 Working Party Working Document: Judging industry self-regulation: when does it make a meaningful contribution to the level of data protection in a third country? https://ec.europa.eu/justice/article29/documentation/opinion-recommendation/files/1998/wp7_en.pdf [access: 24.11.2022].

WP 29 (2001). Article 29 Working Party Working Document on IATA Recommended Practice 1774 Protection for privacy and transborder data flows of personal data used in international air transport of passengers and of cargo. https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2001/wp49_en.pdf [access: 24.11.2022].

WP 29 (2003), Article 29 Working Party Opinion 3/2003 on the European code of conduct of FEDMA for the use of personal data in direct marketing https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2003/wp77_en.pdf [access: 24.11.2022].

WP 29 (2008), Article 29 Working Party Opinion 3/2008 on the World Anti-Doping Code Draft International Standard for the Protection of Privacy. https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2008/wp156_en.pdf [access: 24.11.2022].

WP 29 (2009), Article 29 Working Party Second opinion 4/2009 on the World Anti-Doping Agency (WADA) International Standard for the Protection of Privacy and Personal Information, on related provisions of the WADA Code and on other privacy issues in the context of the fight against doping in sport by WADA and (national) anti-doping organizations. https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2009/wp162_en.pdf [access: 24.11.2022].

WP 29 (2010), Article 29 Working Party Opinion 4/2010 on the European code of conduct of FEDMA for the use of personal data in direct marketing. https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2010/wp174_en.pdf [access: 24.11.2022].

WP 29 (2015), Article 29 Working Party Opinion 02/2015 on C-SIG Code of Conduct on Cloud Computing. https://ec.europa.eu/justice/article-29/documentation/opinion-recommendation/files/2015/wp232_en.pdf [access: 24.11.2022].

WP 29 (2018), Article 29 Working Party letter to CISPE. file:///C:/Users/68366/Downloads/wp29_letter_to_cispe_final_ifp_9DD8DA13-948C-4F0E-50D80A5D97A2BB3E_49993.pdf [access: 24.11.2022].

Yeung K., Bygrave L. (2022). Demystifying the modernized European data protection regime: Cross-disciplinary insights from legal and regulatory governance scholarship. Regulation & Governance, vol. 16, no. 1, pp. 137–155. https://doi.org/10.1111/rego.12401.

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.147

Rubén Pérez Fernández[1]

WHAT TO CONSIDER WHEN IMPLEMENTING REMOTE CONTROL TOWERS? COLOMBIA CASE STUDY

Abstract: The aim of this article is to assist anyone considering implementing these systems. Along the document the main differences between conventional and remote control are stated, with the intention to clarify what advantages they can bring, the changes involved when adopting remote towers, and a brief outline of a transition plan for adopting these systems. Subsequently, the benefits to a country's air navigation from utilizing these systems is discussed by studying the case of Colombia, a country with a unique orography. In addition, the specific characteristics of the airports are analysed to propose the candidates which may have the best outcome if remote tower systems are implemented.

Keywords: remote tower system, air navigation, change management, cost-effectiveness, transition plan

Received: 13 November 2022; accepted: 27 December 2022

[1] Universidad Politécnica de Madrid (UPM), Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio (ETSIAE) Madrid, Spain. ORCID ID: https://orcid.org/0000-0002-9064-5480, email: ruben0016@gmail.com

Introduction

Remote towers transform the conventional provision of air traffic services (ATS) for air traffic controllers, allowing operators to monitor the activity of several aerodromes from a remote tower center (RTC). In this way, the performance of Air Navigation Service Providers (ANSPs) is optimised through cost reduction and efficiency benefits being a direct consequence of the avoidance of the construction of a conventional control tower.

The provision of air traffic service represents between 20 to 50 percent of the total costs of operating an airport, so optimizing the way in which it is given is an important issue as it could radically change air traffic control. Cost-effectiveness in the operation of airports is a major concern. 47 percent of European airports are lossmaking, and 75 percent of those, with fewer than 1 million passengers per year, are not generating any profits. (Nyström, 2019)

Remote tower systems (RTS) were initially developed for low-density aerodromes to achieve a more beneficial method to provide ATS centralising resources and allow exceptional flexibility in service provision. The main incentive for the implementation of RTS is to find an efficient option that can tackle conventional control, ensuring the same levels of safety and security.

The remote aerodrome concept allows the provision of ATS from remote facilities to the controlled areas, without the need for direct observation. Therefore, the service is provided through surveillance systems that monitor the airfield and its vicinity by using cameras and sensors that transmit images via a digital network to the operators.

Although there is not an established regulatory framework for the conversion from conventional to remote tower, new operational procedures are needed, in addition to detailed instructions, for operators to ensure a smooth transition between both operational modes. These innovative systems demand a change management which needs to cover the operational and human environment to guarantee their safe and proper functioning.

Remote control vs. conventional control

What does it change? Remote towers offer the possibility to control the operations of one or more aerodromes or airports from one single position. Due to the surveillance systems installed on runways, taxiways, and hotspots at the airport operated, air traffic control operators (ATCO) and aerodrome flight information service operators (AFISO) are capable of monitoring the operations from a remote tower center (RTC). An RTC is the geographical independent facility from which ATS is provided by indirect observation via surveillance system. For low-density aerodromes or airports, it is possible to control several small airports from a single RTC.

Regarding conventional control, ATS is provided from a control tower located in airports, from which operators monitor the operation of aircrafts in the manoeuvring area and its surroundings guiding them to and from the airport with radio communications, digital aids, and direct visual surveillance. Although situational

awareness on digital towers can be controversial, as ATCO and AFISO do not have direct out-of-the-window (OTW) view, it has been demonstrated that the combination of advance surveillance systems and radio communications in RTS is better compared to conventional towers by allowing greater situational awareness.

The ground-breaking feature of RTS implementation was inconceivable until the first airports began to adopt them in 2015. The location of the control tower becomes independent of the controlled aerodrome. Consequently, the position of RTCs can be chosen after conducting a study on the most beneficial areas that allow an efficient use of resources. Nevertheless, RTS could be placed at the same conventional tower in the aerodrome or at a considerable distance in a strategic location with the best conditions for its operation.

If ATS is expected to be provided by the conventional method at an airport or aerodrome, it would require the construction of a fully equipped control tower. In contrast, digital towers offer a more pragmatic solution which leads to a reduction of cost and time until it becomes operational, as there is no need to build a conventional control tower.

Moreover, these systems are commonly used to complement a traditional tower and thus, increase the information received from blind spots that are not visible from the control tower. Also, RTS could integrate a conventional tower to be used as a back-up system if by any reasons traditional systems are not operative. Therefore, the service provision would always be guaranteed in the event of unforeseen situations or maintenance tasks.

What are the benefits? Remote towers can be operated in two different modes: single or multiple. Single operational mode only differs from conventional towers by allowing the tower to be located away from the airport, but only controls one airport at a time, reducing the potential to save capital. With multiple mode, two or three airports with low/medium traffic could be controlled from a single RTC at the same time. Multiple remote towers can create cost savings via economies-of-scale. Clearly, the potential for cost savings is larger for multiple remote towers than for single remote towers. The regulatory framework to operate multiple towers is, as of today, not in place (Nyström, 2019).

Remote towers represent a solution for non-towered aerodromes when considering service provision. RTS can offer a feasible alternative to the time-consuming construction of a conventional control tower. Low density aerodromes can use remote devices to develop them and stimulate those with growing demand. The instalation of a digital tower can be an exceptional feature not only for those airfields under ATS supervision, but also for controlled airfields in remote areas that are difficult to access and could be controlled from one single location.

Airports with a large manoeuvring area can cover the blind spots with remote tower systems, adding them to the conventional tower. Likewise, high efficiency in the use of capital and human resources can be achieved by avoiding the construction of a second control tower and its corresponding equipment with all devices and the personnel required for its operation. RTS can improve operational safety through new

technologies, reducing delays, expediting arrivals and dispatch of aircrafts with no need for the construction of an additional control tower.

They can also ensure the provision of service in case of planned or unplanned maintenance without having to reduce the airport's capacity or for contingency plans in case of unforeseen failures of conventional systems offering an effective solution.

Furthermore, airports with a high rate of low visibility conditions and H24 airports could also benefit from its implementation, to enhance the control of operations during low visibility conditions or at night, to complement service provision with infrared and high-definition cameras. As for scheduled airports, RTS can offer service that can adjust perfectly to their specific demand allowing time-sensitive control for airports at the required times, offering a high degree of flexibility.

From the perspective of an ANSP, in charge of the control of airports with low operations, remote locations and/or difficult access, using RTS would not only mean a reduction of cost in service provision, but could also be beneficial for ATCO/AFISO personnel. They would be able to control these airports from a single center without having to be physically at the airport. Consequently, it could be beneficial to choose a location for the RTC in an appealing area for staff, which would enhance hiring.

What does the change involve? Over the last decade remote towers technology has been developed to become a feasible solution to control air operations. To cope with a change of such magnitude in which the operation becomes fully digital, dealing with new devices and systems, the importance of achieving an effective change management becomes a critical factor.

Safety. For the time being, implementing RTS involves a significant change to the functional system concerning ANSP, airspace users and regulatory agencies. It does not require any specific safety assessment methodology apart from the requirements specified by European Union Aviation Safety Agency (EASA) or the Federal Aviation Administration (FAA).

As part of the safety assessment for an airport operated remotely, it is a prime necessity to include a transition plan outlining the differences when using RTS. In addition, safety risks should be managed from the point of view of the changes involved when implementing digital towers, identifying internal and external changes that might have a negative impact on safety and a hazard identification for any changes.

When operating with RTS the operation becomes fully digital relying on IT, so importance should be given to the transfer of data between surveillance, communications and management systems. The operational devices and data bases must be shielded to guarantee acceptable levels of safety and security facing potential cyberattacks.

Moreover, the ANSP is responsible for identifying all hazards of any change in the functional system compared to conventional control in addition to those features that are not related to RTS. However, the use of these systems may have a different impact on the probability of occurrence of these hazards, and the actions to be taken and the effects of the impact must be recorded.

Human Factors. The first to be affected by the transition to digital towers are controllers as they must adapt to new systems, meaning new operational procedures. The human factor is the key element to guarantee a successful transition to these systems. Operating in remote towers, controllers can obtain more information from other sources, therefore, it is necessary to study how this new operating scenario affects personnel.

The main change that controllers will face is adapting to not having OTW view and accommodating to the screen which may not have the same resolution as a direct visual and will allow an augmented vision. For this reason, the high definition of the cameras placed at the airport and the angle of vision they can cover is essential. Consideration should be given to how the screens will affect ATCO/AFISO when multitasking, how long they can be looking directly at the screen, and how to distribute the attention when operating with these systems.

Another important factor is to analyse how it affects ATCO/AFISO receiving all information from digital devices controlling their workload and how screens can affect the operator fatigue and workload. Especially when operating in multiple mode, providing service to two airports, ensuring that the information is clearly received by the personnel without mixing parameters from different airports.

Human factors assessment examines the suitability of the technical components involved in an ATS task, to be successfully accomplished by ATCO/AFISO. It should cover all the relevant areas affected by the change.

- Human Machine Interface (HMI).
- Working environment.
- Procedures and working methods.
- Organisation and human-human interaction.
- Change management.

Moreover, it must be defined how tasks are going to be managed with these systems. It should be re-established the roles and responsibilities for each position determining the operational methods and the duty at each position. It must be defined the changes and the impact it may have on personnel not only in their performance but also in their long-term satisfaction.

Transition Plan. It is the core element that will ensure the correct operation of a digital tower. The importance of creating a transition plan will allow a proper conversion from conventional control to remote towers. It is the duty of ANSPs to coordinate with the airport operator to establish the transition plan for providing remote ATS.

The procedures in which ATCO/AFISO should operate in every scenario should be stated and even though it is not mandatory, consideration should be given to including a training plan that ensures that personnel are suitable to provide service with these systems.

Shadow mode operation is a validation technique prior to an operational remote tower in which ATS is provided conventionally at the airport but remote tower systems receive all the information from the environment. Shadow mode can be:

- Passive, without interfering with service provision but receiving live information of the aerodrome and its vicinity.
- Active, in which the new system can provide service to a user in parallel with the conventional control to test the performance of RTS.
- Advanced, when RTS will be fully active in operation and run in parallel with the conventional system as back up if by any reasons there is a failure in RTS.

The transition to RTS must be performed in three phases. First, the conventional tower provides ATS. In the next phase there should be some control transfer in which the service is still provided by the conventional tower, but the data and parameters are also received at the remote tower under shadow mode to initiate system test procedures. Finally, if the shadow mode operation is successful, the remote tower will be able to provide ATS on its own.

Colombia case study

Colombia has a unique geography with three mountain ranges in the central part that cross the country from north to south, and the Amazon in the southern regions. Therefore, it is hard to reach certain areas and, in some cases, can only be reached by plane. In addition, the country has a large number of airports (represented in Figure 1 as green dots), most of them with low or medium density, which is perfectly suitable for the provision of RTS services.

One of the solutions provided by digital towers is to solve the problems of accessibility in specific areas with difficult access by being able to control one or more airports from a RTC that could be in a city with easier access. This could also be a great advantage for attracting ATCO/AFISO personnel.

These systems can transform a country's air navigation, and Colombia is a country with remarkably favourable conditions, which can have a positive result if remote towers are deployed at some key airports.

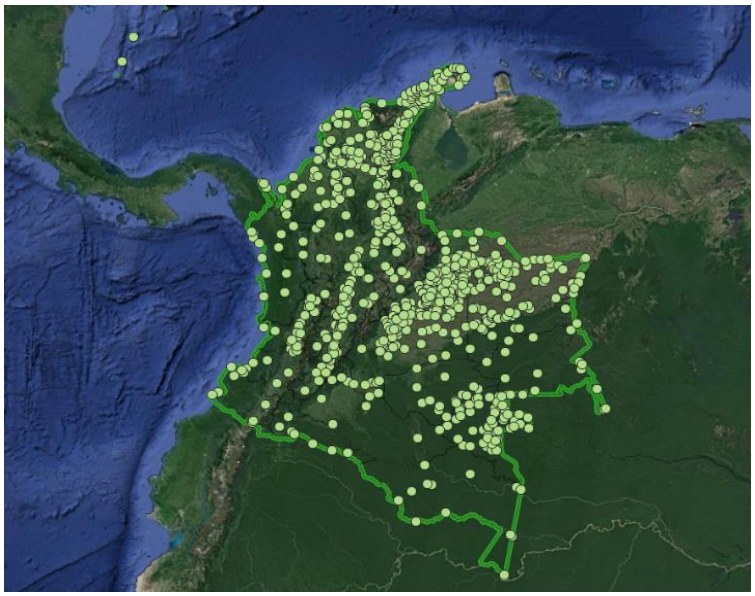


Fig. 1. Colombian airports.
Source: own elaboration based on QGIS

Digital towers allow a better use of human resources and capital. Therefore, regarding the placement of RTCs, it is considered that the biggest population centers in Colombia offer better accessibility than smaller cities and may be more attractive for hiring qualified personnel in Bogotá, Medellín, Cali and Barranquilla (represented in Figure 2 as blue dots)

Table 1. Biggest population centers in Colombia

City	Population
Bogotá	7.149.540
Medellín	2.359.801
Cali	1.811.385
Barranquilla	1.115.490

Source: Departamento Administrativo Nacional de Estadísitca de Colombia (DANE, 2018)

The criteria applied to carry out the study of which airports may have the best outcome if RTS are implemented is based on grouping them in four areas covering all airports in the north, south, east, and west regions of the country. It is a prime necessity that the data is capable to be transmitted with the lowest latency possible between the different airports and aerodromes.

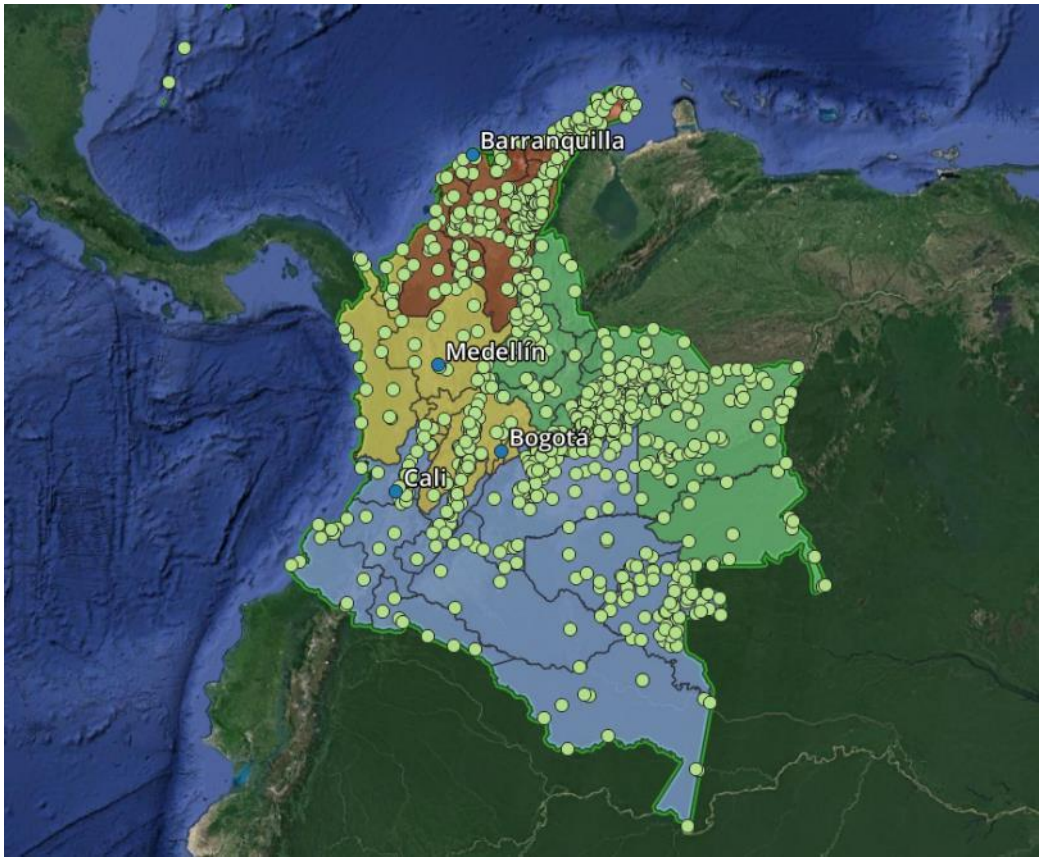


Fig. 2. Airports distribution
Source: own elaboration based on QGIS

Since the multiple operating mode on remote control is under development, and so far, only the provision of the same type of ATS has been approved for several airports, only those airports that share the same ATS are taken into consideration to be controlled by the same RTC. This does not imply any restriction in the provision of service, being able to switch between the different operating modes adding, closing, or transferring airports.

An additional critical factor when deciding the location and area of responsibility of the remote tower is the size and number of aerodromes that can be controlled in multiple mode. The complexity of the traffic, the individual operational aspects of each airport, the geographical location, and traffic levels are analysed. It has been demonstrated that the level of air traffic and its complexity has the greatest impact on the workload of air traffic controllers, so only those airports that receive the same type of traffic and have a compatible number of operations, are combined.

For the exact location of the digital towers, it would be necessary to carry out an additional study, assessing on a case-by-case basis whether it is more convenient to transform conventional towers into RTCs in the selected airports or establish a different place for the location of the RTC.

Candidate airports

Once all of the airports in relation to the criteria exposed were studied, the following were selected as the airports of major importance.

Table 1. Candidate airports

Airport	City & Population	Airport operator	Traffic	Air operations 2020	Air operations 2021
Palonegro	Bucaramanga 523.426	Aeropuertos de Oriente	National & International IFR/VFR ATC	10.144	15.562
Camilo Daza	Cúcuta 624.729	Aeropuertos de Oriente	National & International IFR/VFR ATC	4.708	9.505

Source: Unidad Administrativa Especial de Aeronáutica Civil (Aerocivil, 2018)

Camilo Daza International Airport, located in Cúcuta, capital city of Norte de Santander, and Palonegro International Airport in Bucaramanga, capital city of Santander, are two airports located in the eastern mountain range of Colombia. With the intention of improving the ATS services in Colombia, these airports are proposed to be remotely controlled from a digital tower located in another city with better access.

Both of them have very similar characteristics as they are both controlled airports that admit flights under visual and instrumental flight rules (VFR/IFR). In addition, they receive and dispatch both domestic and international flights, and although Palonegro

Airport has a greater number of operations, both could be controlled with RTS. Both airports are operated privately by the company "Aeropuertos de Oriente de Operados por KAC," so the implementation of the digital tower would require negotiations and agreements with this company and also with the Colombian institution "Aerocivil."

Due to the fact that both airports are located in the eastern Colombian ranges, it is estimated that the access to Bucaramanga and Cúcuta is likely to be more difficult than to other cities outside the mountain range. Regarding the location of the remote tower, it is considered that the city of Medellín (280 kilometres away from the Palonegro International Airport and 390 kilometers from Camilo Daza International Airport) would be the an attractive location for the establishment of a RTC. Thus, the RTC could be placed in Medellín, from which, the airports of Palonegro and Camilo Daza would be controlled.

Fig. 3. Camilo Daza and Palonegro candidate airports
Source: own elaboration based on QGIS

Conclusions

Establishing a network of remotely controlled airports is a revolutionary change for a country's air traffic control service. Nevertheless, the capital required to carry out the project is expensive, as these systems require significant investment. In addition, the return on investment is quite long, an average of about twenty years. This is one of the main barriers to the implementation of the service, as it is focused mainly on small and medium sized airfields.

Even though remote towers support the concept of reducing costs and optimising resources, in many cases the same modus operandi as in conventional towers are still used, trying to minimize the differences which reduce the potential for savings. It is true that there are certain technical issues which concern the multiple operational mode of remote towers which is still in development, but there is some reluctance to change, as it implies reducing ATCO/AFISO personnel.

Remote aerodrome concept is a revolutionary idea that can bring significant benefits to air navigation; however, it is taking a long time to be implemented globally as there are no standards that indicate how to implement them in different scenarios.

Colombia is a country with very favourable conditions for the implementation of remote control towers, not only reducing costs for ANSPs, but also solving accessibility problems. In all South America, there is only one operational remote control tower at Santa Cruz airfield, a military base operating in single mode. If these systems are adopted in Colombia, it would be one of the pioneer countries in the continent.

References

Aeroermo (2021). Colombia initiates Pilot Project for the Remote Control of Air Traffic through Digital Towers. https://www.aeroermo.com/home/colombia-inicia-proyecto-piloto-para-el-control-remoto-del-trafico-aereo-a-traves-de-torres-digitales/ [access: 15.10.2022].

Aerocivil (2018). Special Administrative Unit of Civil Aeronautics.

Balogh G. (2022). Digital remote towers. Change management us key to success. https://www.eurocontrol.int/sites/default/files/2022-06/skyway76-advertorial-indra.pdf [access: 19.10.2022].

Beek S.D. (2017). Remote Towers: A Better Future for America's Small Airports. Reason. https://reason.org/wp-content/uploads/2017/07/air_traffic_control_remote_towers-1.pdf [access: 04.11.2022].

CANSO (2021). Guidance Material for Remote and Digital Towers. https://canso.fra1.digitaloceanspaces.com/uploads/2021/04/canso_guidance_material_for_remote_and_digital_towers.pdf [access: 05.09.2022].

DANE (2018). National Administrative Department of Statistics of Colombia.

EASA (2020). Easy Access Rules for Guidance Material on Remote Aerodrome Air Traffic Services.

https://www.easa.europa.eu/sites/default/files/dfu/easy_access_rules_for_guidance_material_on_remote_aerodrome_air_traffic_services.pdf [access: 05.09.2022].

EASA (2021). Easy Access Rules for Air Traffic Management/Air Navigation Services (Regulation (EU) 2017/373). https://www.easa.europa.eu/en/downloads/125141/en [access: 05.09.2022].

FAA (2020). Remote Tower Systems Concept of Operations (ConOps). https://www.faa.gov/airports/planning_capacity/non_federal/remote_tower_systems/media/ rt-conops-version-1-0-2020-04-07.pdf [access: 07.09.2022].

FAA (2022). Remote Tower (RT) Systems Minimum Functional and Performance Requirements for Non-Federal Applications. For use in class D airspace. https://www.faa.gov/airports/planning_capacity/non_federal/remote_tower_systems/media/ draft-Remote-Tower-Systems-Requirements-3.0-2022-01.pdf [access: 07.09.2022].

Kearney P., Li W.-C. (2018). Multiple remote tower for Single European Sky: The evolution from initial operational concept to regulatory approved implementation. Elsevier. https://www.sciencedirect.com/science/article/pii/S0965856417303397 [access: 21.10.2022].

Nyström S. (2019). How competition and technology and technology can and cannot contribute to reducing costs of air traffic control. Copenhaguen Econocmics. https://copenhageneconomics.com/wp-content/uploads/2021/12/reducing-costs-of-air-traffic-control.pdf [access: 07.10.2022].

OACI (2019). Implementation of remote control tower (R-TWR) in Brazil. https://www.icao.int/SAM/Documents/2019-06901-SAMIG24/SAMIG24_WP6.6%20R-TWR%20BRAZIL.pdf [access: 11.10.2022].

SESAR (n.a.). Solution #52 – Remote tower for two low density aerodromes. https://www.sesarju.eu/sites/default/files/documents/solution/Sol52%201_Remote_Tower_t wo_low_density_airports_contextual_note.pdf [access: 10.09.2022].

SESAR (2020). Remotely provided air traffic service for multiple aerodromes. https://www.sesarju.eu/sites/default/files/documents/solution/Sol52%201_Remote_Tower_two_low_density_airports_contextual_note.pdf [access: 10.09.2022].

SESAR. (n.a.). SESAR and the digital transformation of Europe's Airports. https://www.sesarju.eu/sites/default/files/documents/reports/SESAR%20and%20the%20digital%20transformation%20of%20europe%20airports.pdf [access: 08.09.2022].

Shmelova T., Rizun N., Kredentsar S., Yastrub M. (2021). Enhancement of the Methodology for the Selection of the Optimal Location of the Remote Tower Centre. https://ceur-ws.org/Vol-3101/Paper25.pdf [access: 11.10.2022].

Unidad Administrativa Especial de Aeronáutica Civil. (2020). Aerodrome information & Data base. https://www.aerocivil.gov.co/atencion/estadisticas-de-las-actividades-aeronauticas/Paginas/bases-de-datos.aspx [access: 15.10.2022].

GIS Odyssey Journal

2022 • Volume 2 • Number 2

https://doi.org/10.57599/gisoj.2022.2.2.159

César Montañés Alonso[1]

STUDY OF THE LOCATION OF A HELIPORT IN CATALONIA

Abstract: The objective of this project is to identify one or several municipalities in Catalonia that, after considering the above factors, have the potential to serve as a location for a heliport. Throughout the enterprise's site selection process, ArcMap 10.8 geographic information system (GIS) technologies are employed. All of the layers of information used, the layers of analysis, and the multiple approaches used are all described. This section of the investigation closes with an examination of three potential communities for a new heliport.

Keywords: Catalonia, Heliport, ICAO: The International Civil Aviation Organization, Catalan public services, Site

Received: 6 November 2022; accepted: 3 December 2022

[1] Universidad Politécnica de Madrid, The School of Aeronautical and Space Engineering (Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio, ETSIAE), Madrid, Spain, email: cesar.montanes@gmail.com

Introduction

The helicopter serves a vital purpose. In current society, their duty is to support or enable social and economic progress. Helicopters are currently used in a wider range of situations as a result of ongoing technological and functional advancements. Helicopters are becoming increasingly popular in our culture, particularly in the fields of public service and aerial labor.

There are two trends regarding the Catalan heliport network that aim to modernize and address the needs of the different Catalan airport networks, which are the deployment of a 24-hour network and the modernization of facilities, and the modernization and renewal of the fleet of helicopters based in Catalonia.

The most important consideration is the requirement for heliports for public health, fire, security, emergency, and civil protection services. This requirement for a Catalan heliport network will be established, and it will be a problem to address because it is one of the work's objectives: the specification of the heliport to be located and the study of the heliport's location.

After the sort of heliport to be installed on the site has been selected, the indications and guidelines for the promotion of new heliports are examined. This guarantees that the qualities to be taken into account for site analysis are known.

The definition of the heliport type to be located will be addressed, a set of metrics will be defined that characterize the heliports in accordance with the standards established by the ICAO, and that will be used in subsequent sections.

This definition is important to carry out the investigation, specifically because the type of heliport to be located influences the possibility of locating it in one place compared to another.

When all the information on the type of heliport has been presented, the essential foundations will have been established to continue with the site selection study. Later, possible locations within Catalonia and under a series of parameters in which to locate the heliport will be searched, and a location that can house the heliport will be searched for.

The selection of the final site or sites for the type heliport is the main objective of this project.

Definition of heliport

The definition of the heliport to be located based on the current needs of the Catalan heliport network is as follows: “Permanent heliport of restricted use that operates 24 hours a day that serves for medical transport or emergency medical service with HEMS (Helicopter Emergency Medical Services) authorization that aims to provide urgent medical assistance. Likewise, it will provide service to search and rescue emergencies (SAR) and extinction and fight against forest fires carried out by the Fire Department of Catalonia. Also for police work by the Mossos d'Esquadra and other aerial work such as maintenance of wind farms or supervision of nature reserves”.

A permanent heliport is an aerodrome or specified area on an artificial surface or elevated structure for the arrival, departure, or surface movement of helicopters, and may include fixed buildings, equipment, and service facilities. It is essential to specify that the heliport in question will be a public heliport, not of general interest.

The Government of Catalonia, in accordance with the provisions of article 140 of the Statute of Autonomy, has exclusive jurisdiction over airports and heliports located in the territory of Catalonia that do not have the legal classification of general interest.

Consequently, it is the direct obligation of the Generalitat to create, manage and plan this type of infrastructure to meet the demands of the territory, ensure connection and contribute to the economic progress of the region.

According to the previous law, the action of the Generalitat as airport administration includes two phases in the case of heliports: a first authorization prior to the establishment of the facility, which requires the formulation of the corresponding project, and a second authorization that allows the commissioning installation operation.

The criteria for the selection of the location of the facilities

The use of helicopters for emergency services or for other purposes related to public safety will not be restricted or conditioned in any way by these requirements.

Nor do they affect commercial or private heliports that are planned to be located in rural or low-density locations and that do not entail any type of disturbance for the people who live or work in the surroundings.

Additionally, private heliports that plan to conduct fewer than 350 operations per year will not be affected in any way by this change.

On the other hand, this does not mean that any plan for the location of a new heliport is exempt from taking into account all the possible repercussions that may have an effect on the noise level or the level of safety.

Accessibility. The objective must be that the number of facilities in the general network allows 95% of the citizens of Catalonia to have the possibility of accessing a heliport in less than 20 minutes by private transport. This can be achieved by ensuring that facilities are evenly distributed across the overall network.

The roads used to enter and leave the area. During entry and exit maneuvers, residential areas and any other equipment sensitive to helicopter noise in the flight path should be avoided as much as possible.

This criterion recommends, when it is feasible to do so, anticipating entry and exit maneuvers through water (such as the ocean, swamps, rivers, etc.), as well as communication facilities (highways, railways, etc.).

The shortest possible distances between other projects and residential areas.

Although the distance does not define whether or not the activities of a given heliport would generate an auditory effect, it is convenient to think that there should be no less than 400 meters of space between a heliport and a residential block.

If the heliport is located in a residential neighborhood, this distance can be reduced to 100 meters. If it is an industrial area, this distance could be reduced to 100 meters.

These distances, which are merely indicative, could be shorter depending on the relative layout of entry and exit routes and sensitive areas, the expected frequency of use of the facility, the types of helicopters and the hours of operation. In addition, these distances could be affected by the number of opening hours of the facility.

The objective of this project is to identify one or several municipalities in Catalonia that, after considering the above factors, have the potential to serve as a location for a heliport.

However, the objective of this work is to provide the responsible authority or make way for further investigations or work that can be carried out for a deeper examination of the precise site and design of the heliport. Knowing the analysis that justifies the selection of each site and the reasons why they are clearly recommended can serve as a useful tool.

Thus, in fact, this work provides that target authority or subject for a new task, the essential tool for the decision-making process, whether it be the construction or design of a heliport on the chosen sites or a study of viability of the latter.

Methodology

It will be determined why the chosen sites are the most appropriate and advantageous, and for this a methodical process of elimination or screening will be followed with the help of the ArcGIS computer program. The objective of this effort is to determine why the chosen locations are the most appropriate and advantageous.

As a result of this decision, one or more definitive sites will have been identified which, depending on the criteria considered, would be the most suitable for the economic sustainability of the heliport.

Process to find the location

For the study of potential areas for new heliport sites, the ArcGIS ArcMap 10.8 geographic information system (GIS) tools will be used. All files were downloaded from the website of the Department of the Vice Presidency and Digital Policies and Territory: https://territori.gencat.cat/es/06_territori_i_urbanisme/observatori_territori/mapa_urbanistic_de_catalunya/serveis_web_i_dades_obertes/descarrega-de-dades/format-shapefile-shp/ . And from the website of the National Geographic Information Center: https://centrodedescargas.cnig.es/CentroDescargas/index.jsp .

Base layers

In this first point, the layers used as the basis of the study are presented. These layers serve to delimit the work area, in this case Catalonia and the division of the Catalan territory into provinces, counties and municipalities.

Fig. 1. Representation map of the Catalan territory
Source: own elaboration

Fig. 2. Representation map of the Catalan provinces
Source: own elaboration

Fig.1. Representation map of the Catalan counties
Source: own elaboration

Fig.2. Representation map of the Catalan municipalities
Source: own elaboration

Work layers

This section shows the layers with which the study will be carried out. They are layers with geographic information related to the area of Catalonia and is suitable for finding a new location for a heliport.

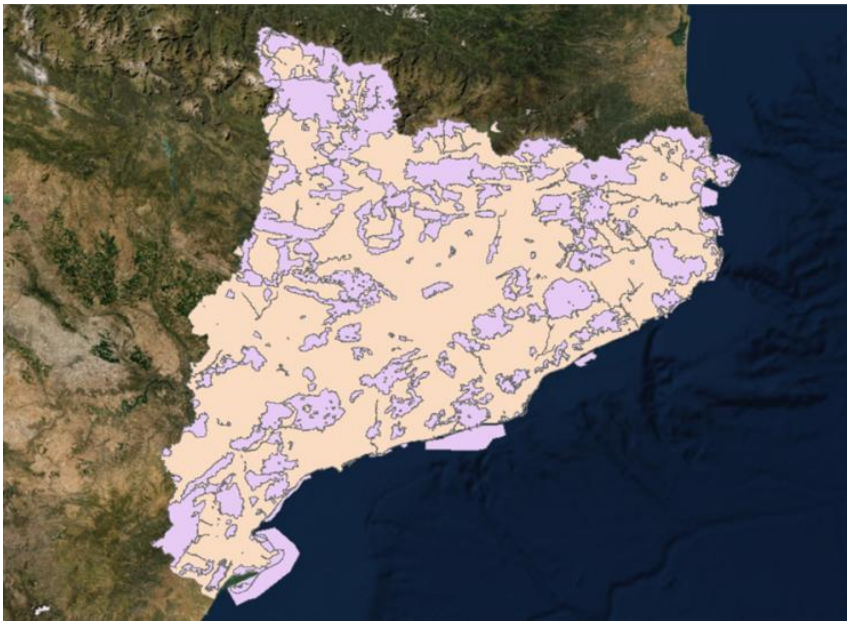


Fig. 5. Representation map of spaces of natural interest in Catalonia
Source: own elaboration

This map shows the Sistema d'Espais Naturals Protegits de Catalunya (the SENP), which is currently made up of 184 natural spaces of special ecological value protected

by the Plan for spaces of natural interest (PEIN), with an area equivalent to 32% of the Catalan territory.

Within these spaces, the so-called special protection natural spaces, declared in accordance with Law 12/1985, have a higher level of protection. They include national parks, natural parks, natural sites of national interest and nature reserves.

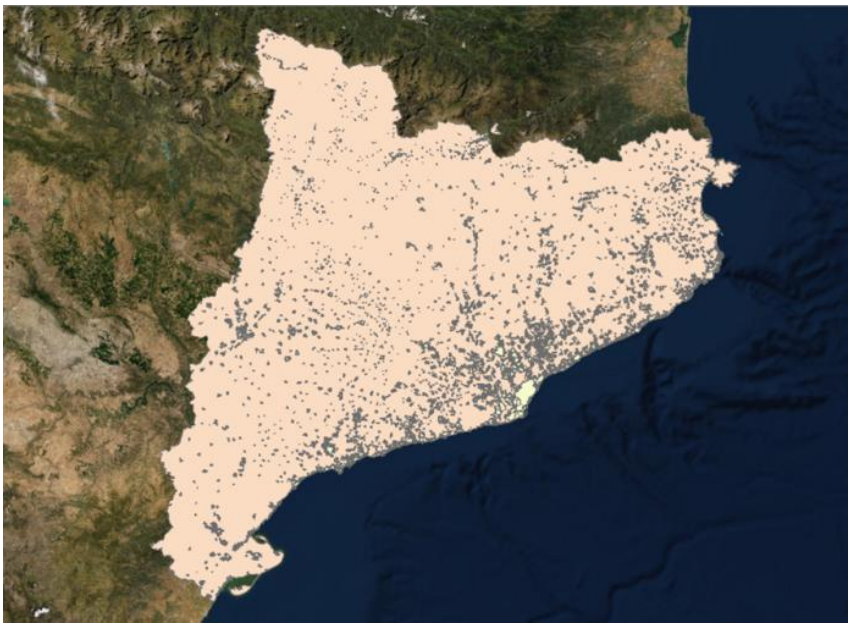


Fig. 6. Representation map of the population centers of Catalonia
Source: own elaboration

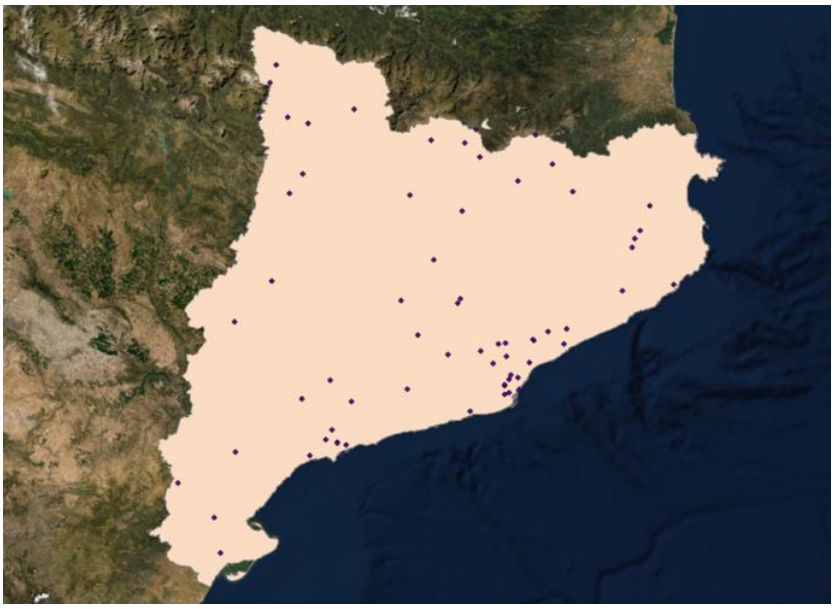


Fig.3. Representation map of the distribution of heliports in Catalonia
Source: own elaboration

For the study, 67 of the 70 Catalan heliport infrastructures will be taken into account, since the heliports of Hotel Juan Carlos I, Port Aventura and Sant Martí Sescrots, being private, are not considered a problem for the progress of the study.

Initial approaches

Once the layers with which to work have been exposed, it is time to begin the search for favorable areas for the location of our heliport. For this, certain considerations must be taken into account.

Catalonia has 7,722,037 inhabitants, according to the 2020 population census, spread over the 947 Catalan municipalities. The majority of citizens (close to 95%) are concentrated in some 300 municipalities with more than 2,000 inhabitants and are therefore considered an urban population.

Therefore, the recommendation on the location of new heliports regarding accessibility is where the objective is established that the heliport network allows 95% of Catalan citizens to have the possibility of accessing a heliport in less than 20 minutes by private transport, will be the first parameter for our study0).

For this, the municipalities with more than 2000 inhabitants will be selected, which will be called populated municipalities. And all those municipalities that contain a heliport in their vicinity will be eliminated.

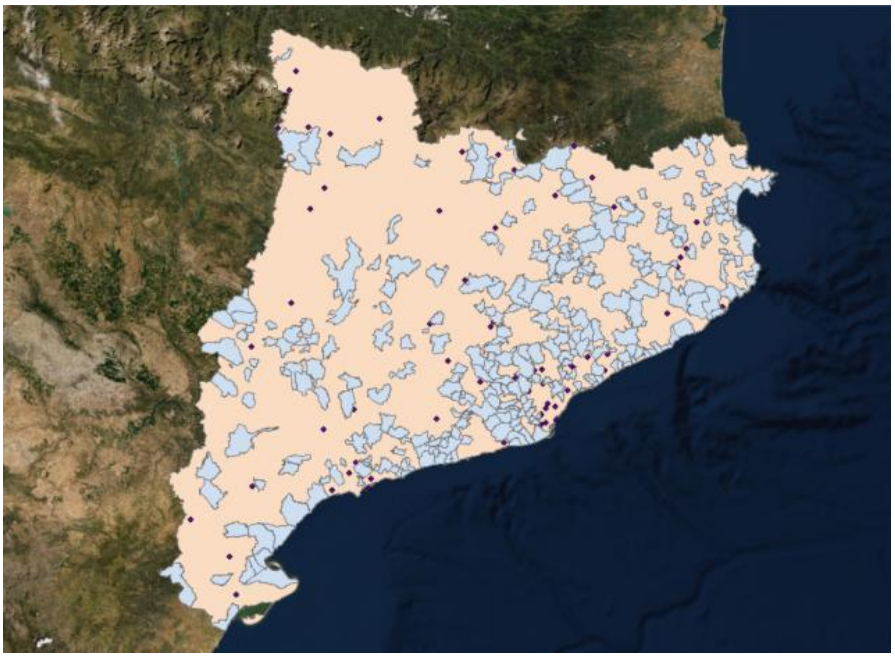


Fig.4. Map of the Catalan populated municipalities without a heliport
Source: own elaboration

The next step has been to locate the population centers of the inhabited municipalities and create an area of influence (Buffer) around them of 15 km, which is the distance that has been taken as optimal by the provisions of the recommendation of the possibility access to a heliport in less than 20 minutes by private transport.

And once the buffers have been prepared from the population centers of the populated municipalities without a heliport, all those areas of influence in which there is no heliport within them are selected.

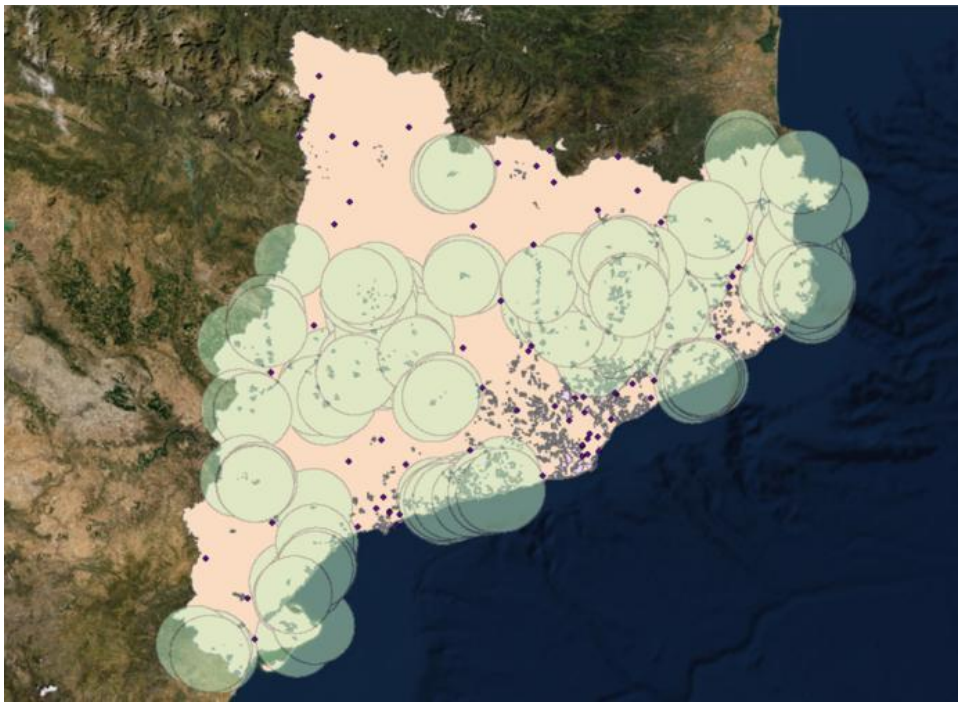


Fig.5. Map of the areas of influence of the selected municipalities
Source: own elaboration

Map with the representation of the areas of influence or buffers (green circles) of the population centers of the populated municipalities without a heliport, and that do not have any heliport within a radius of 15km.

Initial analysis

What has been obtained so far are the population centers that are found among the populated municipalities that do not contain a heliport and are more than 15 km from the nearest heliport. There are more than 300 population centers. So the next step is the analysis of the areas of influence. This will be done by counting buffer intersections, since each population nucleus generates its own buffer.

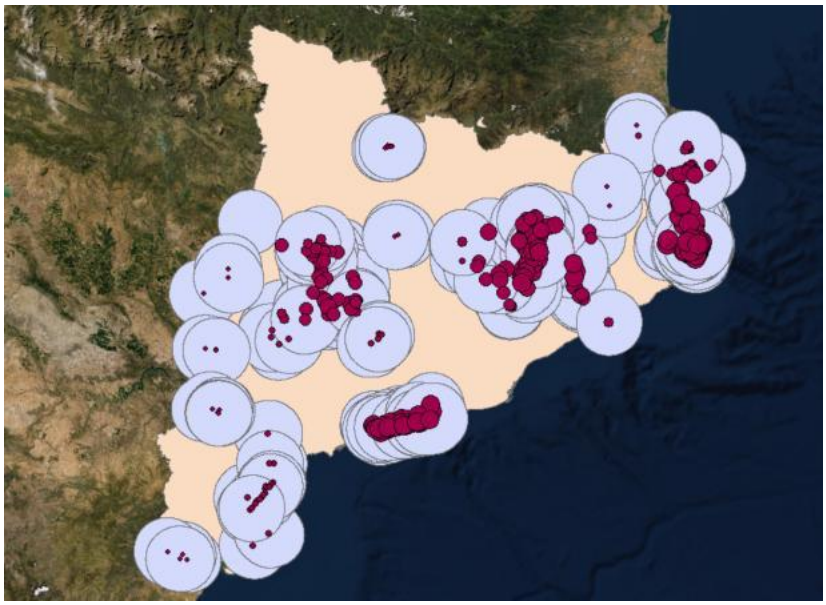


Fig.6. Density map of the areas of influence of the selected municipalities
Source: own elaboration

This map graphically represents the zones of influence explained above and the smaller maroon circles represent the number of intersections between zones of influence. The larger the garnet circle and the more garnet circles there are in the same area, it means that a large number of contiguous population centers meet the conditions stated above. We differentiate four zones that we will analyze separately:

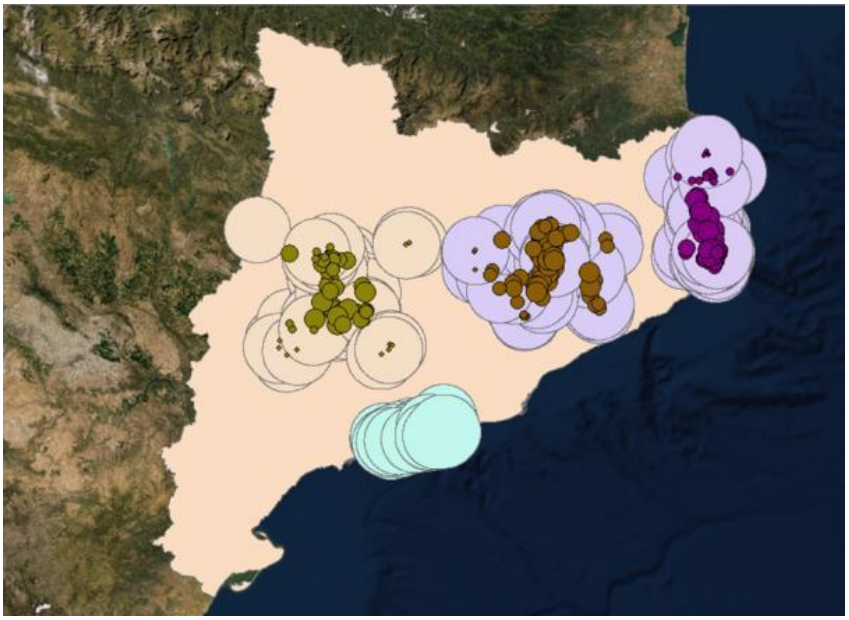


Fig. 11. Map of the 4 selected areas
Source: own elaboration

The areas to be analyzed in depth have been isolated, eliminating small population centers that were far from these areas.

The four areas demarcated by the areas of influence are going to be located according to the municipalities that are contending under these areas, to facilitate the analysis.

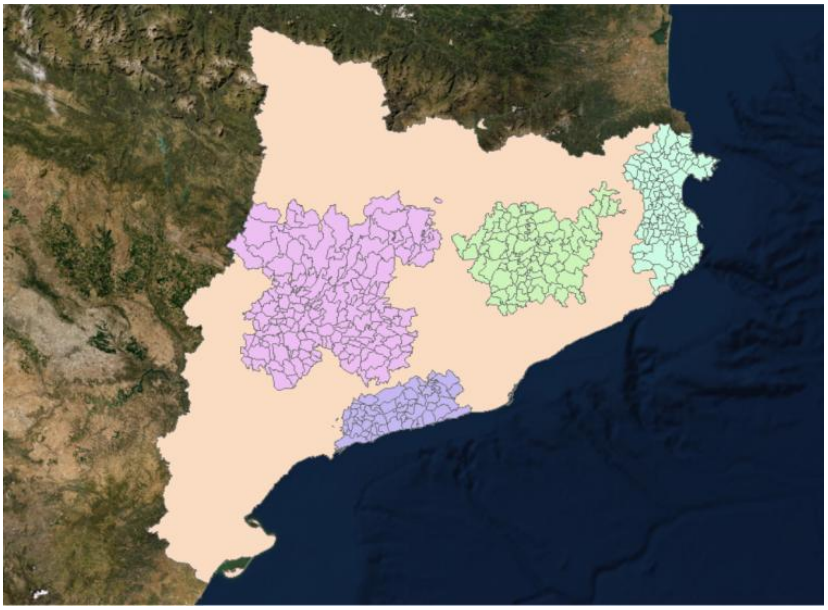


Fig. 12. Map of the representation of the municipalities of the selected areas
Source: own elaboration

The four different groups of municipalities represent the different potential areas for the location of a new heliport.

To finalize the search, the next step has been to generate areas of influence of 15km from the existing heliports and eliminate all those municipalities that were included in the areas of influence of the heliports.

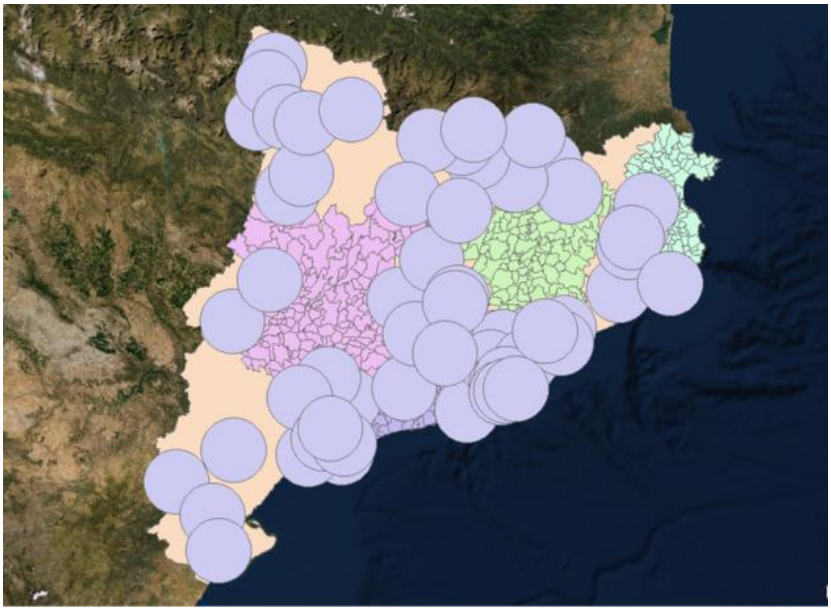


Fig. 7. Map of the representation of the selected zones and the zones of influence of the existing heliports
Source: own elaboration

As can be seen in the last illustration, the purple southern zone that had been selected for the analysis will be discarded at this time since, as we can see, most of the selected municipalities are included in the area of influence of some heliport, so we dismissed this area for the location of a new heliport.

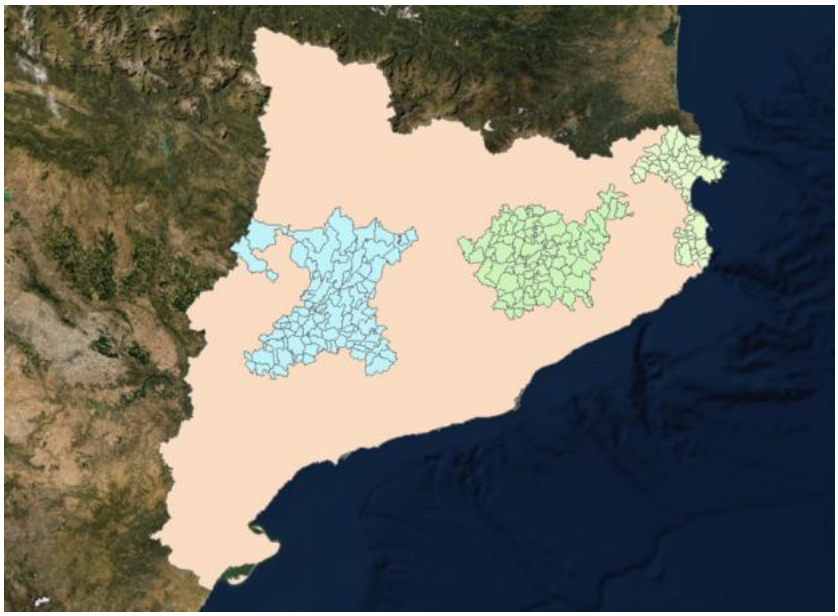


Fig. 8. Map of the final selection of the selected areas
Source: own elaboration

In this image we can see the three areas with which we will continue the analysis. The result, after applying the zones of influence of the existing heliports in Catalonia, and eliminating the set of municipalities that were to the south (purple) for reasons of size, is that of three clearly differentiated zones, zone A (blue) composed of 86 municipalities, mostly belonging to the province of Lleida, zone B (green) made up of 82 municipalities, the majority belonging to the province of Barcelona and zone C (yellow) made up of 54 municipalities, located in the province of Gerona.

In order to find an optimal location area, which in this study will be a municipality, a central municipality has been selected, which is at an average distance from the rest of the neighboring municipalities.

In addition, for the selection of the municipalities, the spaces of natural interest in Catalonia will also be taken into account, so the municipality to be chosen is a municipality that meets the characteristics and requirements that we have been explaining throughout the analysis, and that in the final approximation, it is located at a medium distance from the rest of the municipalities of the designated areas and that it is not located in its majority in any of the areas of the spaces of natural interest.

Approach and final analysis

In this final section, the candidate municipality for the location of a new heliport will be selected, as a result of the analysis carried out.

And finally, the optimal areas for locating the heliport will be marked, away from spaces of natural interest and away from population centers, at least 400 meters as indicated in the reminders for the location of new heliports.

- ZONE A:

With the above, it is concluded that the optimal municipality to establish a new heliport in the first zone is the municipality of Agramunt:

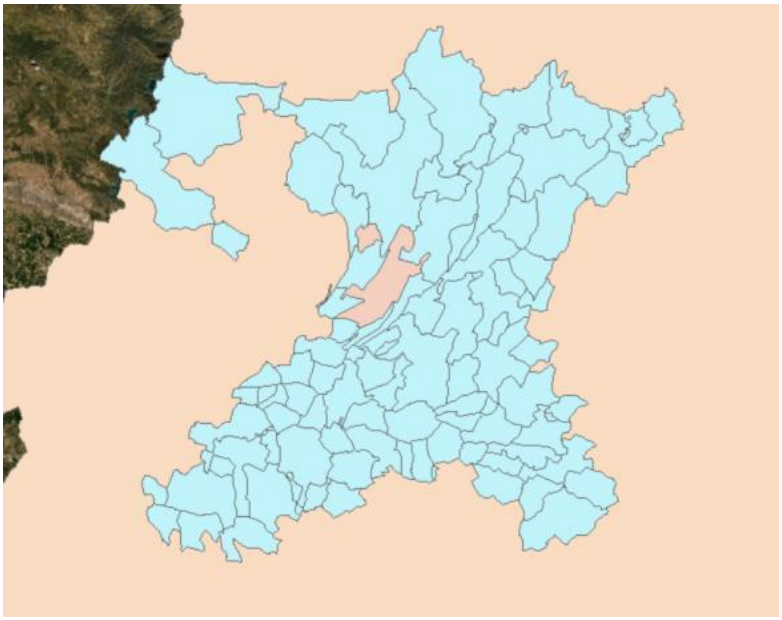


Fig. 9. Representation map of the municipality of Agramunt
Source: own elaboration

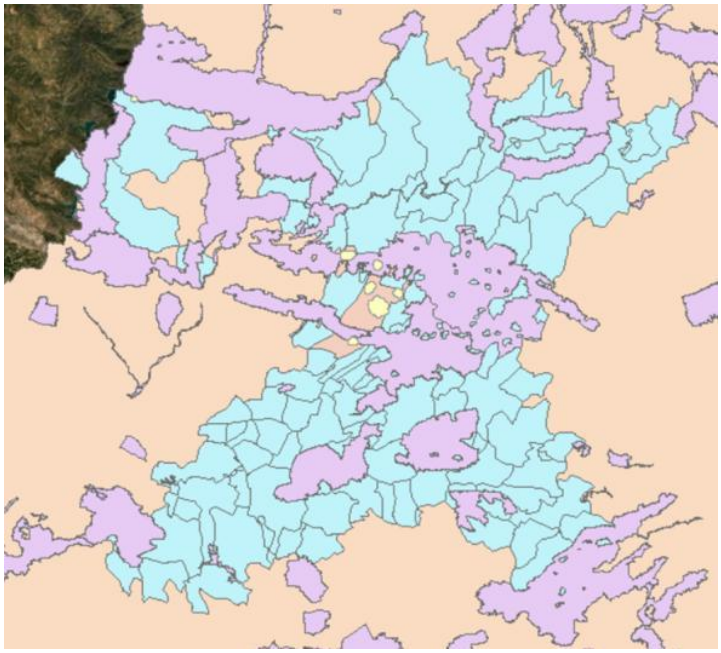


Fig. 10. Representation map of the municipality of Agramunt, the population centers and the spaces of natural interest
Source: own elaboration

This image shows the area of influence of the population centers in yellow, the spaces of general interest in pink, and the rest of the municipality of Agramunt in orange, in which it has been concluded that the location of a new heliport is of interest.

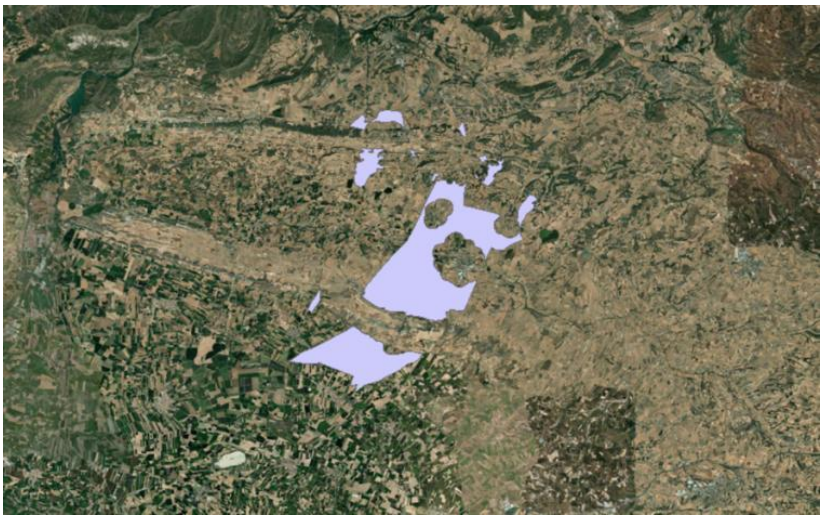


Fig. 11. Representation map of the potential areas of Agramunt for the location of the heliport
Source: own elaboration

In this last representation, the areas of the municipality of Agramunt which are of interest for the location of the heliport can be seen in purple

- ZONE B:

In the second zone, it is concluded that the optimal municipality for the location of a new heliport is the municipality of Santa Eugenia de Berga.

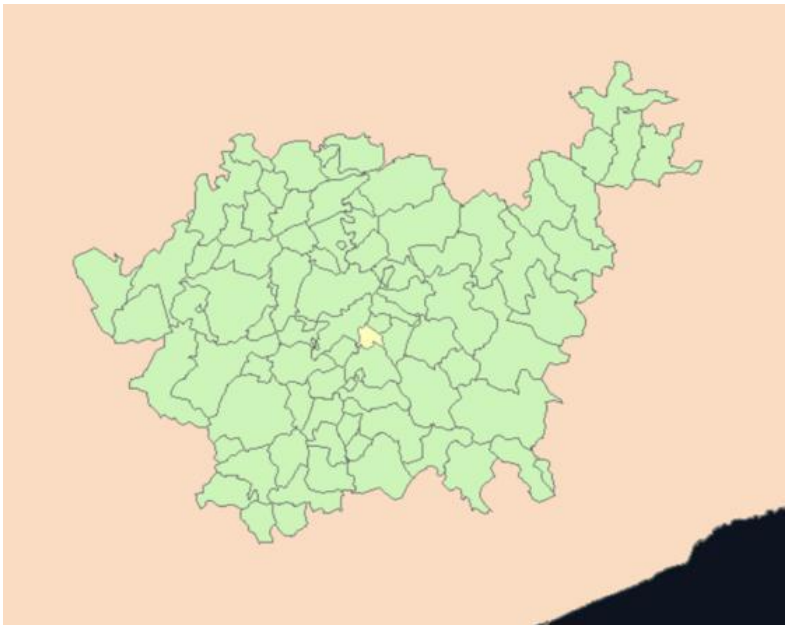


Fig. 12. Representation map of the municipality of Santa Eugenia de Berga
Source: own elaboration

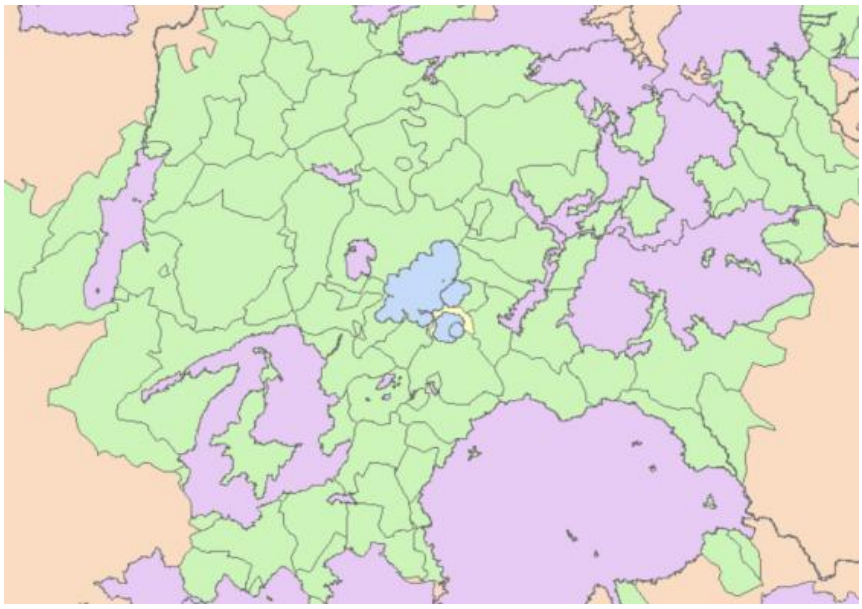


Fig. 13. Representation map of the municipality of Santa Eugenia de Berga, population centers and spaces of natural interest
Source: own elaboration

In this image it can be seen that the yellow zone is the appropriate one for the location of a new heliport, far from the zone of influence of the population centers (blue) and of the spaces of natural interest.

Fig. 14. Representation map of the potential areas of Santa Eugenia de Berga for the location of the heliport
Source: own elaboration

In this last representation, the areas of the municipality of Santa Eugenia de Berga are shown in purple, which are of interest for the location of the heliport.

- ZONE C:

In the last area of the study, it is concluded that the optimal municipality for the location of a new heliport would be the municipality of L'Escala.

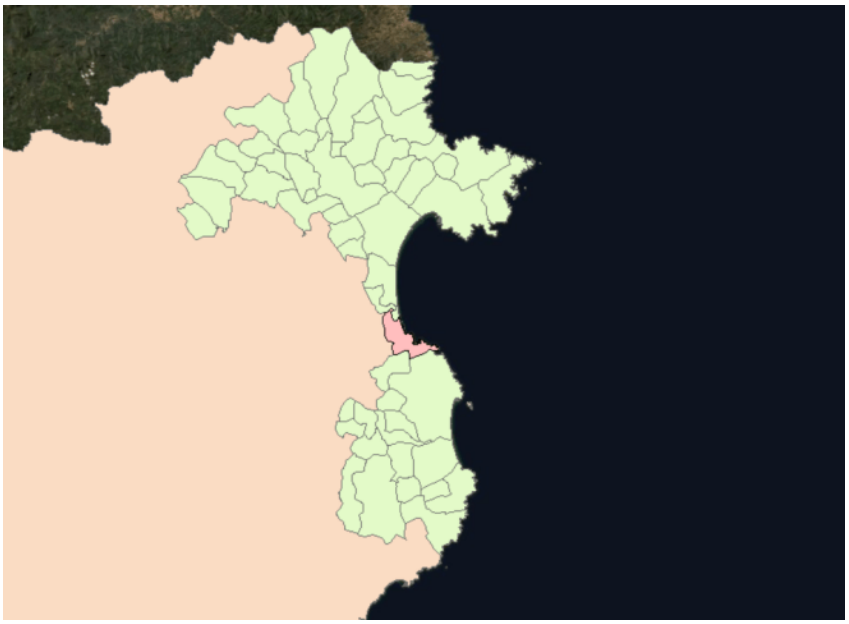


Fig. 15. Representation map of the municipality of L'Escala
Source: own elaboration

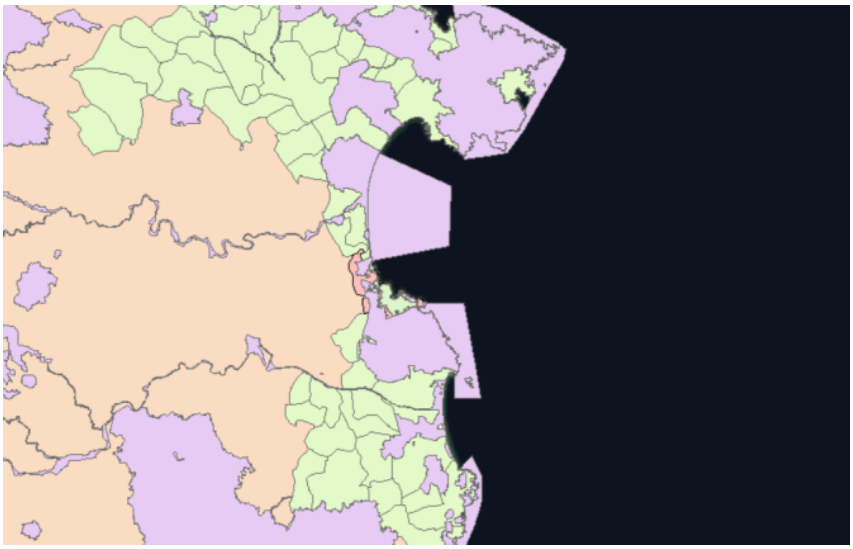


Fig. 16. Representation map of the municipality of L'Escala, population centers and spaces of natural interest
Source: own elaboration

In salmon color would be the final area for a possible location of a new heliport in Catalonia, since the rest of the municipality is under the area of influence of the population centers or in a space of natural interest.

Fig. 17. Representation map of the potential areas of L'Escala
for the location of the heliport
Source: own elaboration

In this last representation, the areas of the municipality of L'Escala are shown in purple, which are of interest for the location of the heliport.

Conclusion

With the premise of the need for a heliport oriented to Catalan public services, it was decided that a permanent heliport for restricted use 24 hours would be located to provide services to the Catalan public services.

To begin the siting study, it was considered essential to carry out the first two objectives to contextualize the reason for the siting study and the type of heliport to be sited.

The methodology used for the development of this study was the elimination or screening of less appropriate or less advantageous locations with the help of the ArcGIS computer program. And finally, after the work carried out with the program's tools, the result is 3 potential areas for the location of a new permanent restricted-use heliport to support Catalan public services.

The reason why a specific location is not offered is because it is not the objective of this work. None of the objectives of the work is the design of the heliport, so the procedures for the design of the heliport have not been carried out.

This work is understood as the study of the location of a heliport in Catalonia based on the needs of the heliport network. Serving this work as a guide for future studies in which you want to locate a heliport in the Catalan terrain. This work offers the most favorable locations according to the needs not only of Catalonia but of society.

This work opens the door to new studies by the authority or other entity for both educational or corporate purposes, in which the objective topic is provided. The tool is

supplied for the design or construction study in the chosen locations as well as the feasibility study.

References

AIP, Servicio de Información Aeronáutica de España. Procedimientos VFR en el TMA de Barcelona (*Aeronautical Information Service of Spain. VFR procedures at the Barcelona TMA*).

Casas L. (2012). Turismo en Helicóptero por los parajes más bellos de catalunya (*Helicopter tourism through the most beautiful places in Catalonia*). La Vanguardia. https://www.lavanguardia.com/local/tarragona/20120913/54350153891/turismo-helicoptero-parajes-bellos-catalunya.html [access: 31.10.2022].

Cataluña cuenta con 24 helicópteros y 10 aviones Air Tractor para la Campaña Forestal de 2022 (*Catalonia has 24 helicopters and 10 Air Tractor planes for the Forest Campaign of 2022*). Aerotendencias (2022, June 15). https://www.aerotendencias.com/aviacion-general/59115-cataluna-24-helicopteros-10-air-tractor-campana-forestal-2022/ [access: 30.10.2022].

Departamento de la Vicepresidencia y de Políticas Digitales y Territorio. Plan de aeropuertos, aeródromos y helipuertos 2009-2015 (*Department of the Vice Presidency and Digital Policies and Territory. Plan for airports, aerodromes and heliports 2009-2015*).

El Sem Renueva Su Flota e incorpora 4 helicópteros que pueden volar de noche (*The Sem Renews its fleet and incorporates 4 helicopters that can fly at night*) (2016). La Vanguardia. https://www.lavanguardia.com/vida/20161124/412137191684/el-sem-renueva-su-flota-e-incorpora-4-helicopteros-que-pueden-volar-de-noche.html [access: 31.10.2022].

El servicio de emergencias médicas de cataluña renueva con un airbus H135 El Primero de cuatro helicópteros (*The Catalan emergency medical service renews four helicopters with an Airbus H135 El Primero*). Aerotendencias (2016, November 24). https://www.aerotendencias.com/aviacion-general/36335-servicio-emergencias-medicas-cataluna-airbus-h135-primero-cuatro-helicopteros/ [access: 2.11.2022].

Figueiral J.O. (2021). La Ciudad de los helipuertos (*The city of heliports*). The New Barcelona Post. https://www.thenewbarcelonapost.com/barcelona-ciudad-con-mas-helipuertos/ [access: 25.10.2022].

Infraestructuras Aeroportuarias (*Airport Infrastructures*). Territorio. https://territori.gencat.cat/es/03_infraestructures_i_mobilitat/ports_i_aeroports/aeroports/infraestructures_aeroportuaries/ [access: 25.10.2022].

Ley 14/2009, de 22 de julio, de aeropuertos, helipuertos y otras infraestructuras aeroportuarias (*Law 14/2009, of July 22, on airports, heliports and other airport infrastructures*). Boletín Oficial del Estado.

Lleida Estrena Nou Heliport multidepartamental (*Lleida Opens New Multi-departmental Heliport*). Govern.cat. https://govern.cat/salapremsa/notes-premsa/103749/lleida-estrena-nou-heliport-multidepartamental [access: 2.11.2022].

Los Mossos d'esquadra incorporan dos Helicópteros Airbus H135 (*The Mossos d'esquadra incorporate two Airbus H135 Helicopters*). Aerotendencia. (2022, March 25). https://www.aerotendencias.com/aviacion-general/58580-los-mossos-desquadra-incorporan-dos-helicopteros-airbus-h135/ [access: 2.11.2022].

Organización de Aviación Civil Internacional (*International Civil Aviation Organization*) (2013). Helipuertos, annex 14, vol. 2. OACI.

Organización de Aviación Civil Internacional Doc. 9261: Manual de helipuertos (*International Civil Aviation Organization Doc. 9261: Heliport Manual*) (1995). OACI.

Territori I població (*Territory and population*). gencat.cat. https://web.gencat.cat/ca/temes/catalunya/coneixer/territori-poblacio/ [access: 26.10.2022].

Territorio y Sostenibilidad Presenta Las actuaciones y Mejoras de la Red de helipuertos Y aeródromos de catalunya. Aeroports de Catalunya (*Territory and Sustainability Presents the actions and improvements of the network of heliports and aerodromes in Catalonia. Airports of Catalonia*). https://aeroports.gencat.cat/es/actualitat/noticia/Territori-i-Sostenibilitat-presenta-les-actuacions-i-millores-de-la-xarxa-dheliports-i-aerodroms-de-Catalunya [access:24.10.2022].

Territoris.cat, A. C. N. Lleida és on l'helicòpter Nocturn del Sem Ha Fet més serveis. Territoris.cat. https://www.territoris.cat/articulo/societat/lleida-es-on-lhelicopter-nocturn-sem-ha-fet-mes-serveis/20190716222658058032.html [access: 23.10.2022].

Unitat de Mitjans aeris. SEM. https://sem.gencat.cat/ca/emergencies-mediques/serveis/serveis-especialitzats/unitat-mitjans-aeris/ [access: 27.10.2022].

Vilaller reclama "celeritat" al govern per a poder acollir vols nocturns d'emergències. Lleida.com. (2022, February 23). https://www.lleida.com/noticia canal/vilaller-reclama-celeritat-al-govern-poder-acollir-vols-nocturns-demergencies [access: 24.10.2022].