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CONTENT/SADRŽAJ

A Message from the Editor-in-Chief

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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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Information on the journal in English and Serbian can be found at the journal web page: https://sjem.fim.edu.rs/index.php/sjem.

Prof. Dr. Vladimir Tomašević, FRSA

Reč urednika

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.

Informacije o časopisu i poziv za autore, na srpskom i engleskom jeziku, nalaze se na web stranici časopisa: https://sjem.fim.edu.rs/index.php/sjem.

Prof. dr Vladimir Tomašević, FRSA

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Reciklaža i valorizacija tekstilnog otpada

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Apstrakt: Tekstilna industrija značajno doprinosi ekološkim izazovima , vođena prekomernom potrošnjom, brzom modom i oslanjanjem na neodržive materijale. Tekstil je četvrta roba koja ima uticaj na životnu sredinu, sa značajnim posledicama, uključujući iscrpljivanje resursa, emisije gasova staklene bašte i zagađenje, dodatno opterećeno dugim periodom raspada sintetičkih materijala i oslobađanjem mikroplastike. Napori za ublažavanje ovih pitanja uključuju propise EU koji promovišu recikliranje i principe cirkularne ekonomije. Metode reciklaže, kao što su: mehaničke, hemijske, biološke i hibridne, igraju ključnu ulogu u valorizovanju tekstilnog otpada u proizvode visoke vrednosti, kao što su geotekstili, kompoziti, izolacioni materijali i biogoriva. Ovi procesi, ne samo da smanjuju količine stvorenog otpada, već nude i ekološke prednosti, kao što su ušteda energije i smanjene emisije. Uprkos njihovom potencijalu, prepreke kao što su složena struktura otpada, neadekvatna infrastruktura, ekonomski izazovi i nedosledni propisi, ometaju široko usvajanje. Održiva tranzicija zahteva koordinisane napore u svim industrijama, kreatorima politike i potrošačima. Naglasak na inovacijama u tehnologijama recikliranja, biorazgradivim materijalima i energetski efikasnoj proizvodnji, može pojačati uticaj valorizovanih materijala, čineći kružne tekstilne sisteme izvodljivijim. Svest potrošača i odgovorna potrošnja dodatno jačaju ovu promenu. Rešavanje ovih izazova je od vitalnog značaja za smanjenje otpada, očuvanje resursa i unapređenje održive budućnosti za modnu i tekstilnu industriju.

Ključne reči: Tekstilni otpad, Reciklaža tekstila, tekstilne valorizacione tehnologije, Održiva praksa, Valorizovani materijali

Recycling and valorisation of textile waste

Abstract: The textile industry is a major contributor to environmental challenges, driven by overconsumption, fast fashion, and reliance on non-sustainable materials. Textiles are the fourth most environmentally impactful commodity, with significant consequences including resource depletion, greenhouse gas emissions, and pollution, worsened by synthetic materials' slow decomposition and microplastic release. Efforts to mitigate these issues include EU regulations promoting recycling and circular economy strategies. Recycling methods, such as: mechanical, chemical, biological, and hybrid, play a key role by valorizing textile waste into high-value products such as geotextiles, composites, insulation materials, and biofuels. These processes not only reduce waste but also offer environmental benefits like energy conservation and reduced emissions. Despite their potential, barriers such as waste complexity, inadequate infrastructure, economic challenges, and inconsistent regulations hinder widespread adoption. A sustainable transition requires coordinated efforts across industries, policymakers, and consumers. Emphasizing innovation in recycling technologies, biodegradable materials, and energy-efficient production can amplify the impact of valorized materials, making circular textile systems more feasible. Consumer awareness and responsible consumption further strengthen this shift. Addressing these challenges is vital for reducing waste, conserving resources, and advancing a sustainable future for the fashion and textile industry.

Keywords: Textile Waste, Textile Recycling, Textile ValorisationTechnology, Sustainable Practices, Valorised Materials

1. Introduction

Over the course of the last century, clothing has been elevated beyond its basic function, acquiring greater emotional, psychological, cultural and societal significance.

However, this shift in value, combined with the onset of the“Petrochemical Era” in the 1950s, has resulted in overconsumption of clothing, much of it composed of non-sustainable materials. Due to its association with fashion and economic status, the apparel industry has made a significant contribution to the volume and rate of waste generation (Navone et al., 2020).This includes the excessive use of finite fossil-based resources and energy. Textiles are the fourth most environmentally significant commodity globally, with textile waste i.e. the material discarded throughout the textile production process, causing considerable environmental, climate, and social impacts from a resource and waste perspective (European Environment Agency, 2024). According to the European Environment Agency (EEA) report, textiles accounted for 16.7 million tonnes of waste in 2018, making it the fourth largest waste stream in the EU by weight. The EEA predicts a 63% increase in clothing consumption, from 62 million tonnes in 2019 to 102 million tonnes in 2030 (Stefan et al., 2022). To limit the environmental impact of textile waste, the European Union has implemented several key regulations and directives aimed at promoting sustainability. The Waste Framework Directive (Directive 2008/98/EC, 2008) mandates that EU member states collect textiles separately by 2025, ensuring that materials are diverted from landfills and facilitating recycling and reuse. Additionally, the EU's Circular Economy Action Plan, part of the European Green Deal, outlines measures to reduce waste generation, improve resource efficiency, and promote circular strategies in various industries, including textiles. These initiatives are designed to reduce the environmental footprint of textiles throughout their lifecycle, from production to disposal, fostering a more sustainable and circular economy.

Textile waste includes a variety of materials such as fibres, fabrics, garments, and textile products that are no longer required for their original purpose and can occur at different stages of the textile supply chain. Based on composition, origin and characteristics, waste can be classified as natural fibres (cotton, wool, silk), synthetic fibres (polyester, nylon, acrylic), blended fibres, and textile products with complex structures or treatments like laminates, coated fabrics, and composite materials (Shirvanimoghaddam et al., 2020). The composition of textile waste produced globally in 2018 was estimated at 64% synthetic or originating from petrochemicals in general, and 36% natural fibres divided as follows: 24% cotton, 6% cellulosic, 1% wool and other natural fibres. Total weight was estimated at 105 million tonnes (Stone et al., 2020). Natural materials are more environmentally friendly than synthetic fibres, which are made from non-sustainable petrochemical-based products and require significant amounts of energy to produce (Payne, 2015). Therefore, managing the textile industry and its waste is crucial for reducing environmental impact, conserving resources, and promoting sustainable practices throughout the textile lifecycle (Bianco et al., 2023).

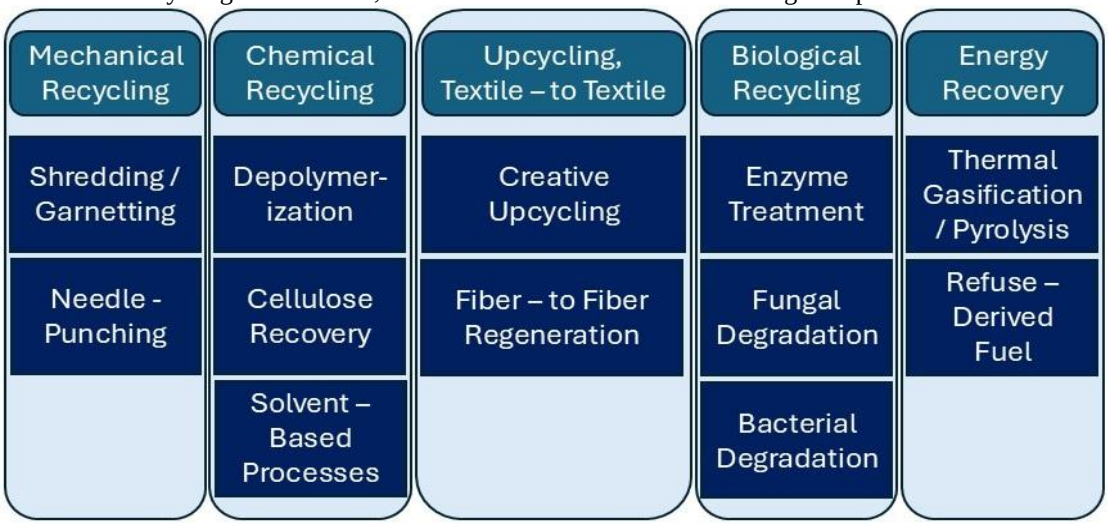
2. Recycling

Factors such as economic development, textile consumption patterns, and waste management infrastructure can influence waste generation rates and management practices. Common collection streams may include household or municipal solid waste collection, commercial or industrial collection, event-based collection initiatives, charitable organisations, textile collection bins, textile sorting facilities, textile recycling centers and landfill disposal. Landfill disposal is generally considered the least desirable option for textile waste management due to its negative impact on the environment, loss of resources, and contribution to landfill capacity issues (Mishra et al., 2022; Islam et al., 2019). However, in certain cases, landfill disposal may be necessary for certain types of textile waste that are not economically or technically feasible to recycle or recover. Effective collection streams and deposition methods for textile waste require coordination and collaboration among stakeholders, including waste management authorities, recycling companies, businesses, non-profit organisations, and consumers.

The most common methods for recycling textile waste include mechanical recycling, chemical recycling, upcycling, textile-to-textile recycling, energy recovery and hybrid recycling (Pensupaet al., 2017). Upcycling and textile-to-textile recycling involve repurposing and transforming the textile respectively, to new products of equal or higher value. Mechanical and chemical recycling break the textile down to fibres or its chemical constituents and reuses the recovered material, while hybrid recycling combines both methods. When textile waste cannot be recycled into new textile products, it can be used as a fuel source for energy recovery through incineration or combustion processes. Biological recycling is also a method that is gaining attention recently, as it is a sustainable solution depending on biotechnology, that could play a transformative role in textile waste management, especially for blended fabrics, natural fibers, and low-energy systems. Further categorization of the technologies employed can be seen in Table 1.

Innovative approaches are employed to develop a more sustainable, cheap and efficient process to address textile waste in the fashion and textile industries. Converting waste into value-added products is essential to reducing environmental pollution and thereby achieving a circular economy through proper waste management practices (Singhal et al., 2023; Lu et al., 2022; Mishra et al., 2022).

Table 1. Further categorization of the technologies used in the different recycling categories. Hybrid recycling is not shown, as it combines methods from the categories presented.



3. Life Cycle Assessment and Valorisation

The environmental impact of a product from its production until its elimination (cradle to grave) is evaluated in a Life cycle assessment (LCA). A comprehensive LCA can be complex due to the variety of materials and methods involved in the manufacturing and recycling processes. Regarding textile waste recycling and valorisation, key aspects that are evaluated in LCA are the recycling technologies mentioned above, in comparison to virgin textile production. Mechanical recycling is assessed to have reduced energy consumption compared to virgin textile production. Chemical recycling can potentially lower the emissions generated through the process, while upcycling and donation extends the lifecycle of textiles, reducing the need for new materials and the volume of textile waste produced.

Finally, incineration of textile waste can provide energy recovery in comparison to landfill disposal.Valorisation of textile waste involves finding innovative ways to repurpose textile waste into valuable products and may include fibre recycling, combined with the recycling technologies mentioned above, or upcycling techniques such as cutting, stitching, quilting, and embellishing pieces of textile into new products with added value.This exploitation not only facilitates the environmental benefits mentioned above, but also has social benefits, by creating economic opportunities and support local communities through job creation, skills training, and social inclusion programs, particularly in regions with strong textile manufacturing traditions.

Table 2. Products originating from textile waste.

Waste Used	**Method**	**Product**	**Reference**
Synthetic	Mechanical (Needle -punching)	Geotextiles	Leon et al. 2016
Blended	Mechanical (Shredding)	Textile fiber – reinforced composites for insulation, acoustic panels, or construction materials	Echeverria et al. 2019, Hassanin et al. 2018, Jin et al. 2025
Leather	Mechanical (Shredding, Mixing)	Leather-rubber composites for use in apparel and shoes	Barrera Torres et al. 2025
Sludge	Hybrid	No-slumpconcretemixtures	Fernandes et al. 2025
Blended (Polyester – Cotton)	Hybrid	Antibacterial and UV protected textiles	Darwesh et al. 2024

Salt-rich Wastewater	Chemical	Skin/hide preservation in the leather industry	Ramesh et al. 2024
Blended (Cotton-Spandex)	Chemical (Solvent – Based Processes)	UV-blocking cellulose/graphene films and transparent polyurethane (PU) film	Xia et al. 2025
Natural	Biological (Biodegradation)	Compost, soil enrichment	Subramanian et al. 2020, Selvam et al. 2019
Wastewater	Biological (Bacterial Degradation)	Treatedwater for irrigation	Sen et al. 2019, Pazdzior et al. 2019
Blended	Biological (Fungal Degradation)	Synthetic fibers for re-processing and re-use, increased landfill space	Freemanetal. 2024
Blended	Biological (Fungal Degradation / Bioremediation)	TW was used as substrate for edible fungi cultivation	Hazelgrove&Moody, 2024
Synthetic (Viscoze)	Carbonization	Absorbents of pesticides in water	Tasić et al. 2025
Sludge and Tannery Fleshing	Energy Recovery (Co-hydrous Pyrolysis)	Energy recovery (biocrude, biochar, syngas)	Hossain et al. 2024

Table 2., shows several examples of products manufactured from textile waste, while Table 3., shows resources recovered from it with potential to use in products.

Table 3. Raw materials originating from textile waste

TW Used	**Method**	**Derived Material**	**References**
Blended	Mechanical	Raw materials for spinning into yarns and fabrics	Raiskio et al. 2025
Blended	Hybrid (Shredding, Calcination, Hydrothermal)	δ-MnO_2/C photothermal catalyst with high activity to remove indoor CH_2O	Wang et al. 2025
Synthetic (Polyester)	Hybrid (Milling, Enzymatic Hydrolysis)	PET of reduced crystallinity, terephthalic acid (TPA) for industrial applications	Zhou et al. 2025
Cellulose-rich	Chemical(CatalyticHydrothermalConversion)	Levulinic acid (solvents, fuel and oil additives, plasticizers, and pharmaceuticals)	Ozsel 2021
Cellulose-rich	Chemical (HydrothermalHydrolysis)	Hydrogengas	Ozsel 2021
Synthetic (Coloured Polyester)	Chemical (Aminolysis/ Glycolysis)	bis(2-hydroxyethyl) terephthalamide (BHETA) and bis(2-hydroxyethyl) terephthalate (BHET)	Anbarasu et al. 2024
Synthetic	Chemical (Ionic Liquid-assisted Regeneration)	Transparent renewable jute film (degradable packaging, electrically conductive films)	Zhong et al. 2021

Blended (PET and Wool)	Biological (Enzymatic Hydrolysis)	Pure polyester fibers and amino acids (feedstock material)	Mihalyi et al. 2025, Boschmeier et al. 2024
Blended Synthetic (Viscose and Polyamide)	Biological(EnzymaticHydrolysis)	Polyamide fibers, Polyhydroxybutyrate (PHB) and Bacterial cellulose (BC) (Glucose utilisation)	Mihalyi et al. 2024
Synthetic (Viscose)	Biological(EnzymaticHydrolysis)	D - Lactic acid (Glucose utilisation)	Campos et al. 2024
Non-recyclable	Energy Recovery (Pyrolysis / Gasification / Anaerobic Degradation)	Biofuel (biogas, biodiesel, ethanol, biochar)	Juanga-Labayen et al. 2022, Wojnowska-Baryła et al. 2022, Serrano et al., 2025
NaturalFiber	Energy Recovery (EnzymaticHydrolysis)	Succinic acid (feedstock material, food additive)	Li et al. 2019
Synthetic	Energy Recovery (Catalytic Pyrolysis)	Syngas and CH_4	Kwon et al. 2021

4. Challenges

The valorisation of textile waste presents a promising opportunity to reduce environmental pollution and foster a circular economy. However, several challenges impede the widespread adoption of these practices. One key challenge is the complexity of textile waste streams, which are composed of various materials, fibres, dyes, finishes, and contaminants, making them difficult to sort and process efficiently (Mishra et al., 2022). The diverse nature of textile waste requires specialised handling techniques for different materials, further complicating recycling efforts. Additionally, many regions suffer from a lack of proper infrastructure for waste collection, sorting, and recycling, limiting the capacity to process textile waste and often resulting in reliance on landfills or incineration (Stefan et al., 2021).

Economic viability is another significant hurdle to the effective valorisation of textile waste. The cost of collecting, sorting, and processing waste can often outweigh the value of the recycled materials, making the economic feasibility of textile recycling challenging (Mishra et al., 2022). This issue is compounded by the low consumer demand for recycled textile products and limited awareness of the environmental benefits of sustainable alternatives. Moreover, textile waste is often contaminated with dirt, oil, chemicals, and other impurities, which can degrade the quality of recycled materials, necessitating additional processing steps or purification to meet market standards (Kim et al., 2021). Furthermore, although promising, current recycling technologies such as fibre-to-fibre and chemical recycling remain in the early stages of development, and their scalability and cost-effectiveness need further improvement (Stanescu et al., 2021).

Finally, regulatory and policy barriers are a significant obstacle to the growth of textile waste valorisation efforts. Inconsistent regulations and a lack of supportive policies across regions hinder investment and innovation in the recycling sector (Pensupa et al., 2017). The absence of extended producer responsibility (EPR) schemes and clear waste management regulations impedes the adoption of circular economy principles within the textile industry. Additionally, the culture of fast fashion, characterised by low-cost, disposable clothing, continues to contribute significantly to textile waste generation, complicating efforts to reduce waste and promote recycling (Stanescu et al., 2021).

To overcome these challenges, collaboration among stakeholders, investment in research and development, and the implementation of supportive policies are crucial steps in advancing textile waste valorisation and enabling the transition to a circular economy.

5. Environmental sustainability

The production of synthetic polymers has significant negative environmental impacts. These materials contribute to pollution through the emission of greenhouse gases, the creation of microplastics, and the release of toxic chemicals such as dyes and chemical reagents. Similarly, the production of natural polymers, such as cellulose and protein fibres, used in clothing manufacture can harm the environment. Soil pollution results from the use of pesticides and fertilisers, while large volumes of water are consumed for irrigation in the production of natural fibre-based clothing (Stefan et al., 2022).

To mitigate these issues, it is crucial to identify hotspots within the life cycle of textile products where targeted actions can reduce their overall environmental impact. A cradle-to-grave analysis of textile products, considering type, composition and intended use, can provide valuable insights.

While significant attention has been given to the production and disposal phases, the distribution and consumption phases remain underexplored. Emerging consumption patterns, such as sharing and renting platforms, highlight the need for comprehensive data collection to assess their environmental performance.

Although circular practices have shown potential environmental benefits, further research is required to evaluate potential impact shifts between different life cycle phases. Additionally, there is a notable lack of studies comparing fibre types, ownership models, manufacturing processes, and disposal methods for the same functional unit. Such data would be essential for designing low-impact textile products. Despite growing awareness, the environmental implications of these factors remain under-researched among academics and practitioners in the textile industry (Amicarelli et al., 2022). Nevertheless, current evidence suggests that the production and use phases are the primary contributors to negative environmental impacts, whereas the end-of-life phase generally has a minor impact (Stanescu et al., 2021).

The environmental sustainability of textile waste valorisation depends on the adoption of environmentally friendly technologies, the implementation of sustainable waste management practices, and the integration of circular economy principles into textile production and consumption processes. Key considerations for improving sustainability include resource conservation, waste reduction, energy and emissions reduction, water conservation, and pollution prevention. By prioritising efficiency and adopting a life cycle approach, stakeholders can enhance the environmental sustainability of textile waste valorisation initiatives and contribute to a more sustainable and circular textile industry.

6. Fashion industry

The global fashion industry, currently valued at over $1.5 trillion, is as destructive as it is lucrative, leaving behind vast amounts of textile waste. Up to 80 billion new garments are produced annually, and as much as 92 million tonnes of clothing end up in landfills each year, most of itderiving from synthetic materials (Chen et al., 2021).This waste is driven by the rise of fast fashion, characterised by its rapid production cycles and disposable nature. The fast fashion industry can have significant environmental impacts, such as increased greenhouse gas emissions, water usage, and waste generation. Additionally, the low prices associated with fast fashion brands can lead to exploitative labour practices in garment factories.

The environmental consequences of synthetic textiles are staggering. Each wash of synthetic garments releases tiny plastic microfibres into waterways, contributing up to 500,000 tonnes of microfibres to the ocean every year (Boucher & Friot, 2017).

Consumers play a pivotal role in driving fast fashion. Demand for cheap clothing has led to global clothing production doubling between 2000 and 2015. On average, each individual uses 11.4 kilograms of clothing annually, producing the equivalent of 442 kilograms of CO_2 emissions per capita (Svensson, 2020). Today's consumption patterns are unsustainable: people buy 60% more clothing than they did 15 years ago yet wear each item 50% less frequently. At this rate, global clothing sales are projected to reach 160 million tonnes by 2050 (Andreadakis& Owusu – Wiredu, 2023).

Despite the daunting statistics, solutions exist to mitigate the environmental impact of fashion waste. As consumers, our purchasing habits directly influence the industry, and by adopting sustainable practices, we can drive the transition towards a circular and eco-friendly fashion system. Many brands are also innovating with recycled materials, creating clothing from post-consumer textile waste, discarded plastic bottles, or nylon fishing nets (Leonas, 2017). Supporting brands that specialise in upcycled garments or use organic fibres, which are biodegradable and require fewer resources to produce, fosters sustainable practices within the industry.

Additionally, the fashion industry is increasingly adopting environmentally friendly production methods, such as waterless dyeing techniques, carbon-neutral factories powered by renewable energy, and efficient waste-reduction practices (Mahmud & Kaiser, 2020; Xu et al., 2023), all of which help reduce the environmental footprint of textile manufacturing. Ultimately, raising awareness of the environmental impacts of fashion can inspire change, and by prioritising lifecycle thinking and making mindful choices, consumers can encourage the industry to adopt more sustainable practices.

The transition to a sustainable textile industry requires collective action from consumers, brands, and policymakers. Through resource conservation, waste reduction, and innovative production methods, we can reduce the environmental burden of fashion waste and pave the way for a more circular and sustainable future.

7. Conclusions

The production of textiles demands significant resources, including water, energy, and raw materials, which are often wasted when clothing is discarded instead of being reused or recycled. Discarded textiles take up considerable space in landfills and contribute to greenhouse gas emissions as they decompose. Many of today's textiles are made from synthetic fibres that can take hundreds of years to break down, releasing harmful chemicals into the environment during this process. The increase in textile consumption has led to a corresponding rise in post-consumer waste, exacerbating environmental challenges. The fast fashion cycle, characterised by cheaper textiles with shorter lifespans, has significantly contributed to the growing issue of textile waste. To address this, a shift towards upcycling textile waste has emerged, helping to recover materials and energy consumed during production and reducing the carbon and water footprints of these products. The transition from a linear economy, which dominates the textile industry, to a circular economy has become essential, driven by the scarcity of raw materials and fossil fuels, as well as the severe environmental impacts of waste disposal. As the fashion industry is responsible for a significant amount of waste and pollution, there are now more responsible options for consumers to make choices that align with environmental sustainability. By choosing sustainable brands and adopting more mindful purchasing practices, individuals can contribute to reducing the fashion industry's environmental footprint. Ultimately, the valorisation of textile waste offers substantial environmental benefits, including resource conservation, waste reduction, and the promotion of social opportunities through job creation and community support. While challenges remain in areas such as bioremediation and textile effluent treatment, innovations in technologies like enzymatic hydrolysis and membrane bioreactors show promise in improving textile waste management. By adopting comprehensive waste management strategies, encouraging recycling and reuse initiatives, and raising awareness about the need for change, we can collectively mitigate the environmental impact of textile waste and work towards a more sustainable approach to textile consumption and disposal.

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Proizvodnja briketa od otpadne biomase putem veziva od otpadne biomase

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Apstrakt: U mnogim delovima zemalja u razvoju, korišćenje drveta, kao izvora energije, postaje oskudan resurs. S obzirom na ovo, neophodan je razvoj zamenskog goriva za drveni ugalj. Zgušnjavanje otpadne biomase u brikete od biomase, može da obezbedi alternativno čvrsto gorivo za domaćinstvo, posebno u ruralnim oblastima Etiopije. Ova studija ima za cilj da ispita fizičko-hemijske osobine i kalorijske vrednosti briketa, proizvedenih od otpada biomase drvenog uglja od pirinčane ljuske, koristeći skrob ekstrahovan iz otpadnih plodova jezgra avokada i jezgra manga. Otpadna pirinčana ljuska, sakupljena je iz ruralnih područja severozapadnog Tigraja, dok su otpadni plodovi jezgra manga i zrna avokada, sakupljeni iz grada Mekele. Pirinčana ljuska je karbonizovana u zatvorenoj peći za sagorevanje, a zatim zdrobljena do veličine oko 1 mm u prečniku, da bi se formirao fini prah drvenog uglja. Sitni ugalj je pomešan sa vezivnim sredstvom za skrob, ekstrahovan iz zrna manga i avokada, da bi se formirao potreban briket. Količina skroba, ekstrahovanog iz jezgra avokada je bila 25%, a odnos skroba, ekstrahovanog iz jezgre manga je bio 18%. Grejna vrednost briketa, proizvedenih samo od pirinčanog drvenog uglja u prahu, bila je manja od briketa, formiranih kombinacijom uglja u prahu pirinčane ljuske sa vezivnim sredstvom za skrob, ekstrahovano iz jezgra manga i plodova zrna avokada.

Ključne reči: otpadna biomasa, ekstrakcija skroba, pirinčana ljuska, izvor energije, formiranje briketa

Production of Briquette from Biomass wastes via biomass waste binders

Abstract: In many parts of developing countries, using wood as a source of energy is becoming a scarce resource. Given this, the development of a substitute fuel for wood charcoal is necessary. Densifying waste biomass into biomass briquettes can provide an alternative household solid fuel, especially in rural areas of Ethiopia. This study seeks to investigate the physicochemical properties and calorific values of briquettes produced from biomass wastes of rice husk charcoal using starch extracted from waste fruits of avocado kernel and mango kernel. Waste rice husk was collected from rural areas of North West Tigray whereas the waste fruits of mango kernel and avocado kernel were collected from Mekelle city. The rice husk was carbonized in a closed burning furnace and then crushed to around 1 mm in diameter size to form charcoal fine powder. The charcoal fine was mixed with starch binders extracted from the mango and avocado kernels to form the required briquette. The amount of starch ratio extracted from the avocado kernel was 25 % and the starch ratio extracted from the mango kernel was 18%. The heating value of briquettes produced from rice husk charcoal powder alone was less than briquettes formed by combinations of rice husk powder charcoal with starch binders extracted from mango kernel and avocado kernel fruits.

Keywords: biomass waste, starch extraction, rice husk, energy source, briquette formation

1. Introduction

Briquette is a block of compressed materials suitable for burning. Briquettes can be made from low-cost materials such as old newspapers, and agricultural residues wastes. Briquettes can be used as fuel instead of charcoal and firewood (Kumar, Kumar et al. 2015).

Biomass densification, which is also known as briquetting of solid wastes and agricultural residues has been practiced for many years in several countries. Briquette is a type of clean coal that can help to prevent flooding and serve as a global warming countermeasure by conserving forestry resources through the provision of a stable supply of briquettes as a substitute for charcoal and firewood (Espinoza-Tellez, Montes et al. 2020). As fuel, charcoal briquettes have a higher heating value than wood or plain charcoal. They are almost smokeless when burning and give off intense and steady heat (Erol, Haykiri-Acma et al. 2010). They can be used in the smelting of iron ore since it is compact and dense.Aside from their use as fuel, charcoal briquettes can be converted to other industrial products. In the chemical industry, they are used in the manufacture of carbon disulfide, carbon electrodes, carbon tetrachloride, carbon carbide, sodium cyanide and activated charcoal for purifying air or water.

The Quality of briquette is highly dependent on the source of materials used to make and the operational technologies (Ahiduzzaman and Islam 2016). Briquettes are environmentally friendly renewable sources of energy. It has cleaner and lower emissions of carbon dioxide (CO_2) and other environmental pollutants than charcoal when burning. The other important aspect is it helps solid waste management by converting into fuel sources. Briquettes produced from biomass wastes are fairly good substitute for coal, lignite, and firewood. It can offer numerous advantages; Briquettes are cheaper than coal, oil or lignite, there is no sulfur in briquettes**,** there is no fly ash when burning briquettes**,** briquettes are clean to handle & can be packed in bags for ease of handling & storage. Newspaper, woodchips, rice husks, coffee husks, coir pith, jute sticks, bagasse, groundnut shells, mustard stalks, cotton stalks, sawdust are some of the waste resource use to make briquettes (Sanchez, Aspe et al. 2022). Production of fuel briquettes involves the collection and compaction of a combination of combustible waste materials that are not directly usable because of their low density and processing them into a solid fuel product of any convenient shape that can be burned like wood or charcoal.

Briquetting of biomass improves the handling characteristics of the materials during transportation as well as the storing process. This technology can help in expanding the use of biomass in energy production, since densification improves the volumetric calorific value of a fuel, reduces the cost of transport and can help in improving the fuel situation in rural areas (Vivek, Rochak et al. 2019). Briquetting is one of several agglomeration techniques which are broadly characterized as densification technologies. Agglomeration of residues was done to make them denser for their use in energy production. A briquette made from rice husk is a desirable fuel because it produces a hot, long-lasting and virtually smokeless fire. Successful briquette operations and formations are found mostly in developed countries. However, briquetting operations are not successful in developing countries like Ethiopia and other African countries (Shahapur, Desai et al. 2017). This is mostly due to the high cost of production, lack of awareness of its sustainability, availability of market and poor packaging and distribution systems for the product.

Although the importance of biomass briquettes as substitute fuel for wood, coal and lignite is well recognized, the numerous failures of briquetting machines in almost all developing countries have inhibited their extensive exploitation. Briquetting technology is yet a challenging in many developing countries because of the technical constraints involved and the lack of knowledge to adapt the technology to suit local conditions (Islam, Hossain et al. 2014). Overcoming operational problems and ensuring the quality of the raw material used are crucial factors in determining commercial success for this sector.

Mangoes and avocadoes are among the common fruits commonly consumed by many people in Ethiopia inraw form as well as in juice form. During theprocessing and raw consumption of the seeds, products like the kernel and cover parts are simply disposed of into the environment as garbage. In Ethiopia, rice husks are disposed as a waste without utilizing or dried and burnt which gives very little energy and results into air pollution (Chukwuneke, Umeji et al. 2020). However, the declining fuel wood and charcoal sources and rising prices of electricity, kerosene and LPG cooking gas call for seeking alternative energy sources for both domestic and industrial use (Medashe and Abolarin 2012).

The objective of the study was to investigate the calorific values (heating values) of briquettes formed from biomass wastes and analysis ofbinder performancefor briquette formations by extracting from biomass wastes. In addition to that the purpose of the study was to analyze, the effect of binder to carbonized charcoal ratios on quality of briquettes,and the effect of binder composition on the calorific values based on the waste material used.

2. Materials And Methods

2.1 Study Area

Mekelle is the capital city of Tigray regional state of the federal democratic republic of Ethiopia. According to the Geological Survey of Ethiopia, it is located around 783 kilometers north of the capital city of Ethiopia (Addis Ababa). Administratively, Mekelle is considered as a special Zone, which is divided into seven sub-cities. Mekelle is the economic, cultural, and political hub of northern Ethiopia.According to (Macro 2006) national census report Mekelle City has a total population of 215,914 of which104,925 are male and 110,989 are female. It is found at a coordinate of 39^{o}28' E and 13^{o}29'N at an average altitude of about 2,254 meters above sea level.

2.2 Collection and Preparation of Samples

Raw materials necessary for the production of Bio-Briquette were collected from Mekelle city and rural areas near Mekelle city.Rice husk was collected from farmers around Mekelle city; the wastes of mango kernel and avocado kernel were collected from juice houses within Mekelle city. Metal, plastic and fiber containers have been usedfor handling, sorting and storage of solid waste materials. Plastic containers were used for holding up the components that have substantial moisture content (for example, food waste), to avoid absorption of moisture. The moisture content of rice husk was reduced with open-air sun drying for one day. After drying in the open air, the size was reduced to less than 1 mm by using an electrical jaw crusher. After ground to powder form size analysis of the powder was conductedusing a sieve machine to find uniformity and required size of the powder. It is very important to make a uniform size to bind charcoal fine powder easily with binders.

2.3 Binder Extraction from Biomass Wastes

The extraction procedure of binders from the mango kernel and avocado kernel is described in Figure 1. Following the principles stated by (Syahariza, Li et al. 2010) first, the dirty particles were removed from the kernels of both mango and avocadoand then peeled out the outer covers before cutting for further process since this part doesn't have any starch content. It is stated in Figure 2a, how the kernels were manually peeled using by hand. Then based to processes explained by (Li, Tian et al. 2022) kernels were soaked by a bowl containing water as stated in Figure 2b. Soaking with water was important for kernels to be moister and could be easily milled by the cutter mill. The kernel is milled using a cutter mixer at a rotation of 1500 rpm for one minute as explained by (Syahariza, Li et al. 2010). The crushed kernel has been collected and made ready for extraction by using water and sieve cloth. After the extraction process, the fruitwater separation was done. Finally, the starch and fruit water are separated by using decantation, next to decantation drying using open sun was conducted. The dried binder for mango kernel was packed in plastic back temporally until for further use as shown in Figure 3c**.** By the same process for avocado binder, it was packed in plastic back temporally until for further use as shown in Figure 3d.

Figure 1: Flow sheet for extraction of starch from mango kernel

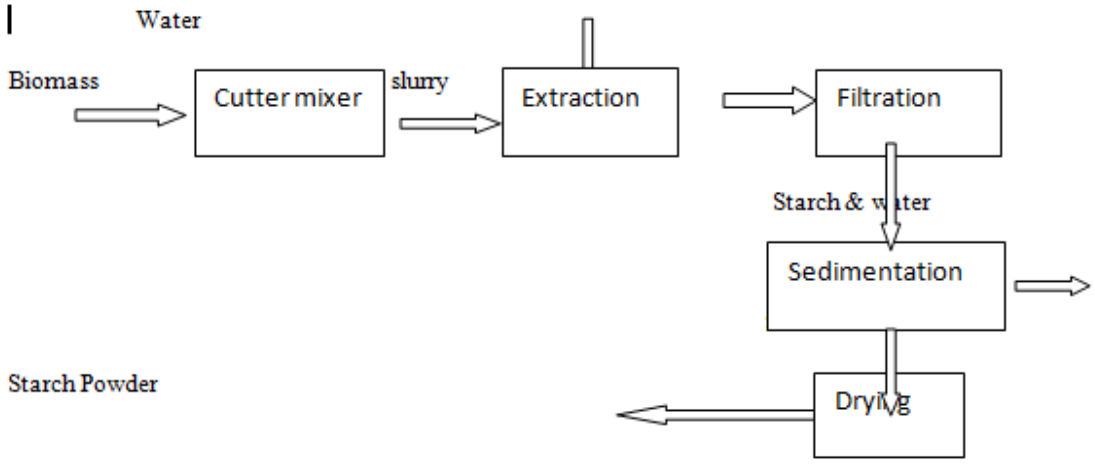

Figure 2: a. Manual Washing and Peeling of the kernels, b. Soaking Process of the kernels

Figure 3: c. Dried and packed AvocadoStarch, d. Dried and packed Mango Starch (powder)

2.4 Preparation of Rice Husk Fine Charcoal

Collected rice husk from the rural areas was first partially burned in an environment where fresh air was controlled. The process is known as charring or carbonization (Onukak, Mohammed-Dabo et al. 2017). The advantage of carbonization is for getting smokeless when the briquette is formed which is considered as key for household users. For carbonization of the rice husk, it was burned in a closed furnace for three days in the absence of oxygen (O_2) (Nuriana and Anisa 2014). After the rice husk was carbonized, the materials were then compacted using a press machine. Then the size was reduced with a crusher to get fine and uniform charcoal.

2.5 Briquette Formation

The charcoal finesprepared from rice husk weremixed with gelatinized starch binders extracted from the mango and avocado kernels. An appropriate mixing using double-shaft mixer was done. A proper mixing was very mandatory and critical to obtain mechanically strong and high-quality product (Sengar, Mohod et al. 2012). Following procedures stated by (Zhang, Sun et al. 2018), after thorough mixing of charcoal fines and the binders, mixtures were fed into the molds where pressure is applied to make the particles compact. The size and shape of the briquettes were shaped with the molds.

After a thorough mixing of charcoal fines and the binders, mixture was fed into molds where pressure was applied to make the particles compact (Ferronato, Mendoza et al. 2022). The size and shape of the briquettes were determined based on the molds. Then briquettes were dried with sunlight in the open air before it was packed to make them strong.

The binder mixing combination proportions used were; avocado starch with rice husk charcoal fine and mango starch with rice husk charcoal. Considering different reviews (Drobikova, Vallova et al. 2018, Obi, Pecenka et al. 2022) different proportional ratios were used by weighing the charcoal fines of rice husk with corresponding binders using a digital weighing scale. The mixture of charcoal fine and binder proportions used to produce the briquettes with desired qualities is summarized in Table 1.

Table 1: Ratio of the Rice husk charcoal fine: avocado/mango kernel powder

S/N^{O}	Ratio of Rice husk: avocado/mango kernel powder
1	100:00
2	90:15
3	75:20
5	75:25

2.6 Proximate Properties of the Formed Briquettes

Moisture content: Using the standard method of (García, Pizarro et al. 2013), the moisture content (MC) of the biomass waste has been determined by heating a known weight of waste in drying equipment. The moisture content of the sample was extracted by laboratory dry oven, without damaging the components of the samples. Samples were dried to constant mass in an oven dryer at 105 ± 5°C and reweighted after moisture was removed.

Density: The density of the briquette was calculated from the ratio of the mass to the volume of the briquette by referring to principles stated in (Jittabut 2015). Mass was obtained by weighing the briquette on the digital weighing scale. The volumes of the briquettes were determined considering the formula of a cylinder by direct measurement of the diameter and height of the briquettes while subtracting the holes of the briquettes (Karunanithy, Wang et al. 2012). To quantity the value it is based on equation 1 statedbelow.

$$\rho = \frac{M}{V} \quad (1)$$

Where; ρ =density (kg/m^3); M=mass (kg); V=volume (m^3) =π (D^2 –nd$^{2)}$* H/4, (where D is diameter of the briquette, H= is height of the briquette d is diameter of the hole and n = is number of holes in a briquette)

Calorific value:The gross calorific value of the produced bio briquettes was determined with the guidance of (Özyuğuran and Yaman 2017). The equipment used to determine the calorific value wasthe oxygen bomb calorimeter. Approximately 2 g of developed briquette fractionwas burnt in the bomb calorimeter until complete combustion was obtained. The difference between themaximum and minimum temperatures obtained was used to compute the gross calorific values of the biomass materials as shown in equation 2.

$$Q = \frac{(Cwater + Ccal)\,(T2 - T1)}{Wf} \quad (2)$$

Where; Q = Calorific value ofthe material (KJ/kg); W_f = Weight of the biomass material (kg); C_{cal} = Heat capacity of the bomb calorimeter (kJ/kg ^oC); $T_2 - T_1$ = Rise in temperature (^oC); C_{water}= Heat capacity of water (kJ/kg^oC)

Ash content: The ash content of the formed briquette was estimated bythe principles stated(Parikh, Channiwala et al. 2007).Insertingthe briquette in a muffle furnace for ignition set at 550 ^oC for some duration of time until the briquette is completely converted to ash and will be calculated as follows:

$$\text{Ash Content (\%)} = \frac{Weight\ of\ Ash}{Initial\ \ weight} * 100 \quad (3)$$

3. Results and Discussion

3.1 Starch content of the binders

Amountby mass weight for each wasted avocado kernel and mango kernel was prepared. The process of extracting the starch from the raw fruits wasexplained in section 2.3. After extraction, the separation of the extracted starch from water and other impurities was done. Finally, the starch and water were separated by using decantation and drying was conducted using open air using sun light. The amount of starch extracted from each raw kernel is depicted in Table 2. The percentage of extracted starch from the raw kernels can be determinedusing the formula explained in Equation 4.

Table 2: Amount of starch obtained in dry basis

Biomass used	**Wet weight of bio mass used (gram)**	**Starch in dry weight (gram)**
Mango kernel	1567.16	174.14
Avocado kernel	5447.3	274.01

$$\text{Starch ratio} = \frac{\text{weight of starch in dry basis}}{\text{dry weight of the biomass used}} * 100\% \quad (4)$$

Starchratio for mango kernel= $\frac{174.14}{579.7}$*100%

Starch ratioof mango kernel= 30.04%

Starchratio of avocado kernel= $\frac{274}{1716}$ * 100%

=15.96%

3.2 Moisture content of binding powders

Analysis of samples for determining the moisture content is as shown in equation 5. The difference in mass before and after the drying process is used to calculate the total solids and the moisture content. After drying samples wereweighed again and MC was calculated using the equation below:

$$MC = \frac{w-d}{w} * 100 \quad (5)$$

Where; w= initial weight of binding starch, d = weight of starch after drying

The result of the moisture content of the extracted powders of the mango kernel and avocado kernel is presented in Table 3

Table 3: Analysis of moisture content of samples

Samples used	Wet weight (gm)	Dry weight of sample (gm)	Percentage of Moisture content (MC %)
Mango kernel	35.04	12.96	63
Avocado kernel	86.16	27.15	68.5

3.3 Proximate Properties of Formed Briquette

Table 1 show that the moisture content of bio briquettes was found to be in the range of 4.42 to 8.14%. The lowest moisture content was found at 4.42 % for rice husk: mango starch binder (75:25). The maximum moisture content was found 8.14% for rice husk: mango starch (100:0). The moisture content of briquette fuels has been decreased when the content of the rice husk has increased.

Density: The physical properties of formed briquettes including the density, is as observed in Table 4. The maximum bulk density was found to be 545.7 kg/m^3. The maximum density value of the formed briquette was, with the proportion of rice husk: mango starch (75:25). The lowest bulk density was found to be 459.5Kg/m^{3}and this was at the proportion of rice husk: mango starch (100:00).

The density of briquette fuels is increasing with the increase of the binder proportions in both Mango and Avocado starches.

Table 4: Physical properties of formulated briquettes

Rice husk: Avocado kernel combinations	**Height*Diameter (cm*cm)**	**Diameter of holes (cm)**	**Weight (g)**	Volume (cm^3)	**Density (kg/m^3)**
100:00	7*12	1.5	306.8	667.64	459.5
85:15	7.5*12	1.5	332.5	715.33	464.8
80:20	6.5*12	1.5	290	619.95	467.5
75:25	6.8*12	1.5	309	648.5	476.5
Rice husk : Mango kernel combination					
100:00	6*10	1.3	200	407.32	491.4
85:15	5.8*10	1.3	205	393.74	520.3
80:20	5.3*10	1.3	192	359.8	533
75:25	5*10	1.3	185	339.43	545.7

Ash content: The ash content of the formed briquette was as depicted in **Table 5**. The result showed that the ash content of briquettes decreased with an increase in the percentage composition of binders. Hence binder composition has a great role in the ignition efficiency of briquettes.

Calorific value: Table5 below shows the proximate values of the briquette product including the calorific values. The calorific value of formed briquettewas found to be in the range of 12.9 to 15.3MJ/kg. The maximum calorific value was found 15.3 MJ/kg in the ratio of rice husk: mango kernel (75:25) combination.The lowest calorific value was found to be 12.9 MJ/kg in combinations of rice husk and Avocadokernel (100:0) ratio.The calorific value was decreased as the percentage composition of binding powder decreased. This may be due to the blending of biomass and the addition of valuable components which are combustible substances that contribute to the total heat value released (Sharma, Das et al. 2002).

Table 5: proximate properties of formedbriquettes

Rice husk: Avocado kernel combinations	**M.C (%)**	**Ash (%)**	**Calorific (KJ/Kg)**
100:00	11.1	20.3	12,924.00
85:15	11.4	19.4	13,326.00
80:20	11.9	18.9	14,725.00
75:25	12.3	17.8	15,002.00
Rice husk: Mango kernel combination			
100:00	11.8	19.1	13,520.00
85:15	12.2	18.6	14,237.00
80:20	12.5	17.5	15,102.00
75:25	12.7	^{17}.2	15,321.00

4. Conclusion

Recycling biomass wastes into fuel briquettes contributes to solving societies' needs by generating income, providing a new and cheap alternative source of energy, avoiding excess waste disposal of solid waste to the environment. Renewable fuel briquettes are environmentally friendly alternative fuel sources replacing expensive and depleting fuel sources including firewood, coal, liquid propane gas and kerosene. The research output indicates that briquettes formed from rice husk binding with biomass wastes such as mango kernel and avocado kernel increased the quality of heating value. The calorific value of briquettes formed from rice husk alone is less than briquettes formed by combinations of rice husk powder with starch binders extracted from mango kernel and avocado kernel fruits.

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Upravljanje i bezbednost u savremenim organizacionim sistemima – strategije, izazovi i tehnološka rešenja

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Abstrakt: Upravljanje i bezbednost predstavljaju osnovne stubove održivog razvoja za savremene organizacije. U radu se analiziraju ključni aspekti upravljanja bezbednosnim rizicima i primena savremenih tehnologija za zaštitu poslovnih procesa i podataka . Posebna pažnja posvećena je implementaciji integrisanih sistema upravljanja (IMS), analizi rizika i Internetu stvari (IoT) u unapređenju bezbednosnih protokola. U radu se takođe istražuje uloga ljudskog faktora u bezbednosti, značaj kontinuirane edukacije zaposlenih i razvoj strategija kriznog upravljanja . Kroz studije slučaja predstavljene su najbolje prakse iz različitih industrija , naglašavajući važnost proaktivnog pristupa i usvajanja inovativnih rešenja. Zaključak daje preporuke za unapređenje sistema upravljanja i bezbednosti, sa posebnim fokusom na buduće trendove i izazove u digitalnoj eri.

Ključne reči: Menadžment, bezbednost, analiza rizika, veštačka inteligencija, blockchain, IoT, integrisani sistemi, edukacija zaposlenih, upravljanje krizama.

Management and security in modern organizational systems – strategies, challenges, and technological solutions

Abstract: Management and security represent the fundamental pillars of sustainable development for modern organizations. This paper analyzes key aspects of security risk management and the application of modern technologies to protect business processes and data. Special attention is given to the implementation of integrated management systems (IMS), risk analysis, and the Internet of Things (IoT) in enhancing security protocols. The paper also explores the role of the human factor in security, the importance of continuous employee education, and the development of crisis management strategies. Through case studies, best practices from various industries are presented, highlighting the importance of a proactive approach and adopting innovative solutions. The conclusion provides recommendations for improving management and security systems, with a particular focus on future trends and challenges in the digital era.

Keywords: Management, security, risk analysis, artificial intelligence, blockchain, IoT, integrated systems, employee education, crisis management.

1. CONCEPT OF MANAGEMENT AND SECURITY

Management

Management is a key process in every organization, encompassing planning, organizing, leading, and controlling resources to achieve defined objectives (Drucker, 2020). The primary goal of management is to ensure the efficient use of resources—human, financial, material, and informational—to gain a competitive advantage and achieve long-term development.

According to Kotler and Keller (2022), management is a decision-making process involving strategic and operational planning, goal setting, resource allocation, performance monitoring, and evaluation. Modern management is characterized by a high degree of dynamism, the need for rapid adaptation to changes, and continuous learning.

Functions of management (Fayol, 2019):

- **Planning:** Defining goals and strategies for their achievement. Planning can be short-term, medium-term, or long-term.
- **Organizing:** Creating an organizational structure and allocating resources necessary to achieve goals.
- **Leading:** Involves motivating, communicating, and leading teams to achieve desired results.
- **Controlling:** Monitoring activities, measuring performance, and taking corrective actions when necessary.

Security

Security comprises a set of measures and activities aimed at protecting people, data, infrastructure, and business processes from various threats (ISO 27001, 2022). In modern business environments, security is not only a technical aspect but a strategic priority that requires a holistic approach and integration of various protection systems. Security can be classified into three key areas:

Physical security

Physical security encompasses measures to protect facilities, people, and assets from unauthorized access, theft, vandalism, and natural disasters (Smith, 2020). According to NIST standards (2021), key elements of physical security include:

- **Access control:** Use of access cards, biometric systems, and video surveillance.
- **Perimeter protection:** Physical barriers, security gates, and fences.
- **Alarm systems:** Detection of unauthorized access and rapid incident response.

Information security

Information security refers to the protection of data and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction (ISO 27001, 2022). Information security encompasses:

- **Confidentiality:** Ensuring that information is accessible only to authorized individuals.
- **Integrity:** Maintaining the accuracy and completeness of information.
- **Availability:** Ensuring that information and systems are accessible when needed.

According to Whitman&Mattord (2020), information security measures include data encryption, regular backups, antivirus programs, and network protection through firewalls.

Operational Security

Operational security involves protecting business processes, procedures, and systems that enable organizational continuity (Davenport, 2021). The key components of operational security are:

- **Incident Management:** Rapid response to security incidents and conducting forensic analysis.
- **Business Continuity Planning (BCP):** Preparing the organization to maintain operations during and after crises.
- **Disaster Recovery Planning (DRP):** Defining procedures to restore systems to normal operation after disruptions.

Integration of management and security

The modern approach implies that management and security are interrelated processes. Security is a critical component of corporate management, directly impacting asset protection, customer trust, and business continuity (Kotler & Keller, 2022). Integrated management systems (IMS), which combine quality standards (ISO 9001), environmental protection (ISO 14001), and information security (ISO 27001), enable companies to manage risks systematically and improve security practices.

2. PRINCIPLES OF SECURITY MANAGEMENT

Integrated management system (IMS):

Security management represents a systematic approach to identifying, assessing, and controlling risks to protect people, assets, and business processes. Modern principles of security management rely on the application of international standards, systematic risk analysis, and continuous improvement of security practices (ISO 31000, 2022). The following section elaborates on the key principles of security management, with a particular focus on the Integrated Management System (IMS) and risk analysis.

The Integrated Management System (IMS) combines various management standards into a unified framework, enabling organizations to simultaneously meet requirements for quality, environmental protection, and information security. IMS not only simplifies processes but also enhances efficiency through integrated risk management (ISO, 2021).

IMS standards:

According to the International Organization for Standardization (ISO, 2022), the key standards that constitute IMS are:

- **ISO 9001 – Quality management system:** Focuses on customer satisfaction and continuous process improvement (Kotler & Keller, 2022).
- **ISO 14001 – Environmental management system:** Aims to reduce the negative environmental impact of business operations (Smith, 2021).
- **ISO 27001 – Information security management system:** Establishes standards for data protection and management of information security risks (Whitman &Mattord, 2020).

IMS Risk analysis formula (Integrated risk assessment formula – IRAF):

To ensure integrated risk management across all IMS aspects (ISO 9001, ISO 14001, ISO 27001), it is essential to develop a formula that combines key indicators of quality, environmental risks, and information security threats. The following is an innovative formula for IMS risk analysis (IRAF):

IRAF formula (integrated risk assessment formula):

$$\mathbf{IRAF} = \left(\mathbf{R_q} + \mathbf{W_q}\right) + \left(\mathbf{R_e} + \mathbf{W_e}\right) + \left(\mathbf{R_i} + \mathbf{W_i}\right)$$

Where:

- RQ– Risk related to quality (ISO 9001)
- RE– Risk related to environmental protection (ISO 14001)
- RI– Risk related to information security (ISO 27001)
- WQ– Quality risk weighting factor (impact on business operations)
- WE – Environmental risk weighting factor (impact on the environment)
- WI – Information security risk weighting factor (impact on data security)

Explanation of the formula:

- Each risk (RQ,RE,RI) is calculated as:

R=P×S×D

- P (Probability) – Likelihood of the risk occurring (scale 1 to 5)
- S (Severity) – Impact of the risk on the organization (scale 1 to 5)
- D (Detectability) – Likelihood that the risk will be detected before causing harm (scale 1 to 5)
- The weighting factors (WQ,WE,WI) represent the importance of each IMS component to the organization. These factors should sum to 1:

$$\mathbf{W_q} + \mathbf{W_e} + \mathbf{W_i} = \mathbf{1}$$

Example of IMS risk analysis (IRAF):

For a company implementing IMS, risk values and weights are:

- **Quality risk (W_q):**P=4,S=3,D=4⇒RQ=48
- **Environmental risk (W_e):** P=3,S=5,D=3⇒RE=45
- **Information security risk (W_i):** P=5,S=4,D=2⇒RI=40

For a company implementing IMS, risk values and weights are:

Weighting factors:

- WQ=0.4 (40%) – Emphasis on quality (ISO 9001)
- WE=0.3 (30%) – Environmental protection (ISO 14001)
- WI=0.3 (30%) – Information security (ISO 27001)

Applying the formula:

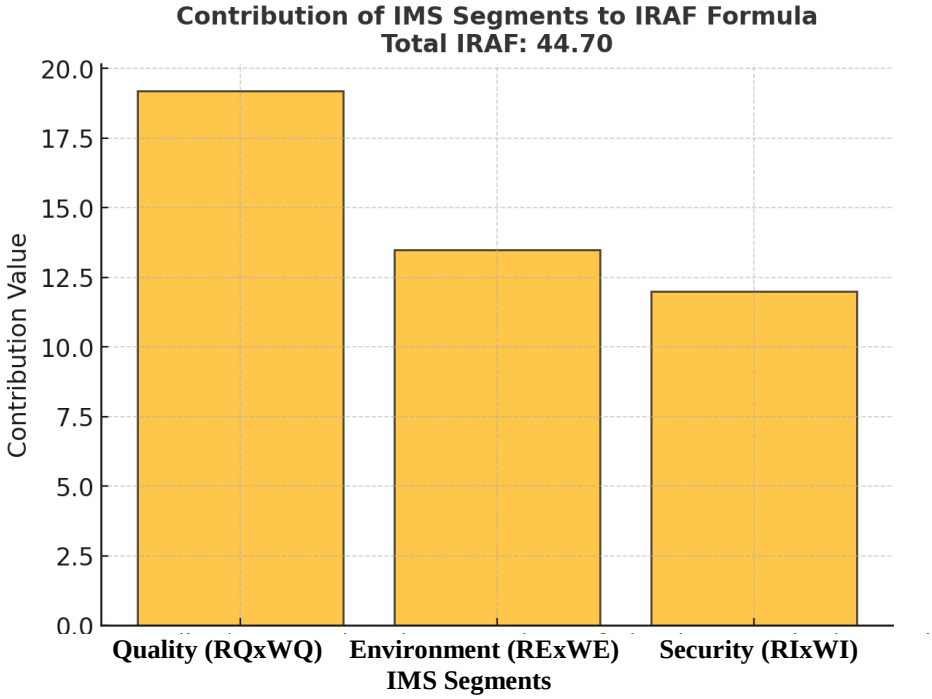
Interpretation of IRAF results:

- **IRAF < 30:** Low risk – No immediate action required.
- **30 ≤ IRAF < 50:** Medium risk – Corrective measures recommended.
- **IRAF ≥ 50:** High risk – Immediate action required, and a review of IMS policies is necessary.

Advantages of the IRAF Formula:

- **Comprehensive approach:** Integrates quality, environmental, and information security risks.
- **Flexible application:** Adaptable to various industries by adjusting weighting factors.
- **Efficient decision-making:** Provides a clear, numeric indicator of overall IMS risk.

Graph.1



Graph showing the contribution of each IMS segment (Quality, Environment, and Information Security) to the total IRAF value:

- Quality (RQ × WQ): Contribution: 19.2
- Environment (RE × WE): Contribution: 13.5
- Information Security (RI × WI): Contribution: 12.0

3. MODERN CHALLENGES IN SECURITY MANAGEMENT

Security management is a critical aspect of modern organizational operations, involving strategies, technologies, and procedures aimed at protecting data, assets, and business processes from emerging threats. In today's digital era, organizations face complex security challenges that require comprehensive solutions and proactive strategies. This section explores contemporary security management challenges, technological solutions, and strategic approaches to mitigate risks and ensure business continuity.

Modern challenges in security management

Cybercrime: Hacker attacks, phishing, and ransomware

Cybercrime is one of the most significant threats to organizations globally. According to Whitman&Mattord (2022), cyber-attacks, including phishing, ransomware, and malware infiltration, have increased exponentially in recent years. Hackers exploit vulnerabilities in systems to steal data, disrupt operations, and demand ransom payments.

- **Phishing attacks:** Deceptive emails and messages designed to trick employees into revealing sensitive information (Symantec Threat Report, 2022).
- **Ransomware:** Malicious software that encrypts company data and demands payment for its release (Europol, 2021).
- **Data breaches:** Unauthorized access to confidential information, leading to financial losses and reputational damage (Ponemon Institute, 2022).

A notable case is the Colonial Pipeline ransomware attack (2021), which disrupted fuel supply across the U.S. East Coast, underscoring the catastrophic impact of cybercrime on critical infrastructure.

Insider threats: Unauthorized access by employees

Insider threats pose a significant security risk as they originate from individuals within the organization. These threats can be intentional, such as data theft, or unintentional, such as accidental information leaks. According to Verizon Data Breach Investigations Report (2022), insider threats account for 34% of all data breaches.

- **Malicious insiders:** Employees who misuse their access for personal gain or to harm the organization (Cole, 2021).
- **Negligence:** Human error, such as misdirecting emails or weak password management (Whitman&Mattord, 2022).
- **Social engineering:** Manipulating employees into divulging confidential information (Mitnick, 2020).

A study by IBM Security (2022) highlights that insider-related incidents are more costly than external attacks, with an average cost of $11.45 million per incident.

Technological changes: Rapid advancement of IoT

The rapid evolution of technologies such as Internet of Things (IoT) presents both opportunities and challenges for security management. According to Davenport&Ronanki (2021), while these technologies enhance operational efficiency, they also introduce new security vulnerabilities.

- **IoTsecurity risks:** IoT devices often have weak security protocols, making them susceptible to hacking (Gartner, 2022).
- **5G Networks:** Increased connectivity with 5G technology expands the attack surface for cybercriminals (Ericsson Mobility Report, 2022).

For example, the Mirai botnet attack (2016) exploited unsecured IoT devices, creating a massive DDoS attack that disrupted major internet services globally.

Regulatory compliance: Adapting to laws such as GDPR and data protection acts

Compliance with data protection regulations is a major challenge for organizations, especially those operating globally. Regulations such as the **General data protection regulation (GDPR)** in the European Union and local data protection laws require organizations to implement stringent security measures to protect personal data.

- **GDPR (EU):** Mandates consent for data collection, the right to data erasure, and immediate reporting of data breaches (European Commission, 2022).
- **CCPA (California Consumer Privacy Act):** Ensures consumer rights to data access and deletion (California Department of Justice, 2021).
- **Local Data Protection Laws:** Such as the Serbian Law on Personal Data Protection (aligned with GDPR).

Failure to comply results in severe penalties, as seen in the case of British Airways (2019), which was fined £20 million under GDPR for a data breach affecting 400,000 customers.

Technological solutions for security management

Blockchain technology: secure data storage and information exchange

Blockchain technology offers a decentralized and tamper-proof method for storing and sharing data, significantly reducing the risk of data manipulation (Nakamoto, 2008).

- **Data integrity:** Blockchain ensures that once data is recorded, it cannot be altered, providing a secure audit trail (Swan, 2020).
- **Secure transactions:** Facilitates encrypted peer-to-peer transactions without intermediaries (Pilkington, 2022).
- **Smart contracts:** Automated contract execution when predefined conditions are met, reducing human errors and fraud (Buterin, 2021).

A notable example is IBM Food Trust, which uses blockchain to enhance food supply chain traceability, improving security and reducing fraud.

IoT (Internet of Things): Smart sensors and automated access control

IoT technology enhances physical security through smart sensors and automated access control systems. According to Gartner (2022), there will be over 15 billion IoT-connected devices by 2025, revolutionizing security management.

- **Smart sensors:** Monitor premises for intrusions, detect environmental hazards (e.g., smoke, temperature fluctuations), and alert security teams in real time (Cisco IoT Report, 2022).
- **Automated access control:** Uses biometric systems, smart cards, and mobile apps to regulate entry, ensuring only authorized individuals have access (Bosch Security Systems, 2022).
- **IoT Security solutions:** Include secure device authentication and end-to-end encryption to prevent cyber-attacks (Fortinet, 2022).

An example is Amazon's Ring Security System, which provides real-time surveillance and remote control through IoT-connected devices.

Cloud technologies: Secure data storage and disaster recovery

Cloud computing provides a secure and scalable solution for data storage, backup, and recovery, essential for business continuity (Armbrust et al., 2022).

- **Secure data storage:** Implements advanced encryption standards (AES-256) to protect stored data (AWS Security Whitepaper, 2022).

- **Rapid recovery:** Offers automated backups and disaster recovery solutions, ensuring business continuity in the event of a breach (Microsoft Azure, 2022).
- **Multi-factor authentication (MFA):** Adds an extra layer of security, preventing unauthorized access even if passwords are compromised (Google Cloud Security, 2022).

The Capital One Data Breach (2019), which exposed data of over 100 million customers, highlights the importance of securing cloud infrastructure against insider threats.

Strategies for security management

Security policies: Defining internal procedures and conducting employee training
A well-defined security policy outlines the rules and procedures for protecting organizational assets. According to NIST (2021), effective security policies include:

- **Clear procedures:** Detailed instructions on handling sensitive data and responding to security incidents.
- **Employee training:** Regular workshops to educate employees on cybersecurity threats such as phishing and social engineering.
- **Access Management:** Implementing role-based access controls (RBAC) to restrict data access based on job responsibilities.

A survey by CybSafe (2022) found that organizations with regular security training programs reduced phishing-related incidents by 72%.

Business continuity planning (BCP): Maintaining critical functions during a crisis

Business Continuity Planning (BCP) ensures that critical operations continue during and after a crisis (ISO 22301, 2022). Key components include:

- **Risk assessment:** Identifying potential disruptions and their impact on operations.
- **Continuity strategies:** Developing recovery plans such as remote work solutions and alternate supply chains.
- **Simulation exercises:** Regular testing through drills and mock scenarios to evaluate plan effectiveness.

For instance, during the COVID-19 pandemic, companies with effective BCPs, such as Amazon, quickly transitioned to remote operations, minimizing disruption.

Incident response plan (IRP): Rapid response to security incidents

An Incident Response Plan (IRP) outlines procedures for detecting, responding to, and recovering from security incidents (Whitman &Mattord, 2022). Key components are:

- **Incident identification:** Rapid detection and classification of security breaches.
- **Roles and responsibilities:** Clearly defined responsibilities for each member of the response team.
- **Communication plan:** Internal and external reporting procedures, including regulatory notifications.
- **Post-incident analysis:** Conducting root cause analysis and implementing corrective actions.

A case study from Equifax (2017) shows how the lack of a proper IRP resulted in a delayed response to a data breach, affecting 147 million customers and incurring $700 million in fines.

4. THE FUTURE OF MANAGEMENT AND SECURITY

The future of management and security is being shaped by rapid technological advancements and emerging digital innovations.

As organizations adopt cutting-edge technologies to enhance their operations, they must simultaneously address new security challenges. This section explores key technological trends that will define the future of security management.

5G Network integration: Faster data exchange and new cybersecurity challenges

The rollout of **5G networks** is revolutionizing data transmission, enabling faster speeds, lower latency, and enhanced connectivity for billions of devices (Ericsson Mobility Report, 2023). This technology will drive innovations such as smart cities, autonomous vehicles, and real-time industrial automation. However, along with its benefits, 5G introduces significant security challenges.

Advantages of 5G in security management:

- **Real-time data transmission:** 5G enables instantaneous communication between security devices, such as surveillance cameras and intrusion detection systems, improving response times (Qualcomm, 2023).
- **IoT expansion:** The network can connect millions of IoT devices, from smart sensors to automated access control systems, enhancing situational awareness (Gartner, 2023).
- **Enhanced remote monitoring:** Security teams can monitor multiple locations in real time using cloud-based platforms supported by 5G connectivity (Cisco, 2022).

Cybersecurityrisks associated with 5G:

Despite its advantages, 5G networks present several security challenges:

- **Wider attack surface:** With billions of connected devices, hackers have more entry points to exploit vulnerabilities (NIST, 2022).
- **Network slicing vulnerabilities:** 5G's ability to create virtual networks (network slicing) increases the risk of targeted attacks if a slice is compromised (Verizon Security Report, 2023).
- **Supply chain threats:** Dependence on third-party hardware and software providers introduces risks of compromised equipment (Huawei Security Report, 2022).

Strategies to mitigate 5G security risks:

- **Zero-trust architecture (ZTA):** Implementing strict verification protocols for every device accessing the network (Forrester Research, 2022).
- **End-to-end encryption:** Ensuring data is encrypted during transmission across 5G channels (Ericsson, 2022).
- **AI-Driven threat detection:** Utilizing AI to analyze network traffic and detect anomalies in real time (Davenport &Ronanki, 2022).

Quantum cryptography: Revolutionizing data protection

Quantum cryptography represents the future of secure communication, leveraging the principles of quantum mechanics to safeguard data. Unlike traditional encryption methods, which rely on complex mathematical algorithms, quantum cryptography uses quantum properties such as superposition and entanglement to create unbreakable encryption. How quantum cryptography works:

- **Quantum key distribution (QKD):** This technique uses photons to transmit encryption keys. Any attempt to intercept the key changes its quantum state, immediately alerting the parties involved (Bennett & Brassard, 1984).
- **No-cloning theorem:** Quantum states cannot be copied without detection, making eavesdropping impossible (Nielsen & Chuang, 2020).

Advantages of quantum cryptography in security:

- **Unbreakable encryption:** Protects sensitive data from cyber-attacks, including those from quantum computers (Gisin et al., 2022).
- **Secure data transmission:** Ensures secure communication channels between remote locations (Cambridge Quantum Computing, 2022).

- **Future-proof security:** Provides long-term protection against advancements in decryption technologies.

Challenges of quantum cryptography:

- **High cost:** Implementing quantum communication infrastructure requires specialized equipment, such as quantum repeaters and photon detectors (IBM Research, 2022).
- **Limited range:** Current QKD systems have distance limitations, making global deployment challenging (China's Micius Satellite, 2022).
- **Interoperability issues:** Quantum encryption systems may not be compatible with existing digital infrastructure (MIT Technology Review, 2022).

Case study: China's quantum satellite (micius, 2022)
China successfully demonstrated quantum-encrypted communication between ground stations over 1,200 kilometers using the Micius satellite. This experiment set a precedent for secure global communication without the risk of interception.

Autonomous systems: The role of drones and robots in physical security

The rise of autonomous systems, including drones and security robots, is transforming physical security management. Equipped with advanced sensors, and real-time connectivity, these systems can perform tasks such as surveillance, patrolling, and threat neutralization without human intervention.

Drones in security management:

Drones provide aerial surveillance and rapid response capabilities, particularly useful for large-scale areas such as industrial complexes, campuses, and national borders.

- **Surveillance:** Equipped with thermal cameras, drones can detect intruders even in low-visibility conditions (DJI Enterprise, 2022).
- **Crowd monitoring:** Useful for managing large public events by providing real-time footage to security teams (FAA Report, 2022).
- **Disaster response:** Assists in search and rescue operations by locating survivors and assessing damage (Red Cross, 2023).

Example: Police use of drones at the Tokyo olympics (2020)
Japanese authorities deployed drones to monitor crowds and enforce COVID-19 restrictions, enhancing safety while minimizing the need for on-ground personnel.

Security robots:

Autonomous security robots equipped with sensors can patrol premises, detect anomalies, and respond to threats in real time.

- **24/7 Surveillance:** Robots can continuously monitor areas without fatigue, unlike human guards (Knightscope, 2022).
- **Facial recognition:** Identifies unauthorized individuals and alerts security teams (Boston Dynamics, 2022).
- **Integrated alarms:** Automatically triggers alarms in case of security breaches (AWS IoT, 2023).

Example: Knightscope security robots in shopping malls (2022)
Knightscope robots deployed in malls reduced theft incidents by 20% within the first six months, providing both security and customer assistance.

Benefits of autonomous security systems:

- **Cost-effective:** Reduces the need for large security teams while providing 24/7 coverage (PwC Report, 2022).
- **Rapid response:** Drones and robots can reach incident areas faster than human personnel.
- **Data collection:** Captures and stores data for post-event analysis and security audits.

Security and ethical concerns:

- **Privacy issues:** Continuous surveillance raises concerns about individual privacy (ACLU Report, 2023).
- **Hacking risks:** Autonomous systems connected to networks can be vulnerable to cyber-attacks (Kaspersky, 2023).
- **Job displacement:** Automation may reduce demand for human security personnel, impacting employment (World Economic Forum, 2022).

5. FINAL THOUGHT

The exploration of modern management and security systems has illuminated the intricate relationship between technological advancement, human factors, and strategic foresight. In an era marked by digital transformation and evolving threats, organizations must embrace a proactive and integrated approach to management and security.

The findings in this paper highlight that security is not a standalone function but a critical component of comprehensive management strategies. The adoption of Integrated Management Systems (IMS) that merge quality management (ISO 9001), environmental protection (ISO 14001), and information security (ISO 27001) provides organizations with a holistic approach to risk management. Through the Integrated Risk Assessment Formula (IRAF), organizations can quantify and address risks across multiple dimensions, enabling data-driven decision-making.

From the rise of cybercrime and insider threats to the complexities of IoT and 5G networks, modern organizations face multifaceted security challenges. However, these challenges also present opportunities for innovation:

- **Blockchain technology** offers unbreakable data integrity and transparent transactions (Nakamoto, 2008).
- **IoT solutions** enhance physical security through real-time surveillance and automated access controls (Gartner, 2022).
- **Cloud technologies** provide secure and resilient data storage with rapid disaster recovery capabilities (AWS Security Whitepaper, 2022).

The future of management and security will be shaped by cutting-edge technologies:

- **5G Networks** will accelerate data exchange and enable real-time remote monitoring, but they also demand robust cybersecurity frameworks (Ericsson Mobility Report, 2023).
- **Quantum Cryptography** promises unbreakable encryption, making data interception virtually impossible, thereby revolutionizing secure communications (Bennett & Brassard, 1984).
- **Autonomous Security Systems**, such as drones and robots, will redefine physical security, providing 24/7 surveillance and rapid response to threats (Knightscope, 2022).
- **Invest in Human Capital:** Continuous employee education and cybersecurity training remain crucial in mitigating insider threats and social engineering attacks (Whitman &Mattord, 2022).
- **Adopt Zero-Trust Security Models:** Ensure that all network users and devices are verified, especially in 5G and IoT environments (Forrester Research, 2022).
- **Develop Business Continuity Plans (BCP):** Regularly test incident response and disaster recovery plans to maintain resilience during crises (ISO 22301, 2022).

In the digital era, security is no longer a cost center but a strategic enabler of business growth. Companies that integrate advanced security measures into their operations build trust with customers, partners, and stakeholders.

The convergence of **5G, quantum technologies, and autonomous systems** will not only enhance security protocols but also open new frontiers for innovation and efficiency. The future of management and security belongs to organizations that view security as an opportunity rather than a constraint. By embracing innovation, fostering a security-centric culture, and staying ahead of emerging threats, organizations can turn security challenges into competitive advantages.

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Sveobuhvatna provera bezbednosti informacionih sistema kroz multidisciplinarni pristup

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Apstrakt: Bezbednost informacionih sistema postala je ključna komponenta savremenih tehnologija, s obzirom na stalne pretnje koje dolaze od sajber napada. Ovaj rad istražuje načine na koje se može poboljšati bezbednost informacionih sistema primenom mera bezbednosti u programskom kodu. Fokus je na jednom od najpouzdanijih programskih jezika, Pithon, koji je poznat po svojoj fleksibilnosti i širokoj primeni u bezbednosnim operacijama. Analiziraju se ključne tehnike kao što su šifrovanje, otkrivanje ranjivosti i zaštita od napada malvera, zajedno sa relevantnim primerima koda.

Ključne reči: Verifikacija, bezbednost, informacije, sistemi, multidisciplinarni, pristup

Comprehensive check of security of information systems through a multidisciplinary approach

Apstract: Security of information systems has become a key component in modern technologies, given the constant threats that come from cyber attacks. This paper explores the ways in which the security of information systems can be improved through the implementation of security measures in the program code. The focus is on one of the most trusted programming languages, Python, which is known for its flexibility and wide application in security operations. Key techniques such as encryption, vulnerability detection and protection against malware attacks are analyzed , along with relevant code examples.

Key words : Verification, security, information, systems, multidisciplinary, approach

1. Introduction

Information systems play a vital role in today's business and society. However, as dependence on technology increases, so does the risk of cyber attacks. The development of security mechanisms within the program code becomes crucial for the protection of data and resources within these systems. This paper focuses on Python as a programming language due to its popularity and effectiveness in building security applications.

Earlier research showed that the security of information systems is mainly related to the application of external security tools. However, integrating security measures directly into the program code brings an additional level of protection. Python is often used in this context due to its simplicity and rich ecosystem of libraries, such as cryptography and pycryptodome, which facilitate the implementation of security features.

The methodology of this paper includes the analysis of existing security solutions implemented in Python. For each technique, key factors such as efficiency, scalability, and resistance to attacks were considered. In addition, various attack scenarios were simulated in order to test the robustness of the implemented solutions.

2. Implementation of security mechanisms

2.1. Data encryption

Encryption is a fundamental aspect of data protection. Python provides several tools for encryption, of which cryptography is one of the most widely used. Below is an example implementation of symmetric encryption:

```
python
Copy the code
from cryptography.fernet import Fernet

# Generating the key
key = Fernet.generate_key()
cipher = Fernet(key)

# Data encryption
text = "Sensitive Data"
encrypted_text = cipher.encrypt( text.encode())

# Data decryption
decrypted_text = cipher.decrypt( encrypted_text).decode()
```

2.2. Vulnerability detection

Python allows code analysis to identify potential vulnerabilities using tools such as Bandit. Bandit checks Python code for the most common security flaws.

```
python
Copy the code
import bandit
from bandit.core import config, manager

# Configuration and start of the scan
cfg = config.BanditConfig()
mngr = manager.BanditManager(cfg, "path_to_code")
mngr.run()
```

2.3. Protection against malware attacks

Protection against malware can be achieved by analyzing suspicious files and their behavior using tools such as yara-python which allows identification of malicious files.

```
python
Copy the code
import yara

# Creating rules for malware identification
rules = yara.compile(source='''
rule MaliciousFile
{
strings :
$a = {6A 40 68 00 30 00 00 6A 14 8D 91}
condition :
$a
}
''')

# File scanner
matches = rules.match('path_to_file')
```

3. Discussion

By implementing security measures directly into the program code, we achieve a higher level of security compared to the use of external tools. Python, with its flexibility, enables the development of robust security solutions that can effectively protect information and systems from various types of attacks. The work shows that it is possible to achieve a high level of security of information systems through the direct implementation of security measures within the program code. Python has proven to be an extremely effective tool in this context, thanks to its wide usability and rich ecosystem of libraries.

Further research can expand this topic to include other programming languages and advanced security techniques. This is a paper structure that you can further develop or adapt to your specific needs and research context. Here are ten examples of simulating information system security flaw detection using various tools and techniques in Python:

4. SQL Injection Detection

Simulation of checking for SQL injection vulnerabilities in web applications.

```
python
Copy the code
import sqlite3

def is_vulnerable(query):
# If unfiltered input is used, there is a possible SQL injection vulnerability
try :
conn = sqlite3.connect(':memory:')
conn.execute( query)
return False
except sqlite3.OperationalError:
return True

query = "SELECT * FROM users WHERE username='admin' --' AND password='password123'"
print( is_vulnerable(query))
```

5. XSS (Cross-Site Scripting) Detection

Simulation of checking XSS vulnerabilities in a web application.

```
python
Copy the code
def detect_xss(input_str):
xss_patterns = ['<script>', '</script>', 'javascript:']
return any(pattern in input_str.lower() for pattern in xss_patterns)

user_input = "<script>alert( 'Hacked!')</script>"
print( detect_xss(user_input))
```

6. Weak Password Detection

Simulating the detection of weak passwords using common phrases and words.

```
python
Copy the code
def is_weak_password(password):
common_passwords = ['123456', 'password', 'admin', 'welcome']
return password in common_passwords

password = "123456"
print( is_weak_password(password))
```

7. Man-in-the-Middle (MITM) Attack Detection

Simulation of MITM attack detection by SSL certificate analysis.

```
python
Copy the code
import ssl
import socket
def detect_mitm(host):
context = ssl.create_default_context()
conn = context.wrap_socket(socket.socket(socket.AF_INET), server_hostname=host)
conn.connect( (host, 443))
cert = conn.getpeercert()
conn.close()
```

```
# Certificate validation
return cert['issuer'] != cert['subject']

print( detect_mitm('example.com'))
```

8. Buffer Overflow Detection

Simulation of checking for buffer overflow vulnerabilities.

```
python
Copy the code
def is_vulnerable(buffer_size, input_data):
return len(input_data) > buffer_size

buffer_size = 64
input_data = "A" * 100
print( is_vulnerable(buffer_size, input_data))
```

9. CSRF (Cross-Site Request Forgery) Detection

CSRF vulnerability check simulation.

```
python
Copy the code
def detect_csrf(token_from_user, token_from_server):
return token_from_user != token_from_server

user_token = "123abc"
server_token = "456def"
print( detect_csrf(user_token, server_token))
```

10. Directory Traversal Detection

Simulation of detection of Directory Traversal attack attempts.

```
python
Copy the code
def detect_directory_traversal(input_path):
traversal_patterns = [' .. /', '..\\']
return any(pattern in input_path for pattern in traversal_patterns)

input_path = " .. /etc/passwd"
print( detect_directory_traversal(input_path))
```

11. Port Scanning Detection

Port scan detection simulation.

```
python
Copy the code
import socket

def detect_port_scanning(host, ports):
open_ports = []
for port in ports:
with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as with:
if s.connect_ex((host, port)) == 0:
open_ ports.append( port )
return open_ports

host = "192.168.1.1"
ports = [22, 80, 443, 8080]
print( detect_port_scanning(host, ports))
```

12. Insecure HTTP Method Detection

Simulation of checking for insecure HTTP methods (eg PUT, DELETE).

```
python
Copy the code
import requests

def detect_insecure_http_methods(url):
insecure_methods = []
methods = ['GET', 'POST', 'PUT', 'DELETE', 'OPTIONS', 'HEAD']
for method in methods:
response = requests.request(method, url)
if response.status_code in [200, 201, 204]:
insecure_ methods.append( method )
return insecure_methods

url = "http://example.com"
print( detect_insecure_http_methods(url))
```

13. Brute Force Attack Detection

Brute force attack detection simulation.

```
python
Copy the code
from collections import defaultdict

def detect_brute_force(login_attempts):
attempt_counts = defaultdict( int )
for attempt in login_attempts:
attempt_ counts[ attempt ] += 1
return any(count > 3 for count in attempt_counts.values())

login_attempts = ['user1', 'user1', 'user1', 'user1']
print( detect_brute_force(login_attempts))
```

14. Analysis of ten examples of simulation of detection of flaws in information system security

14.1. SQL Injection Detection

Description: SQL injection attacks allow attackers to enter malicious SQL queries that can change or destroy database data. The example shows a simple vulnerability check using unfiltered input.
Analysis: This simulation shows a basic way of checking for SQL injection vulnerabilities, where it is simply checked to see if the user's input contains SQL comments or other malicious queries. In a real environment, this method of detection would be ineffective because more advanced SQL injection attacks can be hidden behind more sophisticated techniques. That is why it is important to use security practices such as prepared statements and parameterized queries.
Recommendation: Implementation of additional layers of protection such as prepared queries and ORM (Object-Relational Mapping) tools.

14.2. XSS (Cross-Site Scripting) Detection

Description: XSS attacks allow attackers to inject malicious code into web pages that will be executed on the user's end. This simulation checks user input for known XSS patterns.
Analysis: The simulation detects simple XSS attacks by searching for specific strings such as <script> tags. However, more sophisticated XSS attacks can use various techniques to bypass this detection, including character encoding, using different elements, or JavaScript events.
Recommendation: Use of security filters on the server, validation and remediation of user input, and application of Content Security Policy (CSP) to prevent XSS attacks.

14.3. Weak Password Detection

Description: This example detects weak passwords that are common and easy to guess.
Analysis: Detecting weak passwords is an important step in system protection. The simulation uses a predefined list of weak passwords, which is good as a basic measure. However, more advanced attacks use sophisticated brute-force methods and constantly updated password lists.
Recommendation: Implementation of a strong password policy, use of a password manager, and regular user education on security practices.

14.4. Man-in-the-Middle (MITM) Attack Detection

Description: MITM attacks allow attackers to intercept and modify communications between two parties. This simulation validates the SSL certificate to detect a potential MITM attack.
Analysis: This technique can detect simple MITM attacks where the attacker uses a fake SSL certificate. However, more advanced attacks may use a legitimate certificate, making detection more difficult.
Recommendation: Use of HSTS (HTTP Strict Transport Security), certificate with verified root authorities, and regular check of communication integrity.

14.5. Buffer Overflow Detection

Description: Buffer overflow attacks allow attackers to inject excess data into memory space, which can result in malicious code execution.
Analysis: This example shows the basic detection of a buffer overflow attack by checking the length of the input data against the buffer capacity. However, actual buffer overflow attacks are often more complex and involve precise memory manipulation.
Recommendation: Use of languages and compilers that include protection against buffer overflow attacks (eg stack canaries), and regular testing of code for vulnerabilities.

14.6. CSRF (Cross-Site Request Forgery) Detection

Description: CSRF attacks allow attackers to force users to perform unwanted actions on a web application where they are authenticated. The simulation checks the CSRF token match between the user and the server.
Analysis: This example shows basic CSRF attack detection using tokens. This technique is effective if the tokens are generated and verified correctly, but can be vulnerable to attacks if the tokens are poorly implemented or not renewed.
Recommendation: Implement CSRF protection using unique, hard-to-predict tokens for each session or request.

14.7. Directory Traversal Detection

Description: Directory traversal attacks allow attackers to access files and directories outside the allowed scope. This simulation checks the input path for patterns that indicate an attempted traversal attack.
Analysis: The simulation detects simple traversal attack attempts. However, attackers can use encryption or other techniques to bypass basic detection.
Recommendation: Use security APIs for file access, validation and remediation of path entries, and restrictive setting of file and directory permissions.

14.8. Port Scanning Detection

Description: Port scanning is a technique that attackers use to identify open ports on a target. This simulation detects open ports by scanning a series of ports.
Analysis: Simulation is useful for detecting open ports on network devices, but does not offer protection against port scanning. More advanced attackers can use stealth methods to avoid detection.
Recommendation: Implementation of firewall rules that block unauthorized scans, use of Intrusion Detection System (IDS) and Intrusion Prevention System (IPS).

14.9. Insecure HTTP Method Detection

Description: HTTP methods such as PUT and DELETE can be vulnerable if not configured correctly. This simulation checks which HTTP methods are allowed on the server.
Analysis: This example detects insecure methods that can be abused if allowed. However, such detection should be part of a wider security audit that includes correct configuration and restriction of HTTP methods.
Recommendation: Limit the use of HTTP methods to the necessary methods (eg GET and POST), regularly check and update the server configuration.

14. 10. Brute Force Attack Detection

Description: Brute force attacks attempt to break authentication by repeatedly trying wrong passwords. This simulation detects repeated failed login attempts.
Analysis: Detection of brute force attacks is key to protecting against unauthorized access. This example uses a simple method of counting attempts per user, which can be effective for basic protection.
Recommendation: Implementation of mechanisms for locking accounts after a certain number of failed attempts, use of CAPTCHA, and monitoring and analytics of logs to detect suspicious activities.

15. Conclusion

The security of information systems is a key component in the protection of data, resources and operations in modern technological environments. Through ten analyzed examples of simulation of the detection of flaws in the security of the information system, it is clear that security problems can appear at different levels, from the application layer to the network layer, and the detection of these problems requires the application of different techniques and tools.

These examples cover a wide range of security threats, including SQL injection, XSS, weak passwords, MITM attacks, buffer overflow, CSRF, directory traversal, port scanning, insecure HTTP methods, and brute force attacks. Each of these attacks represents a real threat that can have serious consequences for the integrity, confidentiality and availability of information systems.

Key insights from this analysis include:

1. Diversification of Security Measures: There is no universal solution for all security threats. Different threats require specific approaches to detection and mitigation, such as input validation, use of security tokens, data encryption, and implementation of robust authentication mechanisms.
2. Dynamic Nature of Threats: Cyber threats are dynamic and constantly evolving. These simulations cover basic scenarios, but real threats often use more advanced techniques to circumvent standard security measures. That's why it's important to regularly update security protocols and tools, as well as continuously educate security teams.
3. Integration of Security Tools: Attack detection and prevention tools, such as those simulated in the examples, should be integrated into broader security strategies. This includes the use of Intrusion Detection Systems (IDS), Intrusion Prevention Systems (IPS), firewalls, encryption and other protection mechanisms that work in synergy to ensure comprehensive security.
4. Proactive Approach: Instead of relying solely on reactive measures, such as responses to attacks that are already underway, a proactive approach involves regular testing, simulating attacks (penetration testing), and implementing security measures before an incident occurs. This approach helps identify potential vulnerabilities before attackers can exploit them.
5. Importance of Education and Training: Education of users and personnel who manage information systems on best practices in the field of security is of crucial importance. Even the most robust security systems can be compromised by human error, so continuous education is key to maintaining a high level of security.

The analysis shows that the protection of information systems is a complex process that requires careful implementation, regular updating and constant monitoring. Python, as one of the most popular programming languages, provides a rich set of tools and libraries that enable effective detection and prevention of security threats.

However, in order to achieve a high level of security, it is necessary to combine these tools with advanced security practices and a proactive approach that encompasses all aspects of information systems. Only in this way can we ensure that the systems are resistant to a wide range of attacks and that the data and resources they protect are secure.

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Klimatska nepravda u eri globalizacije i tehnološkog napretka

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Apstrakt: Ovaj rad istražuje preseke između ciljeva održivog razvoja (SDG) i Zelene agende, fokusirajući se na ekološke, socijalne i ekonomske izazove i prilike u globalnom kontekstu. Naglašava ulogu međunarodne saradnje, tehnoloških inovacija i ublažavanja klimatskih promena u postizanju održivog rasta i rešavanju ekoloških problema kao što su zagađenje vazduha, gubitak biodiverziteta i upravljanje otpadom. Studija analizira uticaj klimatskih promena, tehnoloških razvoja i energetske tranzicije, sa akcentom na potrebu za pravednijim pristupom u kontekstu globalnih razlika. Dok tehnološke inovacije kao što su veštačka inteligencija (AI) i blokčejn (*eng. Blockchain*) nude potencijalna rešenja za održivi razvoj, one takođe predstavljaju nove izazove u pogledu potrošnje energije i ekološkog uticaja. Rad tvrdi da je potreban uravnotežen pristup koji integriše tehnološke napretke sa sveobuhvatnim ekološkim politikama kako bi se obezbedio pravičan i efikasan zeleni prelaz, naročito u zemljama u razvoju. Takođe, poziva na veću odgovornost i saradnju između zemalja, uz naglasak na klimatsku pravdu kako bi se osiguralo da ranjive populacije ne budu nesrazmerno pogođene ekološkim propastima.

Ključne reči: Održivi razvoj, Zelena agenda, Klimatske promene, Tehnološki razvoj.

Climate Injustice in the Era of Globalization and Technological Advancement

Abstract: This paper explores the intersections between the Sustainable Development Goals (SDGs) and the Green Agenda, focusing on ecological, social, and economic challenges and opportunities in a global context. It emphasizes the role of international cooperation, technological innovations, and climate change mitigation in achieving sustainable growth and addressing environmental issues such as air pollution, biodiversity loss, and waste management. The study analyzes the impact of climate change, technological development, and energy transition, with a focus on the need for a fairer approach in the context of global disparities. While technological innovations such as artificial intelligence (AI) and blockchain offer potential solutions for sustainable development, they also present new challenges regarding energy consumption and environmental impact. The paper argues that a balanced approach is needed, integrating technological advancements with comprehensive ecological policies to ensure a fair and efficient green transition, especially in developing countries. It also calls for greater accountability and cooperation among nations, emphasizing climate justice to ensure that vulnerable populations are not disproportionately affected by environmental disasters.

Keywords: Sustainable development, Green agenda, Climate change, Technological development.

1. Introduction

At the United Nations Conference on Sustainable Development held in 2015, one of the main outcomes was the adoption of 17 Sustainable Development Goals for the period up to 2030 by Member States (Bolyssov et al., 2019). The Green Agenda focuses on global efforts to achieve sustainable development through economic, social and environmental dimensions, with the aim of reducing negative environmental impacts, combating poverty, reducing inequalities, conserving natural resources and promoting inclusive economic growth.

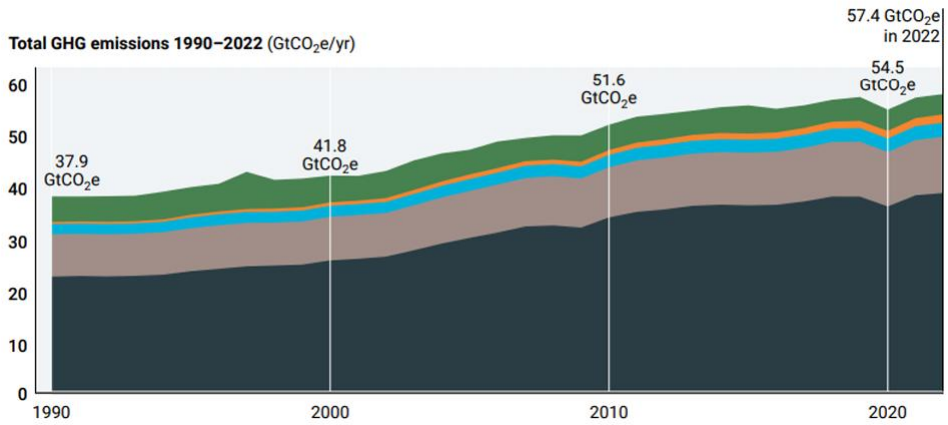
The key principles of sustainable development include respect for human rights, equality, environmental responsibility, integrated solutions and international cooperation, taking into account the different capacities and specificities of each country. The Green Agenda for the Western Balkans provides guidelines, priorities and objectives to be achieved in the areas of : decarbonisation, circular economy, protection and restoration of biodiversity, sustainable agriculture and combating air, water and land pollution (Vasilkov et al., 2021). In order to establish a framework for regional and international cooperation and in line with the priorities set out in the EU Green Deal, the Western Balkan countries are adopting strategies for the development of energy from RES. The project "EU for a Green Agenda in Serbia" aims at the effective implementation of the Green Agenda by improving the legislative framework, co-financing innovative pilot projects and mobilising additional funding. Key results include innovative solutions for cleaner air, reducing industrial emissions, enhancing natural values through green infrastructure, and supporting sustainable food systems and rural development. The Republic of Serbia has demonstrated numerous measures in the domain of climate transition in an effort to promote sustainable production and consumption that protect existing resources and natural capital. The energy system of our country tends to rely more on renewable energy sources, namely the use of wind energy and hydropower, and less on exhaustible resources (Martin, 2023).

The misleading practices of the Green Agenda can be reflected in the unequal distribution of responsibility for emissions of harmful gases, where developed countries often transfer the burden to developing countries, while they themselves do not take appropriate measures to reduce emissions. Technological developments and the application of artificial intelligence (AI) can have a detrimental impact on climate change, as they often lead to increased consumption of energy and resources, as well as emissions from industry and transport, while automation and digitalization can increase production capacities without adequate environmental protection. These negative effects of technology and globalization make it difficult to achieve a just green transition, as they often do not take into account the ecological and social dimensions of sustainable development.

2. Trends, causes and consequences of dealing with climatic changes

Climate change, caused by anthropogenic (human) activity, is one of the biggest global problems, in which greenhouse gas emissions, especially from fossil fuels, play a key role. Greenhouse gas (GHG) emissions trap heat in the atmosphere, and the planet is already 1.2°C warmer than in the 19th century, at the beginning of the Industrial Revolution. In some parts of the world, including the Western Balkans, to which the Republic of Serbia belongs, the average global temperature is 1.5°C higher than in the pre-industrial period. The latest UN Climate Change Report suggests that if the average global temperature increases by 2°C before the end of the century compared to the temperature at the end of the 19th century, life on the planet as it is now will not be possible. If the current trend of greenhouse gas emissions continues, according to this report, we are rapidly approaching this scenario – within the next 20 years the average temperature increase will reach or exceed 1.5°C. On the other hand, with zero global net greenhouse gas emissions, by 2100, global warming is unlikely to be below 2°C. In order to achieve net zero emissions, it is necessary to significantly reduce greenhouse gas emissions, so that they are equal to the amount of carbon dioxide that can be absorbed by the atmosphere (The Emission Gap Report 2022, 2023) .

Figure 1: Global GHG emissions from 1990 to 2022



Source: https://wedocs.unep.org/

Figure 1 shows greenhouse gas emissions in the period from 1990 to 2022 worldwide. As can be seen in this figure, a constant increase in emissions was recorded in the aforementioned period, with a significant increase in greenhouse gas emissions from 2000 to 2010. In the last 10 years, a weaker increase in greenhouse gas emissions was recorded, which is a consequence of the development of awareness about the harmful effects of GHG emissions.

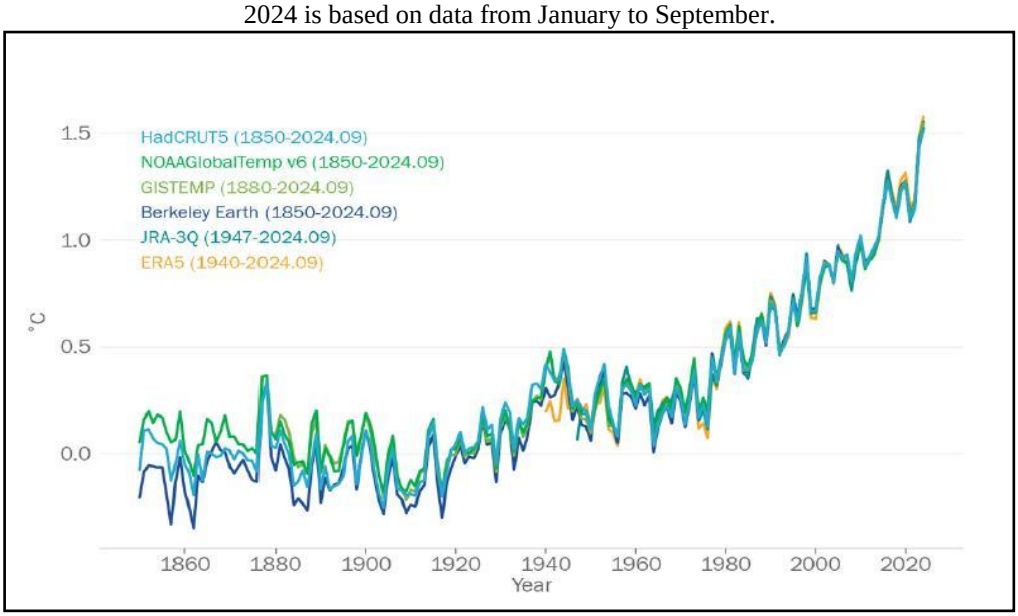
In order to limit global warming to below 2°C, countries have committed to international agreements and a transition to renewable energy sources such as wind, solar and hydropower, known as the "energy transition". Key environmental issues in the world are air pollution and climate change. According to the World Health Organization (WHO), there are six main air pollutants: particulate matter (PM), ozone (O_3), carbon monoxide (CO), sulfur oxides (SOx), nitrogen oxides (NOx) and lead. The greenhouse gases, according to the Intergovernmental Panel on Climate Change (IPCC), are: carbon dioxide (CO_2), methane (CH_4), fluorocarbons (HFCx), fluorocarbons (organic compounds in which all hydrogen atoms are replaced by fluorine, CxFy) and sulfur hexafluoride. Ozone is considered an indirect greenhouse gas. Climate change is caused by emissions of pollutants such as CO, NO, NO_2, greenhouse gases (H_2O, CH_4, O_3) and aerosols, which are interconnected due to common sources and processes. Carbon dioxide is the most important anthropogenic greenhouse gas. The rise in CO_2 levels, which contributes to global warming, is the greatest environmental challenge, requiring urgent mitigation measures, such as reducing emissions and implementing CO_2 capture and utilization (CCU) technologies. These technologies, especially CCU, offer cost-effective solutions because they enable the recycling of CO_2 into useful products, thereby reducing transportation and storage costs (Singh and Yadav, 2021).

The world is facing a serious problem of air pollution that is driven by climate change, and conversely, climate change further worsens air pollution. Air pollution and climate change are closely linked (Sonwani et al., 2022b). Matyssek et al. (2012) stated that air pollution is an integral element of climate change. Human-caused emissions contribute significantly to both processes, air pollution and climate change. Ozone is another gas that, in addition to directly affecting the climate, is indirectly affected by the lifetime of other greenhouse gases, such as methane, causing additional climate effects (Singh and Yadav, 2021). On the other hand, climate change affects ozone concentrations through dynamic and chemical changes in the atmosphere. Climate change is a global challenge with far-reaching consequences for the entire world (Haibach and Schneider, 2013). A comprehensive interdisciplinary approach is necessary to reduce the consequences of climate change and combat air pollution. Achieving SDG 13 requires, the implementation of effective strategies to reduce greenhouse gas emissions, introduce smart agricultural practices, promote renewable energy sources and improve energy efficiency. Also, the implementation of climate change adaptation strategies, the development of green infrastructure, sustainable cities and communities, as well as effective waste management, are key to achieving SDG 11 and reducing the impacts of climate change (Zakaria et al., 2020). Also, sustainable water management (Xiang et al., 2021), air quality and watershed management, as well as improving disaster preparedness systems, with the development of early warning systems, can also be useful in combating climate change (Saxena and Sonwani, 2020; Hussain and Hoque, 2022a).

Concentrations of three key greenhouse gases in the atmosphere – carbon dioxide, methane and nitrous oxide – reached record levels in 2023, the latest year for which global data are available. Carbon dioxide (CO_2) concentrations rose from about 278 ppm in 1750 to 420 ppm today, an increase of 51%. The average annual rate of increase in CO_2 over the past decade has been 2.4 ppm. Fossil fuel emissions have been the largest source of human emissions since the 1950s. The global average concentration of methane (CH_4) rose from 729 ppb in the pre-industrial period to 1934 ppb in 2023, an increase of 165%. The concentration of nitrogen oxides (N_2O) increased from 270 ppb in 1750 to 336.9 ppb in 2023, which represents an increase of 24%. The fact that some years recorded a temperature increase of more than 1.5°C does not necessarily mean that the goal of the Paris Agreement, which aims to limit the temperature increase to 1.5°C above the pre-industrial level, is unattainable (Kennedy et al., 2024).

Figure 2 shows the increase in global temperature for the period from 1850 to 2024. As can be seen in the figure, the increase in global temperature is not constant. A significant increase in global temperature was recorded in the period from 1920 to 1940. A constant and largest increase in temperature was recorded in the period from 1970 to the present.

Figure 2: Annual global temperature anomalies from 1850 to 2024 from six datasets. The average for 2024 is based on data from January to September.



Source: Kennedy et al., 2024

Climate change acts as a risk multiplier, linking global warming to problems such as the loss of key resources, supply disruptions, increased insecurity and social instability, which can lead to migration and conflict. Key questions in climate policy are who should be protected from climate impacts and who should bear the costs. Climate policy will only be successful if the Global North takes greater responsibility for addressing the problems and implements stricter limits than the Global South (Scheffran, 2023). Despite scientific warnings, the global trend towards climate stabilisation is still not visible, and reducing greenhouse gas emissions by half by 2030 and achieving climate neutrality by 2050 is necessary to meet climate security limits (Engels et al., 2023). The issue of climate justice is not adequately regulated in international climate agreements, including the Paris Agreement, and disagreements regarding greenhouse gas emission reduction targets represent an obstacle to a consistent comparative review of the state and progress. Serbia has a larger difference in emissions compared to Greece and Romania, while compared to Albania it has a larger difference in emissions per capita. Serbia's emission reduction targets are more modest than those of neighboring countries, including North Macedonia, while the EU's targets are significantly more ambitious (Todić, 2020).

3. Fair participation of states in climate change

Climate justice links climate change to social inequalities, emphasizing that the most vulnerable populations, who contribute the least to emissions, suffer the most from its consequences. Developed countries often shift the burden of climate change to the poorer, leading to global imbalances in the distribution of damages. Climate justice demands a fair distribution of these burdens and protections for all communities (Porter et al., 2020). It highlights two main groups of people differently affected by climate change: the first, the privileged, who have benefited from fossil fuels and colonial development and are now in a better position to adapt to climate change, and the second, the more numerous group, who have long been exploited and now bear the greatest burden of climate change, although they have not significantly contributed to its occurrence.

This issue is becoming increasingly important for researchers and practitioners, especially in the context of urban planning, as climate injustice is increasingly recognized as a key obstacle to an equitable response to climate challenges (Rickards & Watson, 2020).

The IPCC (Intergovernmental Panel on Climate Change) is a key UN body that assesses the scientific, technical and socio-economic aspects of climate change. Its work helps governments make informed decisions on climate issues, focusing on identifying the most vulnerable groups and understanding their needs. Recent IPCC reports clearly show that delays in reducing emissions will further exacerbate the effects of climate change and increase climate injustices.

For example, the 1.5° C Report highlights climate change as an ethical issue and calls for the protection of the human rights of those at risk, including the rights to water, food, health and life (Masson-Delmotte et al., 2018). The Climate Change and Land Report warns that failure to reduce carbon dioxide could exacerbate climate injustice at the local and regional levels, if appropriate measures are not taken (Shukla et al., 2019).

The issue of "fair share" arises in legal challenges related to the adequacy of countries' efforts to mitigate climate change, as there is a global "carbon budget" that must be respected in order to maintain the 1.5°C temperature increase target. The problem arises because it is unclear when emissions become illegal, as the Paris Agreement does not define clear principles for distributing emissions among countries. This ambiguity complicates legal proceedings aimed at holding responsible countries accountable for their emissions (Liston, 2020). In the context of the climate crisis, the ISDS mechanism for settling disputes between investors and states is considered an obstacle to effectively addressing climate change. Although a reevaluation of international investment treaties is needed, the process of modernization is complex, as balancing the interests of investors and climate objectives creates uncertainty and increases the risk of ISDS claims. Therefore, tribunals should recognize the right of states to regulate as an exception to the standards of fair and equitable treatment, guided by the principles of proportionality and good faith, in order to protect climate objectives without violating investors' rights (Holder, 2024).

Green criminology studies how human activities affect the environment, taking into account not only criminal acts, but also other harmful actions, including irresponsible behavior of companies, governments and citizens, who are motivated by the race for profit and consumerism. This discipline also points to the need for sincere action in protecting nature, instead of creating the illusion of efficient action, while in reality environmental problems are often minimized or dramatically distorted, with the aim of preserving the economic dominance of developed countries (Ignjatović, 2023). Scientific research indicates that reducing consumption in developed countries, while maintaining sustainable changes, can contribute to mitigating unjust environmental damage caused by the dynamics of ecologically unequal exchange (EUE) between the Global North and the South. Activists and scholars emphasize the importance of a global environmental justice movement that uses a multidimensional and intersectional approach to confront social and environmental injustices, restoring agency to communities affected by environmental problems and strengthening their resilience to powerful global and local structures (Jennifer et al., 2018).

4. Climate changes in the light of technological development

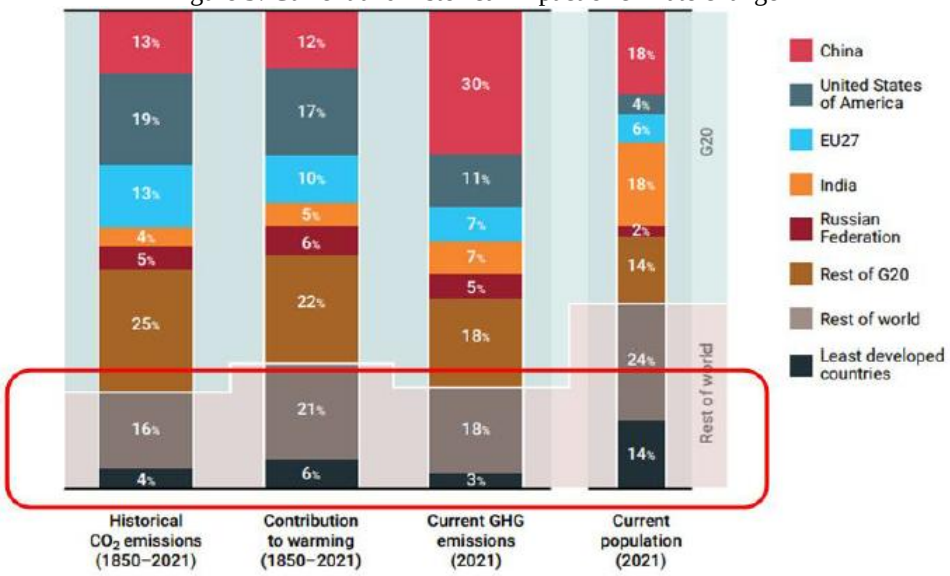
In recent decades, the dramatic increase in global industrial activity has led to a significant increase in the use of fossil fuels, while technological progress has increased carbon footprints and thus global warming (Sharma et al., 2020). Research (Tao et al., 2023) has shown the impact of climate change and technological innovation on economic growth, energy consumption and carbon dioxide emissions in Asian and European countries, revealing significant regional differences in the effects of innovation, with European countries benefiting more. The study highlights the need for targeted technological innovation in Asian countries to improve energy efficiency and reduce emissions, while technology transfer from Europe increases emissions in Asia.

The richest countries in the world are accelerating their emission reductions, while poor countries are increasing them intensively. Figure 3 shows the current and historical impact of climate change on different countries. As can be seen in the aforementioned figure, the populous developing countries are disproportionately newly established. These countries are increasing their emissions because they are relying on the cheapest energy sources (for example, coal) due to their ever-increasing energy needs.

In recent years, modern technologies such as Blockchain technology and Artificial Intelligence (AI) have been increasingly applied in the fight against climate change. Blockchain technology is a disruptive technology that advances information technology and the act of sharing information. Blockchain technology functions as a ledger in which data used in transactions or communication is stored, and which is accessible online or in digital blocks (Parmentola et al., 2022).

This technology is now applied in various fields (Centobelli et al., 2021), and recently it has often been applied with the aim of improving environmental sustainability (Glavanits, 2020).

Figure 3: Current and historical impact of climate change



Source: https://wedocs.unep.org/

The presented research (Thalhammer, et al., 2022) points to the application of blockchain technology in the fight against climate change, focusing on areas such as emissions trading, sustainable energy, mobility and the green finance sector, where blockchain improves transparency and data tracking. Although blockchain can significantly contribute to climate action, challenges such as legal framework, data privacy and energy efficiency indicate the need for further research and development of more efficient and environmentally friendly solutions for using this technology in the fight against climate change. Blockchain technology has the potential to transform the economy by harmonizing transparency and efficiency with the goal of achieving a more sustainable world, but it is important to balance its positive and negative effects on the environment (Parmentola et al., 2022).

AI plays a key role in optimizing energy consumption, forecasting demand and reducing the load on energy systems, contributing to sustainability and reducing the carbon footprint. However, the rapid development of AI, especially in training large language models, leads to increased energy consumption, which poses a challenge to achieving carbon neutrality, as high energy costs and increasing energy consumption increase the carbon footprint. Therefore, scientific efforts are focused on improving the energy efficiency of AI systems and reducing their negative impact on the environment (Pimenow et al., 2024). Research results (Zhang et al., 2023) indicate that Bitcoin mining has a significant environmental impact, with an asymmetric relationship between cryptocurrency energy consumption and CO 2 emissions, which requires the implementation of appropriate policy reforms to reduce its negative impact on climate change. Research (Huynh et al., 2021) calls for the design and implementation of regulations and strategic plans that would encourage the transformation towards sustainable cryptocurrency mining, thereby reducing carbon footprints and alleviating environmental concerns related to the cryptocurrency ecosystem. In order to mitigate the environmental consequences of cryptocurrencies, it is necessary to promote technological innovations in renewable energy and their application in the cryptocurrency market (Wang et al., 2018).

5. Conclusion

The Green Agenda and the pursuit of the Sustainable Development Goals (SDGs) represent both challenges and opportunities at the global level. While the transition to a green economy, based on renewable energy sources and sustainable practices, is crucial for long-term environmental and economic stability, there are significant obstacles that need to be overcome. These include the uneven distribution of responsibility for greenhouse gas emissions, the negative effects of certain technologies, and economic disparities between countries. A more inclusive and equitable strategy is needed in the future to ensure that all countries, regardless of their economic status, can participate in the global efforts to combat climate change.

Legislative frameworks need to be strengthened, investments in green technologies increased and international cooperation enhanced.

The role of new technologies, such as artificial intelligence (AI) and blockchain, also needs to be carefully assessed to ensure that their environmental impact is minimized while maximizing their potential for sustainable development. The global community must strive for a just transition that recognizes the historical responsibilities of industrialized countries and ensures that developing countries are not left behind in the pursuit of climate justice. This includes addressing the needs of the most vulnerable communities affected by environmental disasters and promoting international cooperation to ensure a fairer sharing of the costs and benefits of climate action.

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Primjena PDCA ciklusa u kreiranju i razvoju brenda grada

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Apstrakt: Ovaj rad predstavlja primjenu PDCA ciklusa (Planiraj-Uradi-Provjeri-Djeluj), kao metodološkog pristupa u kreiranju i razvoju Brenda grada. Faze PDCA ciklusa su prilagođene procesu brendiranja grada, kroz četiri ključna koraka. Faza planiranja (Planiraj), obuhvata analizu imidža grada, identifikaciju ciljnih korisničkih grupa i definisanje strategije brenda. Druga faza (Uradi) fokusira se na implementaciju strategije, uključujući razvoj vizuelnog identiteta i sprovođenje marketinških kampanja. U trećoj fazi (Provjeri), mjeri se uspjeh napora u brendiranju prikupljanjem povratnih informacija i analizom tržišta. Završna faza (Djeluj), usmjerena je na kontinuirano prilagođavanje i unapređenje strategije brenda, na osnovu dobijenih rezultata. Predložena primjena PDCA ciklusa omogućava sistematsko upravljanje procesom brendiranja, prilagođeno dinamičnim promjenama i potrebama različitih korisničkih grupa. Na teorijskom nivou, ovo istraživanje pruža okvir za dalja istraživanja u oblasti upravljanja brendom, posebno u pogledu efikasnosti različitih modela upravljanja. Istraživanje ukazuje da gradske vlasti i menadžeri Brenda, treba da razmotre primjenu PDCA ciklusa, kao alat za kontinuirano unapređenje svojih strategija brendiranja.

Ključne riječi: PDCA ciklus, brendiranje grada, lokalni razvoj, korisnici usluga grada, kontinuirano unapređenje.

Application of the PDCA cycle to the creation and development of a city brand

Abstract: This paper presents the application of the PDCA cycle (Plan-Do-Check-Act) as a methodological approach in the creation and development of a city brand. The stages of the PDCA cycle are adapted to the city branding process through four key steps. The planning phase (Plan) involves the analysis of the city's image, identification of target user groups, and defining the brand strategy. The second stage (Do) focuses on the implementation of the strategy, including the development of a visual identity and execution of marketing campaigns. In the third phase (Check), the success of the branding efforts is measured through feedback collection and market analysis. The final stage (Act) is aimed at continuous adjustment and improvement of the brand strategy based on the obtained results. The proposed application of the PDCA cycle allows for systematic management of the branding process, tailored to dynamic changes and the needs of different user groups.At a theoretical level, this research provides a framework for further studies in the field of brand management, particularly regarding the efficiency of various management models. The research indicates that city authorities and brand managers should consider the application of the PDCA cycle as a tool for the continuous improvement of their branding strategies.

Keywords: PDCA cycle, city branding, local development, city service users, continuous improvement.

1. Introduction

Economic growth and the development of production depend on innovation and the spread of knowledge, which drive the transformation of local production systems. Local firms are key to introducing innovations into development processes, and the knowledge accumulated within organizations forms the foundation for progress (Miljanović, 2016).

Strong cities-brands-play a crucial role in global economic development, attracting foreign investments and enhancing their nations. Their ability to recognize changes in both internal and external environments, through local economic plans, enables the building of a city brand, creating conditions for the implementation of development strategies.

A city, as a system with a complex structure, stochastic nature, dynamic, open, and with real functional characteristics, will be viewed through the lens of a process approach. This approach allows for an understanding of the city not only as a static entity but as an organism in constant interaction with its environment. This emphasizes the importance of continuous processes that shape its development, including economic, social, and cultural dynamics, which together define the city as a changing and complex whole. The application of the PDCA (Plan-Do-Check-Act) cycle to the building and development of a city brand can be understood as a key process framework that enables continuous improvement and adaptation in line with changes in the city's internal and external environments. The PDCA cycle, consisting of phases of planning, implementation, result checking, and adjustment, can be related to various aspects of city development and branding.The PDCA cycle is an important part of quality management theory. It represents the core idea of total quality management, divided into four phases: Plan, Do, Check, and Act (Xiao et al., 2024).

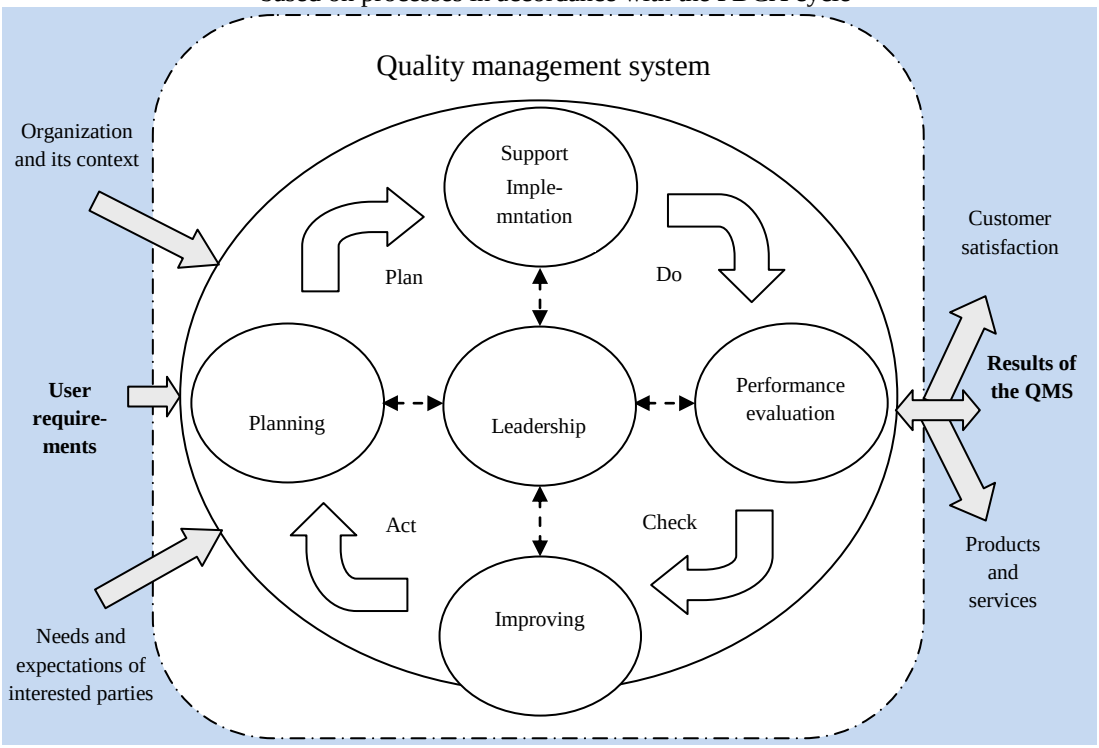
This study provides a theoretical framework for the application of the PDCA cycle in the city branding process, highlighting its potential for long-term development and brand recognition. Further research will focus on the empirical verification of the effectiveness of this methodological approach to determine how much the PDCA cycle contributes to the optimization of branding strategies and enables city authorities and experts to better understand market dynamics and user needs.

2. The PDCA cycle

The PDCA cycle, also known as the Deming cycle, is a key concept in Lean Manufacturing, first developed in the 1930s by Walter A. Shewhart and later refined by William Edward Deming in the 1950s (Realyvásquez-Vargas et al., 2018). PDCA stands for Plan, Do, Check, Act, emphasizing problem-solving without assuming pre-determined solutions.

The Planning phase involves setting SMART goals and creating a detailed plan to meet them. In the Do phase, the plan is tested on a small scale, allowing for controlled implementation and data collection, identifying potential issues (Gray, 2021). The Check phase evaluates the results, comparing actual outcomes with expectations, determining if changes are effective and sustainable (Hock et al., 2024). The iterative nature of PDCA enables continuous improvement, and in the Act phase, successful changes are standardized. If the results are unsatisfactory, the cycle begins anew with adjustments (Protzman et al., 2022).

Figure 1: Schematic representation of the quality management system model based on processes in accordance with the PDCA cycle



Source: (SRPS ISO 9001:2015)

PDCA is widely applied across industries to improve management, processes, and products due to its systematic, adaptable nature (Ružičić & Mićić, 2020). The cycle aligns with the ISO 9001:2015 standard, which emphasizes process management and interaction through the PDCA framework (Vučurević, 2023), representing a shift from a functional to a process-oriented quality management approach, Figure 1.

The Deming Circle provides a systematic approach to continuous improvement. If expected results are not achieved after a cycle, a new cycle should begin with an improved plan based on accumulated knowledge from previous cycles. Identifying and managing processes within an organization forms the foundation of the principles of process approach.

3. City Branding

Cities, as complex social organizations, can be analyzed from various angles, including spatial, economic, cultural, and social relations. City branding focuses management on broader urban issues, aiming for long-term competitiveness and sustainable community development within a wider market context.

City branding is increasingly important as cities recognize the need to promote themselves as brands, not just to residents but also to businesses and visitors. Research explores both online and offline city branding, seeking to understand how visitors perceive cities and gather information (Molina et al., 2017). Efforts include creating a favorable city image through visuals, storytelling, and events to gain a competitive edge (Boisena et al., 2018).

City branding has three key dimensions: physical attributes like logos or architecture, functional attributes such as business opportunities and cultural activities, and personality traits tied to emotional and cultural connections (Li X, 2017). These dimensions work together to foster positive relationships between the city and its target audience, encouraging engagement (Alhamari et al., 2022).

City branding is also a dialogue between governments and residents, aiming to build public support for political structures and governance (Budnitsky & Jia, 2018). Social participation plays a key role in achieving branding goals (Kolotouchkina & Seisdedos, 2018). While assessing quality of life can be challenging, city rankings still impact competitiveness, making it essential for administrations to emphasize the city’s benefits (Portugal, 2019).

4. Research methodology

The research methodology in this paper is centered on the development of the PDCA cycle as a model for the systematic construction and development of a city brand, as detailed in the doctoral dissertation by Miljanović (2016). This model was designed to continuously adapt branding strategies to various target groups (residents, tourists, businesses, investors), thus enhancing the city's recognition and competitiveness in the market. Miljanović's dissertation provides a theoretical foundation for applying the PDCA cycle in city brand management, enabling strategic development based on evaluations and improvements.

The PDCA (Plan-Do-Check-Act) cycle serves as a tool for the continuous improvement of the branding process through four key phases: planning, implementation, monitoring, and evaluation, followed by strategy adjustment. The methodological approach in this paper follows these steps:

Planning: in this phase, strategic branding goals for the city are defined, the needs of target groups (residents, tourists, businesses) are analyzed, current city image research is conducted, and opportunities for positioning are identified;

Implementation: this phase focuses on executing branding through concrete activities, such as developing visual identity, marketing campaigns, and city promotions. The defined strategies are put into action;

Checking: in this phase, the effectiveness of the implemented activities is evaluated using various quantitative and qualitative methods (e.g., surveys, statistical analyses);

Acting: based on the evaluation results, strategies are adjusted, incorporating necessary improvements and innovations to enhance branding effectiveness and sustainability in the long term.

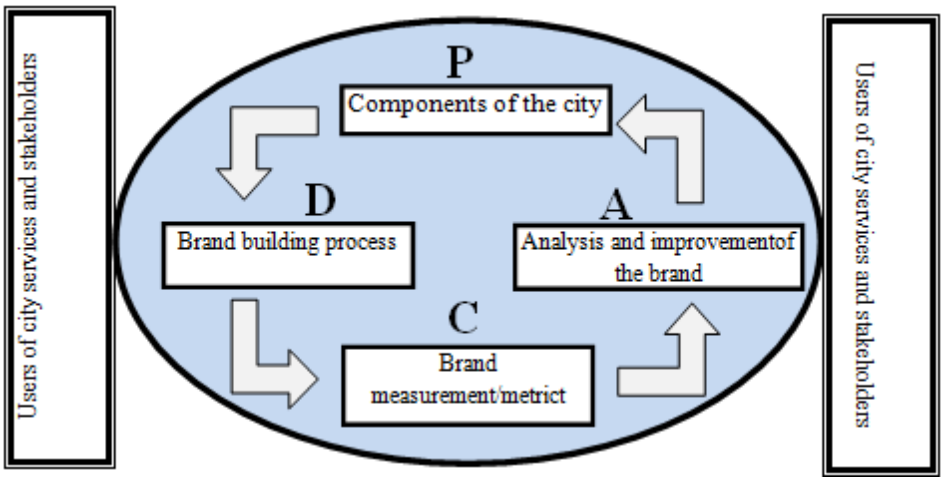
The goal of this methodology is to foster a flexible and adaptive approach to city branding that continuously aligns with the changing needs and expectations of users. This contributes to the long-term strengthening of the brand and its impact on local economic development. The cyclical nature of the model allows cities to consistently evaluate and improve their branding strategies, enhancing the city's image, recognition, and attractiveness as a destination for investment, tourism, and living.

Cities that regularly implement the PDCA approach to branding become more competitive in attracting investments, residents, and tourists compared to those that do not adopt such a methodology. From this methodological foundation, we can infer that applying the PDCA cycle in city branding leads to better alignment of strategies with target groups (residents, tourists, businesses, investors) and that continuous adaptation of city brand strategies based on PDCA evaluations enhances the city's competitiveness in attracting investments, residents, businesses, and tourists.

4.1 Application of the PDCA Cycle to Brand Building and Development

The application of the PDCA cycle (Plan-Do-Check-Act) to the construction and development of a city brand can be explained through four key stages, Figure 2 (Miljanović, 2016).Starting from user requirements on both sides of the model, the PDCA cycle applied to city branding processes is outlined. Effective collaboration between users and employees is essential to create a city brand that reflects genuine user satisfaction. A strategic analysis of the city's characteristics, focusing on the basic needs of urban service users, provides a foundation for branding. This includes considering the expectations of residents, tourists, the economy, and investors.

Figure 2: PDCA cycle applied to the city brand-building processes



Source: (author)

Residents prioritize job opportunities, cost of living, infrastructure, education, healthcare, environmental preservation, and quality of life. Tourists value recreation, hospitality, cultural and natural attractions, and city authenticity. The economy requires efficient public services, fair management, and financial and non-financial support, while investors seek qualified human resources, business-friendly regulations, and well-equipped investment locations. Based on these needs, the branding opportunities for Trebinje will be explored.Figure 2. - PDCA cycle applied to the city brand-building processes.

Plan

In the model, city branding develops through interconnected processes, considering fundamental components like infrastructure, institutions, economy, natural environment, and attractions.

The planning phase involves defining the needs of urban service users, assessing the city’s identity and image, and setting brand development goals. This includes:

Research and analysis: conducting SWOT and PEST analyses, and gathering GIS data to assess the city’s current state.

Target group identification:defining key demographics like tourists, investors, and business owners, and developing the city's positioning strategy;

Brand strategy: forming a strategy based on brand mission and value, focusing on what users truly want, and prioritizing actions to achieve branding goals.

Do

This phase involves the process of building the city's brand, which requires time, dedication, and perseverance. Giffin notes that successful branding relies on building strong, lasting relationships based on trust and consistency. Key steps include:

Understanding core attributes: identifying the products and services the city offers and anticipating the needs of target users;

Developing a visual identity: creating a logo, slogan, colors, and other visuals that represent the brand's values;

Marketing and promotion:developing and executing a marketing plan through social media, events, and fairs, involving professionals to align with the city's goals and vision;

Community collaboration: engaging residents and businesses through workshops and joint events to strengthen the brand.

Check

In this phase, progress is monitored and evaluated against established goals, which includes:

Data collection: employing quantitative and qualitative methods (such as surveys, social media analysis, and visitor statistics) to assess branding effectiveness. Various methods exist for calculating a city's brand value, allowing for evaluation of its image, strength, and overall value. This assessment highlights the role of cities in local economic development, though evaluating a city’s brand is more complex than that of a business due to the wide array of services and revenues involved. Brand value, while intangible, can be gauged by analyzing consumer attitudes and market behaviors, along with financial indicators;

Evaluation of results: comparing the outcomes with the set goals to determine branding success and areas needing improvement. Measuring brand value is a complex process that involves analyzing current conditions and dynamic changes to forecast future trends. Key elements from the consumer perspective include market recognition, image, affinity, and awareness, which help understand the brand's competitive position, identify weaknesses, and outline developmental directions for enhancing business operations.

Act

This phase emphasizes proactive actions based on the findings from the checking phase, aiming to enhance the city branding strategy. Key steps include:

Updating the strategy: The strategy is revised based on evaluation results to better align with the target audience's needs and expectations while considering new market trends and competitive activities. This may involve redefining priorities, altering marketing approaches, or targeting new market segments;

Implementing improvements: Specific measures are introduced to strengthen the brand based on identified opportunities and weaknesses. This could involve launching new campaigns, innovating service offerings, improving visual identity, or collaborating with partners to enhance the city’s recognition. Implementation should be systematic and focused to positively influence brand perception and value;

Continuous improvement: Brand development is an ongoing process requiring constant adaptation and refinement. In this phase, the city fosters a culture of continuous learning and innovation through regular result analysis, environmental monitoring, and readiness to adapt. This dynamic approach ensures the brand's long-term sustainability and relevance in a changing market.

Applying the PDCA cycle to city brand development provides a systematic method for effective planning, implementation, and evaluation of branding activities. This approach aids in identifying and addressing issues, as well as adjusting strategies based on feedback, contributing to the long-term success and recognition of the city brand.

5. Discussion

Based on the theoretical application of the PDCA cycle in city branding, several key conclusions can be drawn that may guide future research and testing of this model:

Increased brand recognition: Cities that systematically implement the PDCA cycle across all brand development stages (planning, implementation, evaluation, and improvement) are likely to achieve higher recognition among target groups. Continuous strategy adjustments can enhance responsiveness to environmental changes and user needs, leading to an improved city image;

Flexibility of branding strategies: The PDCA model fosters greater flexibility in adapting to market changes. Cities that effectively incorporate feedback from the evaluation phase can respond swiftly to competitive pressures and shifts in consumer behavior, keeping their branding strategies dynamic and competitive over the long term;

Long-term economic impact: Cities with a strong brand, built through the PDCA model, may experience positive economic outcomes, such as increased tourism and investment, enhanced perceptions as attractive places to live and work, and greater local community involvement. These insights suggest that the PDCA cycle can strengthen the city brand while directly contributing to economic development;

Role of visual identity and marketing: During the implementation phase of the PDCA model, developing a visual identity and strategic marketing is crucial for successful branding. Cities that maintain a consistent visual identity and execute marketing campaigns through various channels (social media, events, promotional activities) can expect higher engagement and favorability from their target audience.

These conclusions provide a foundation for further research and empirical testing of the PDCA model in city branding, aiming to validate theoretical insights with practical examples.

6. Conclusion

Based on the application of the PDCA cycle to city brand development, it can be concluded that successful branding requires a comprehensive and systematic approach focused on continuous improvement and strategy adaptation. This cycle allows cities to effectively plan, implement, monitor, and adjust brand-related activities, offering flexibility to respond to the changing needs and expectations of various user groups—residents, tourists, businesses, and investors.

The PDCA model's primary strength lies in its ability to help city authorities identify improvement opportunities, respond swiftly to market changes, and adjust strategies according to actual user needs. Cities adopting this model can enhance their image and recognition, making them more attractive for living and business, which in turn supports long-term economic development.

In the initial phase, strategic planning helps understand needs and lays the groundwork for a strong brand. The implementation phase highlights the importance of consistency in visual identity, marketing, and community engagement. The evaluation phase allows for objective monitoring of progress and identification of areas for improvement. The final phase of the PDCA cycle emphasizes taking action based on insights gained, adjusting strategies, and promoting continuous enhancement.

The next step after applying the PDCA cycle is to focus on the "Act" phase, where strategies should be updated based on prior results. This includes implementing specific improvements and continuously monitoring progress to adapt strategies to current user needs and market trends. Strengthening the brand can be achieved through new marketing campaigns, enhanced visual identity, and increased community involvement. This ongoing process ensures that the city brand remains relevant and competitive.

Such an approach positions city branding as a dynamic process that evolves with changes in the environment and user needs, fostering a sustainable and enduring brand that contributes to local and regional development.

This study adds to the literature on city branding, especially regarding the application of the PDCA cycle. Theoretically, it provides a framework for further research in brand management, particularly concerning the effectiveness of different management models. The findings suggest that city authorities and brand managers should consider the PDCA cycle as a tool for continuously improving their branding strategies.

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Industrija 4.0 i neophodne kompetencije i znanja u savremenom okruženju na primeru računovodstvene profesije

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Industrija 4.0 i neophodne kompetencije i znanja u savremenom okruženju na primeru računovodstvene profesije

Apstrakt: Rad istražuje međusobnu vezu između znanja i veština neophodnih u kontekstu četvrte industrijske revolucije i računovodstvene profesije. Četvrta industrijska revolucija ili Industrija 4.0 karakteriše se brzim napretkom tehnologije, uključujući veštačku inteligenciju, automatizaciju, internet tokove i velike podatke, što direktno utiče na evoluciju računovodstvenih praksi. Kroz analizu uticaja ovih tehnoloških inovacija na računovodstvo, istražuje se kako se tradicionalne uloge računovođa transformišu, naglašavajući potrebu za lnovim znanjima i veštinama. Konačno, analizira se kako ova transformacija utiče na ulogu računovodstvene profesije u pružanju dodatne vrednosti organizacijama u dinamičnom poslovnom okruženju.

Ključne reči: Industrija 4.0, znanje, veštine, kompetencije, računovodstvo

Jel klasifikacija: O19, F63, M41

Industry 4.0 and the necessary competences and knowledge in the modern environment on the example of the accounting profession

Abstract: The paper explores the mutual relationship between knowledge and skills necessary in the context of the Fourth Industrial Revolution (4IR) and the accounting profession. The Fourth Industrial Revolution or Industry 4.0 is characterized by rapid technological advancement, including artificial intelligence, automation, Internet of Things, and big data, which directly influences the evolution of accounting practices. Through an analysis of the impact of these technological innovations on accounting, the study investigates how traditional roles of accountants are transforming, emphasizing the need for new knowledge and skills. Finally, it analyzes how this transformation affects the role of the accounting profession in providing additional value to organizations in a dynamic business environment.

Keywords: Industry 4.0, knowledge, skills, competetion, accounting.

Jel clasification:O19, F63, M41

1. Introduction

The fourth industrial revolution represents an era of accelerated technological progress that is transforming global business in all sectors. In this turbulent environment, the accounting profession is no exception, but faces the challenge of adapting to new technological paradigms in order to remain relevant and effective.

A key factor that determines the success of accountants in the era of the fourth industrial revolution is their ability to acquire and apply the advanced knowledge and skills that these technological advances require. This paper explores the deeper interrelationship between the knowledge and skills necessary in the context of the contemporary fourth industrial revolution and the accounting profession. The focus is on identifying key technological innovations such as artificial intelligence, automation, the Internet and big data analytics, which directly affect the evolution of accounting practices.

Special attention is paid to the transformation of the traditional roles of accountants and the need for new competencies is emphasized in order to respond to the challenges and take advantage of the opportunities brought by the Fourth Industrial Revolution.

It will further be analyzed how this transformation affects the role of the accounting profession in the context of providing additional value to organizations in a dynamic and digital business environment. Through a review of the relevant literature, this paper should provide insight into key strategies and guidelines for the education, training and professional development of accountants in order to successfully navigate through the challenges and opportunities brought by the era of the fourth industrial revolution.

The work should also open up new questions for the professional and scientific public.

2. Knowledge as the most important resource

In the 17th century, the famous English philosopher, lawyer, and statesman Francis Bacon proclaimed that "knowledge is power." Even then, he recognized the potential of knowledge to empower and improve individuals and societies. He believed that by acquiring knowledge and understanding the world, people could gain control over it and use its resources to their advantage. Bacon based his view on the belief that knowledge is not just theoretical or abstract, but also has practical implications. In other words, it enables individuals or societies to make informed decisions, solve problems, and achieve their goals.

Over time, knowledge became increasingly important and came to be regarded as a critical resource, alongside physical resources (material goods), capital, land, etc. The concept of knowledge is vast, encompassing many different components, and is constantly evolving. For this reason, there is still no single definition of knowledge. Various authors define knowledge in different ways and from different perspectives. From the perspective of epistemology, the branch of philosophy concerned with human knowledge, knowledge is the same as consciousness (Inkpen, Tsang, 2005). According to another group of authors, knowledge is equivalent to experience, or knowledge is seen as the sum of human cognitive experience. From the perspective of ontology, knowledge is a unique resource produced through the interaction between living and non-living matter. From an economic perspective, knowledge is viewed in relation to human capital and information at the microeconomic level, while at the macroeconomic level, it is mainly considered in relation to technological factors that underlie growth theory (Kešeljević, 2013).

Knowledge is traditionally defined as true, justified belief (Johansson, 2016). The Oxford Dictionary defines knowledge as (i) information, understanding, and skills acquired through education or experience, (ii) awareness of a particular fact or situation (knowledge of something), and (iii) information considered a resource that is used and delivered to industries instead of producing goods (Oxford Dictionary, 2024). According to the Merriam-Webster Dictionary, knowledge is "the fact or condition of knowing something with familiarity gained through experience or association" (Merriam-Webster, 2024).

The concept of knowledge is penetrating, evaluative, agentic, and objective (Vega-Encabo). Penetrating refers to the fact that we are introduced to knowledge from a young age. Evaluative refers to the idea that possessing certain knowledge implies meeting a particular standard or norm. The next characteristic assumes the existence of agents engaged in cognitive tasks and practices. Finally, objectivity is seen in the existence of an objective answer. Moreover, knowledge is crucial in many aspects of human life, as it allows for better decision-making, problem-solving, innovation, and progress. In modern society, knowledge is often viewed as a key resource for economic development, competitiveness, and technological advancement.

3.1. Types of knowledge

The breadth of the concept of knowledge has led to the differentiation of several distinct types of the same: (Whelan, 2024)

- Explicit knowledge
- Implicit knowledge
- Tacit knowledge
- Procedural knowledge
- Declarative knowledge
- A posteriori knowledge
- A priori knowledge

Explicit knowledge is knowledge that covers topics that can be easily documented (in writing) and shared on a large scale. Implicit knowledge refers to learned skills or knowledge. It is acquired by taking explicit knowledge and applying it to a specific situation. Tacit knowledge is intangible information that can be difficult to explain directly, such as things that are often "understood" without necessarily being spoken, and are often personal or cultural. This type of knowledge is informal, learned through experience over time, and usually relates to a particular situation. Declarative knowledge, also understood as propositional knowledge, refers to static information and facts specific to a given topic, which can be easily accessed and retrieved. Procedural knowledge focuses on the "how" behind how things work, and is demonstrated through one's ability to perform a task. A posteriori knowledge is a subjective type of knowledge gained from individual experience. This type of knowledge allows individuals to understand their strengths and weaknesses that arise from their experiences. A priori knowledge is the opposite of a posteriori knowledge and is acquired independently of experience or evidence. This type of knowledge is often shared through logical reasoning or one's ability to think abstractly.

3. Types and characteristics of skills

In the 21st century and the modern turbulent business market, both business operations and performing tasks require a certain level of skills. A set of skills is a list of abilities or capabilities to perform a specific task effectively. Historically, the term "skill" was used to refer to the expertise and technologies of craftsmen (Abdel-Wahab et al., 2005). Skills encompass everything from reading, precision in writing, communication, reasoning, problem-solving, to motivation and self-confidence, judgment, leadership, teamwork, customer orientation, self-control, and continuous learning (Payne, 1999). In short, a skill is an ability that enables an individual to apply their knowledge in practice in order to successfully complete tasks, solve problems, or perform specific activities. Skills are acquired both through learning and through experience.

More than fifty years ago, Knapp (1963) defined skills as a learned ability to achieve predetermined results with maximum certainty, often with minimal use of time or energy, or both. A skill is used to denote expertise developed through training and experience, which includes trade and craft skills gained through training, as well as high levels of performance found in many domains, such as professional practice, art, games, and athletics.

Understanding the difference between knowledge and skills is crucial for personal and professional development. Knowledge refers to the information and understanding acquired through learning and experience. This includes familiarity with facts, theories, and concepts about a subject. On the other hand, skills are the practical application of knowledge to perform tasks efficiently. They develop through practice and experience and involve the ability to apply knowledge in real-world situations.

While knowledge provides the foundation and understanding of concepts, skills enable individuals to execute tasks and achieve specific outcomes. For example, in a professional environment, knowledge of project management theories (knowledge) is different from actual project management (skill). Similarly, understanding coding principles (knowledge) differs from writing programs (skills).

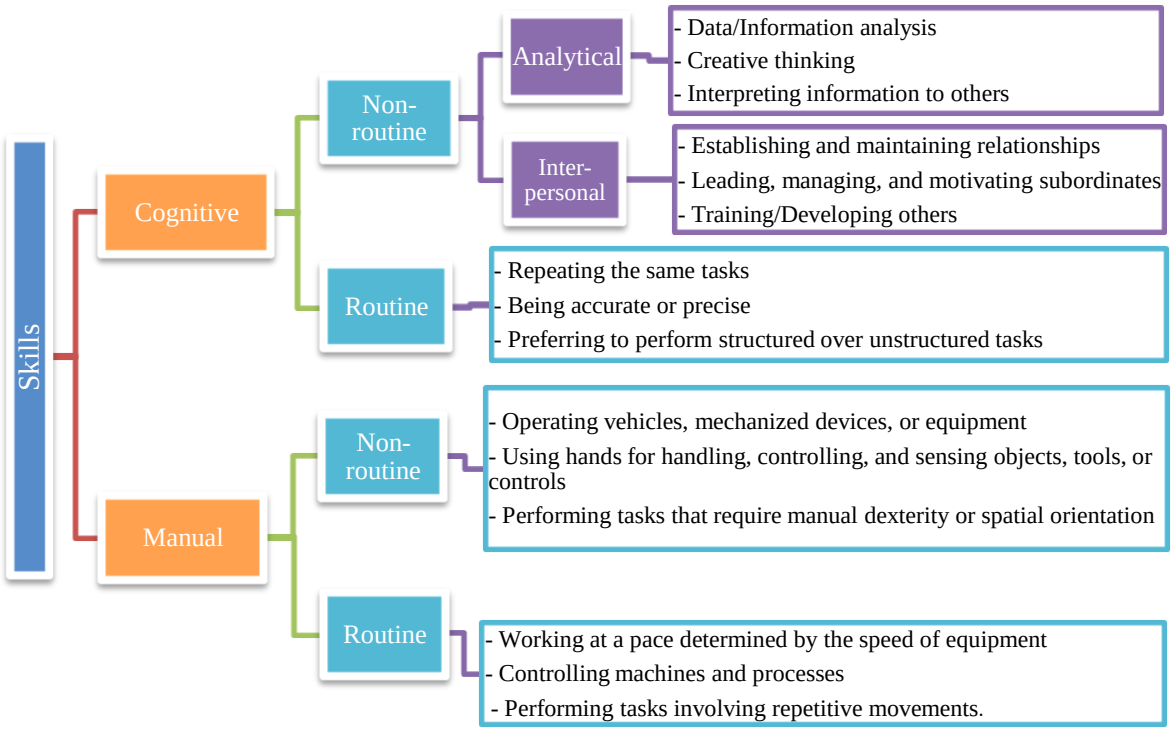
Both knowledge and skills are important. Knowledge provides the theoretical framework, while skills turn that knowledge into action. Employers often seek candidates who not only possess relevant knowledge but also demonstrate practical skills that can contribute to the organization's goals.

In short, knowledge is what you know and understand, while skills are what you can do with that knowledge. Both are essential components of competence and success in various aspects of life.

The complexity of today's world, among other things, is reflected in hyperconnectivity. In such a world, possessing a range of different skills is of vital importance for the survival and success of every individual, as the ability to define, develop, and use one's skills is considered a crucial part of personal and professional affirmation. In this context, it is necessary to make a distinction between different types of skills. Today, the professional literature offers various classifications of skills.

The classification proposed by the World Bank (2013) divides all skills into two main groups: cognitive and manual. With regard to their use, both groups are further subdivided into two subgroups: non-routine and routine skills. Cognitive non-routine skills can be analytical and interpersonal. A detailed typology of skills and sub-skills applied by the World Bank, as well as the characteristic activities, is presented in Figure 1. This success largely depends on acquiring and maintaining both soft and hard skills.

Figure 1: Types of skills and sub-skills



Source: (Adapted from Aedo et al., 2013)

Another typology commonly encountered in the literature is based on the idea that skills are related to an individual's performance level on a specific task or their ability to effectively perform a job, which can be divided into technical elements and behavioral elements (Noe et al., 2015). Technical elements represent hard skills, while behavioral elements constitute soft skills. Hard and soft skills are key components of a well-rounded skill set that individuals use in performing their professional activities. Understanding the differences and synergy between these two types of skills is essential for personal and professional development.

Hard skills refer to specific, teachable abilities that can be quantitatively measured and defined. These skills are typically acquired through formal education, training programs, certifications, and practical experience. Examples of hard skills include: (Indeed, 2024)

- Analytical skills – skills related to data analysis and management: data collection, data analysis, summarization and categorization, reporting, data searching, data visualization, web analytics.
- Sales skills – skills focusing on sales and its aspects, including: sales presentations and demonstrations, product knowledge, client engagement, active listening, conflict management, sales presentations, product development, business communication.
- Marketing skills – marketing is a broad field that requires mastery of many skills: search engine optimization (SEO), copywriting, social media, social media marketing, content management systems.
- Technological skills – these require advanced knowledge and certifications. Examples include: machine learning, natural language processing, HTML, Javascript, CSS, blockchain.
- Computer skills – these refer to knowledge of working with computers and include: operating system optimization, word processing, creating presentations, reporting, communication across different platforms.
- Financial skills – areas affecting the development of financial expertise include: financial modeling, financial systems, data processing, cost analysis, cost reduction, forecasting, risk analysis.
- Project management skills – common project management skills: project planning, business analysis, scheduling, goal setting, delegating, project control.
- Language skills – proficiency in foreign languages.

In contrast to hard skills, soft skills are generally not acquired through formal education and training, and often require dedication, self-reflection, and self-improvement (Lamri, Lubart, 2023). These skills are less tangible and often harder to quantify compared to hard skills. Soft skills are affective abilities that a person possesses in addition to their ability to master formal intellectual and technical knowledge of a discipline, which helps them be accepted in social and work environments. Soft skills are often referred to as "core skills" in the literature. (Ibrahim et al., 2017)

Core soft skills include: (Craig, Stewart, 2024)

- Listening – receiving, retaining, and processing information or ideas.
- Speaking – verbal communication of information and ideas.
- Problem-solving – the ability to find solutions to situations or challenges.
- Creativity – using imagination and generating new ideas.
- Staying positive – the ability to use tactics and strategies to overcome failure and achieve goals.
- Setting high goals – the ability to set clear, tangible goals and create a robust path to achieve them.
- Leadership – supporting, motivating, and developing others to achieve a common goal.
- Teamwork – working collaboratively with others to achieve a common goal.

Soft skills are crucial for nurturing a positive work environment, building strong relationships, and increasing overall productivity and morale within an organization. They are often considered as important as hard skills, especially in leadership roles and positions that involve client interaction, where interpersonal skills play a significant role.

While hard skills demonstrate technical competence, soft skills complement them by enhancing interpersonal effectiveness and the overall workplace dynamic. However, competence should be viewed as a broader concept that encompasses abilities, knowledge, skills, attitudes, and experiences that a person must possess to successfully perform tasks or functions in a given context. Competence also represents the ability to apply relevant skills and knowledge in specific situations.

4. Knowledge and skills in Industry 4.0 and connection with competencies in the field of accounting

Industry 4.0 refers to a smart factory where cyber-physical systems monitor physical processes and create a virtual model of the physical world that aids in decentralized decision-making.

The term Industry 4.0 originated from a German government project for a high-tech strategy aimed at promoting the computerization of factories. Industry 4.0 is synonymous with the Fourth Industrial Revolution.

Industry 4.0 covers three main aspects (Petrillo et al., 2018):

1. Digitization and increased integration of vertical and horizontal value chains: development of customized products, digital customer orders, automatic data transfer, and integrated systems for customer support.
2. Digitization of product and service offerings: complete descriptions of products and related services through intelligent networks.
3. Introduction of innovative digital business models: a high level of interaction between systems and technological capabilities leads to the development of new and integrated digital solutions. The foundation of the Industrial Internet is integrated system accessibility and control across the enterprise in real-time.

The defining characteristic of the Fourth Industrial Revolution is the blurring, and in some cases almost complete elimination, of boundaries between the physical, digital, and biological worlds (Dašić, Anufrijev, 2022).

Above all, Industry 4.0 represents the integration of intelligent digital technologies into manufacturing and industrial processes. It encompasses a set of technologies based on digitization, including the Internet of Things, artificial intelligence, big data, nanotechnology, and robotics. Industry 4.0 in manufacturing processes employs new forms of interaction between machines and humans using a combination of old and new technologies categorized into three groups (Javeed, 2023):

- Hardware: robotics, cobots (collaborative robots), 3D printers;
- Software: big data, artificial intelligence; and
- Connectivity: Internet of Things, actuators, and sensors.

The transition to Industry 4.0 provides numerous opportunities but also highlights the knowledge and skill gaps that must be overcome. In the White Paper, Roland Berger (2016) states that qualifications and skills are divided into "high focus" and "low focus" categories. The segment of important qualifications and skills for Industry 4.0 is further divided into sub-segments (Table 1.).

Table 1: Knowledge and Skills for Industry 4.0

Knowledge of ICT	Ability to work with data
– Basic knowledge of information technologies. – Ability to use and interact with computers and smart machines such as robots, tablets, etc. – Understanding of communication between machines, IT security, and data protection.	– Ability to process and analyze data and information obtained from machines. – Understanding of visual output data and decision-making. – Basic statistical knowledge.
Technical konowledge	Personal skills
– Interdisciplinary and general knowledge of technology. – Specialized knowledge of manufacturing activities and processes on-site. – Technical knowledge of machinery for performing activities related to maintenance.	– Adaptability and ability to change. – Decision-making. – Teamwork. – Communication skills. – Changing mindset for lifelong learning.
More focus	Less focus

Source: (Aulbur et al., 2016)

A detailed overview of the competencies is provided in Table 2.

Table 2: Example of a skill set for Industry 4.0 in relevant academic and research studies

References	Skills/Competencies/Capabilities	
Klement, Strambach, 2019	– Learning to think with the help of software – Able to understand network structures – Learn how to master big data technology – Learn how to work with different data formulas – Understands and masters the process or implementation of work activities – Learn to take on more responsibility in any job – Learn to be communicative and cooperative workers – Learn how to have high innovation and initiative – Focus on developing sensitivity to the environment and social life through technological development and innovations	
Rozmirez-Montoya et al, 2022	– Knowledge of information and production technology – Knowledge of software structures – Understanding the function of hybrid exercises – Experience in mechatronics – Sharpening skills in the social domain of coworker relations – Sharpening abilities in software usage – Ability to change programs – Capable of performing tasks in a measurable way – Able to make decisions – Expert in their field for at least 2 years – Ability to use the internet both manually and with data – Broad and focused knowledge – Expert in processes and technology usage – Have an optimistic spirit – Able to read and assess the use of data on a device or machine in use	
Passig, Cohen, 2013 Sloane, 2011	– Digital skills in the areas of: Industry 4.0 programming and software engineering, data science, data analysis and big data, visualization, Internet of Things, IT architecture, security – Project coordination skills: product management, multi-project management, supply chain and support services, logistics – Soft skills: creativity, design, innovation, leadership, teamwork	
Xiaoguang, 2022	Employees: – Technical skills – Problem-solving ability – Ability to use IT systems – Analytical capacity – Communication – Lifelong learning – Technical and managerial skills – Ability to work in a team – Openness to change – Openness to digitalization – Openness to automation	Managerial staff: – Lifelong learning – Social media skills – Technical and managerial skills connection – Ability to work in a team – Openness to change – Openness to digitalization – Striving for continuous improvement – Participation – Openness to automation – Creativity – Creative thinking – Self-discipline – Self-management

Source: (Adapted fromGajdzik, Wolniak, 2022)

In the environment characteristic of Industry 4.0, the synergy between knowledge and skills is essential for career success and advancement. Employers often look favorably upon individuals who possess a balance between these two components, as they can effectively contribute to both individual tasks and collective team efforts. Although the connection between the Fourth Industrial Revolution and accounting may not be immediately obvious, it is constantly influencing the field of accounting. The characteristics of Industry 4.0 directly impact accounting in several ways:

1. Automation of processes
2. Analytical skills
3. Blockchain technology
4. Artificial intelligence
5. Risk management

The principles of work that were applied in the past have largely remained unchanged, but the work of accountants has significantly transformed with the development of information technology, making it necessary to continuously monitor and adapt to ongoing changes. The use of accounting software has greatly facilitated and advanced the work of accountants (Šarić and Banda, 2023). Today, electronic documents are in use, accounting is performed through accounting programs, and tax and contribution payments are processed electronically. Accounting is increasingly being automated with the help of software that can independently perform routine tasks such as posting transactions, preparing reports, or calculating salaries. This frees accountants to focus on analytical and strategic activities.

Big data enables accounting to analyze vast amounts of information to identify patterns and trends that could impact the financial operations of an organization. From the perspective of forensic accounting, for example, Anufrijev (2024) points out that forensic accountants are increasingly expected to possess analytical skills, but also specialized and expert knowledge in areas such as the fundamentals of accounting, management accounting, economics, banking, law and legal regulations, taxation, criminology, and certain investigative actions. The goal is to provide quality and undisputed information and/or valid material evidence through forensic tools and techniques, which would be crucial for objective conclusions and judicial verdicts in court proceedings. Forensic accountants are often registered as permanent court experts in this important field.

When it comes to blockchain, it has the potential to revolutionize the way financial transactions are recorded and verified, reducing the need for intermediaries and increasing transparency. According to Horvatić and Tafra (2022), the possibilities for applying blockchain technology are numerous: from protocols for recording and storing data on business events to the digitization of key business operations (e.g., supply chain management). Artificial intelligence can help predict future financial outcomes, optimize tax strategies, or even detect fraud. By using AI to analyze processes and controls in organizations, various tools can identify weaknesses that might lead to potential fraud (Anufrijev and Marjanović, 2024). Given the sophisticated information technologies used in Industry 4.0 organizations, this interconnectedness is crucial, as the development of AI increases the number, volume, and technological complexity of fraudulent activities, which are susceptible to rapid transformation and change.

Accounting can leverage the technologies of the Fourth Industrial Revolution to better manage risks, providing real-time information and analysis to aid in decision-making. According to Anufrijev (2023), a key component of risk management is assessing the impact of external elements affecting the business environment, such as new market competition and the total number of competitors in a given industry. Risk indicators might include the number of failed transactions, turnover rates per employee, and the frequency and/or severity of errors and omissions (Živković, 2019). All these changes require accountants and financial experts to be ready to adopt new technologies and adjust to new ways of working.

Thus, the Fourth Industrial Revolution directly impacts the development and transformation of accounting, making it more efficient, accurate, and capable of providing additional value to businesses. Competencies and knowledge in the context of the accounting profession refer to key traits, abilities, or characteristics required to perform accounting tasks.

Knowledge here implies an understanding of theoretical principles and practical skills that accountants must possess to carry out their duties efficiently. In the accounting profession, this includes:

1. Technical knowledge – A deep understanding of accounting standards, laws, regulations, and methods, such as double-entry bookkeeping, balance sheet analysis, and understanding financial statements.
2. Financial analytics – Skills in analyzing and interpreting financial data to make correct business decisions. Additionally, there is growing demand for predictive analytics, which requires competencies in using predictive models and analysis to forecast financial outcomes, cash flows, and other key business parameters.
3. Accounting software and technology – Mastery of accounting programs and tools, as well as tools for automating and robotizing accounting processes.
4. Regulatory compliance – Understanding and applying local and international accounting standards and related laws.
5. Ethics and professionalism – Upholding high ethical standards, integrity, and trust, which are crucial to the accounting profession.
6. Communication and collaboration – Skills in communicating with clients, management, and other stakeholders to ensure clarity in financial information and recommendations.

Furthermore, given the rapid pace of technological development, accountants must also possess the ability to manage organizational changes and effectively implement new technologies. Therefore, the era of the Fourth Industrial Revolution has presented accounting with the need for diverse knowledge and skills to effectively respond to the changes brought by advanced technologies. Today, the accounting profession is expected to demonstrate high levels of technological literacy, analytical skills, data management capabilities, software proficiency, an understanding of business models, strong communication and collaboration skills, and a high standard of ethical and moral conduct.

The foundation for possessing these skills necessary for the modern accountant is knowledge, but it also includes a permanent readiness to upgrade that knowledge, enabling accountants to adapt more quickly to new requirements and harness the benefits of technological innovations of the Fourth Industrial Revolution in accounting practice.

5. Results and Discussion

Discussing the findings, accounting not only adapts to the changes brought about by the Fourth Industrial Revolution but actively leverages these changes as an opportunity for improvement and growth. The key challenge remains balancing traditional accounting principles with new technological possibilities. It is important for educational institutions and professional organizations to adjust their curricula and training programs to equip future generations of accountants to manage effectively in the digital age.

Furthermore, the ethical aspects of using technology, such as data privacy and security issues, require careful consideration and regulation to ensure the integrity of financial information and public trust.

6. Conclusion

In the era of Industry 4.0, rapid technological advancements are setting new demands for the knowledge and skills that are crucial for success in various professions and sectors. Artificial intelligence, automation, the internet, and big data analytics are transforming the way we do business and interact with technology.

Key knowledge in this era encompasses an understanding of advanced technological systems and their application in everyday business processes. This includes the ability to analyze and interpret large volumes of data in order to make informed decisions. It is also important to develop skills in using specialized software solutions to effectively perform business functions.

The Fourth Industrial Revolution represents an inevitable transformation for the accounting profession as well, requiring the adaptation of knowledge and skills to take advantage of advanced technologies.

The key challenge for the future of accounting lies in the ability to integrate traditional principles with new technological capabilities, enabling accountants to become not only a reliable source of financial information but also strategic partners in making critical business decisions. Ongoing education and the adjustment of professional practices are essential for success in the dynamic business environment of Industry 4.0, ensuring that accounting plays a central role in supporting organizational growth and innovation in the digital era. Continuous professional development should be an integral part of every accountant's career, ensuring competitiveness and the ability to make strategic business decisions. The accounting profession in the future will require permanent adaptation and integration of new knowledge and skills, which will ensure its survival and growth in a globalized business world.

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Uloga hotelske industrije u postizanju održivosti turističke destinacije: izazovi i najbolje prakse

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Apstrakt: Hotelska industrija igra ključnu ulogu u oblikovanju održivosti turističkih destinacija , delujući kao most između putnika i lokal nih zajednica . Kako destinacije postoje da izbalansiraju ekonomski rast i brigu o životnoj sredini , hoteli stoje na čelu ovog poduhvata . Oni doprinose ne samo lokalnoj privredi kroz otvaranje radnih mesta i stvaranje prihoda , već imaju i kapacitet da implementiraju održivu praksu koja može značajno da utiče na njihov uticaj na životnu sredinu . Štaviše, hoteli mogu da deluju kao kulturni ambasadori , promovišući lokalno nasleđe i atrakcije , čime se obogaćuju iskustvo posetilaca . Međutim, ova tranzicija ka održivosti je puna izazova , uključujući visoke operativne troškove i otpor različitih zainteresovanih strana . Ovaj rad će analizirati ulogu hotelske industrije u postizanju održivosti turističke destinacije, izazive sa kojima se suočava i najbolje prakse koje ilustruju kako hoteli mogu da podstiču održivi turizam .Rezultati pokazuju davećina ispitanika (74,6%) podržava radionice reciklaže, što ukazuje na snažno prihvatanje inicijativa koje imaju za cilj zaštitu životne sredine, bez značajnih rodnih razlika u stavovima. Pored toga, 54,4% u potpunosti podržava edukaciju o odvajanju materijala za kompostiranje i reciklažu, dok 50,4% podržava upotrebu kanti označenih bojama za sortiranje otpada, što odražava zajedničku svest o važnosti pravilnog upravljanja otpadom.

Ključne reči: hotelska industrija, održivi razvoj, turizam.

The hotel industry role in tearms of achieving tourism destination sustainability: challenges and best practices

Apstract: The hotel industry plays a pivotal role in shaping the sustainability of tourism destinations, acting as a bridge between travelers and local communities. As destinations strive to balance economic growth with environmental stewardship, hotels stand at the forefront of this endeavor. They contribute not only to local economies through job creation and revenue generation but also have the capacity to implement sustainable practices that can significantly mitigate their environmental footprint. Furthermore, hotels can act as cultural ambassadors, promoting local heritage and attractions, thereby enriching the visitor experience. However, this transition towards sustainability is fraught with challenges, including high operational costs and resistance from various stakeholders. This paper will analyze the role of the hotel industry in achieving tourism destination sustainability, the challenges it faces, and best practices that exemplify how hotels can foster sustainable tourism.The results show that the majority of respondents (74.6%) support recycling workshops, which indicates a strong acceptance of initiatives aimed at protecting the environment, with no significant gender differences in attitudes. In addition, 54.4% fully support education on separating materials for composting and recycling, while 50.4% support the use of color-coded bins for waste sorting, which reflects a common awareness of the importance of proper waste management.

Keywords: hotel industry, sustainable development, tourism

1. Introduction

The hotel industry plays a pivotal role in shaping the sustainability of tourism destinations, acting as both a facilitator of visitor experiences and a contributor to local economies (Aboramadan et al., 2022; Patwary et al., 2024). However, as global awareness of environmental issues intensifies, the pressure mounts on hotels to adopt sustainable practices. The challenges faced by the hotel industry in achieving tourism destination sustainability are numerous and complex. One of the most significant challenges is the environmental impact of hotel operations, which can lead to detrimental effects on local ecosystems (Bianco et al., 2023). According to Hoang et al., (2025), hotels often consume large amounts of water for laundry, landscaping, and guest services, straining local water resources, especially in arid regions. Additionally, energy consumption is a critical concern; hotels are major contributors to greenhouse gas emissions due to their reliance on energy-intensive heating, cooling, and lighting systems (Álvarez Gil, 2001). According to the United Nations Environment Programme, the hospitality sector accounts for approximately 1% of global carbon emissions, underscoring the urgent need for interventions (Zhang et al., 20244). Furthermore, waste management presents another formidable challenge, as hotels generate substantial amounts of waste, including food, plastics, and hazardous materials (Aslam Janjua et al., 2024). Inadequate waste disposal practices can lead to pollution and harm local wildlife, creating a pressing need for comprehensive waste management strategies within the industry (Kruesi& Remy, 2024).

In response to these challenges, the hotel industry has begun to adopt best practices aimed at promoting sustainability (Knežević et al., 2024). According to Mandić et al., (2024) many hotels have implemented eco-friendly initiatives such as reducing water usage through low-flow fixtures and linen reuse programs, which not only conserve water but also lower operational costs. Furthermore, the integration of energy-efficient technologies has become increasingly prevalent; for instance, the use of LED lighting and smart thermostats can significantly reduce energy consumption. According to Wong & Wickham (2015) a notable example is the Marriott International chain, which has committed to reducing its carbon footprint by 50% by 2025 through various sustainability initiatives. Sustainable sourcing is another crucial aspect, with many hotels now prioritizing local and organic food products, thereby supporting local economies and reducing transportation emissions (Barbara et al., 2024). Waste reduction programs, such as composting and recycling initiatives, have also gained traction in the hotel sector, with organizations like the Green Hotel Association providing guidelines and resources for hotels seeking to minimize their waste output (Ng et al., 2025). These best practices not only contribute to environmental sustainability but also enhance the reputation of hotels as responsible corporate citizens.

The role of policy and regulation in enhancing hotel sustainability cannot be overstated. Governments around the world are increasingly recognizing the importance of sustainable tourism and are implementing policies that promote environmentally responsible practices within the hotel industry (Xin & Wang, 2023). According to Ertuna et al. (2022), various countries have introduced incentives for hotels to obtain sustainable certifications, such as LEED (Leadership in Energy and Environmental Design) and Green Key, which encourage compliance with rigorous sustainability standards (Sheikh, et al., 2024; Wang et al., 2024). These certifications not only signal a commitment to sustainability but also attract environmentally conscious travelers. According to Galli et al., (2018), regulations on waste management and environmental impact have become more stringent, compelling hotels to adopt best practices or face penalties. According to Pham et al. (2020), the European Union has enacted laws aimed at reducing plastic waste, directly impacting hotel operations and prompting the industry to find innovative solutions to minimize plastic usage. By aligning hotel operations with governmental policies, the industry can foster a more sustainable tourism ecosystem that benefits both the environment and local communities (El-Said et al., 2024).

The paper started from the initial hypothesis H that the implementation of sustainable practices in the hotel industry reduces the negative impact on the environment. This analytical paper delves into the multifaceted challenges faced by the hotel industry in achieving tourism destination sustainability, highlights best practices that have emerged in response to these challenges, and examines the critical influence of policy and regulation in promoting sustainable hotel operations. By exploring these dimensions, our paper aims to clarify the interconnectedness of the hotel industry with sustainable tourism and emphasize the need for a collective effort in addressing the sustainability crisis.

The findings reveal that a substantial proportion of respondents (74.6%) endorse recycling workshops, suggesting a robust acceptance of initiatives designed to safeguard the environment, without notable differences in attitudes based on gender. Furthermore, 54.4% express complete support for educational programs focused on the separation of materials for composting and recycling, while 50.4% advocate for the implementation of color-coded bins for waste sorting, indicative of a widespread recognition of the significance of effective waste management.

2. Methodology

Total number of 252 guests of Mona and Grand hotels from Zlatobor and Kopaonik participated in the research. Of these, 125 respondents were male, and 127 respondents were female. The investigation was conducted in the period from March 2023 to March 2024, when the authors stayed in tourist destinations on several occasions. Observing examples of the best practices of international hotel chains, the aim of the work was to check the situation in hotels in Serbia.Case studies of successful implementation of sustainable practices provide compelling evidence of the benefits that can be realized through commitment to sustainability.

According to Keyhani et al., (2024), the Hilton Hotel chain has made significant strides in reducing its energy consumption by implementing a comprehensive sustainability initiative known as “Travel with Purpose.” This program has led to a reported reduction of 10% in energy use across its properties, illustrating the tangible environmental benefits of such initiatives. According to Wong & Wickham (2015) another notable example is the Marriott International's waste management program, which focuses on reducing food waste through partnerships with local charities and composting efforts. Reports show that Marriott has successfully diverted over 75% of its waste from landfills, showcasing the effectiveness of its waste management strategies. According to Jiang et al., (2025), the InterContinental Hotels Group (IHG) has launched a sustainability initiative that encompasses a wide range of practices, including sourcing sustainable materials and promoting biodiversity. This holistic approach has not only reduced the company's overall environmental impact but has also set a benchmark for others in the industry to follow. These case studies underscore the potential for sustainable practices to yield significant environmental benefits, further supporting the initial hypothesis that such practices can meaningfully reduce the hotel industry's negative impact on the environment.

The hospitality industry has long been scrutinized for its significant environmental footprint. As climate change and ecological degradation become increasingly pressing global issues, the need for sustainable practices within the hotel sector has never been more critical. This paper posits the main hypothesis H that the implementation of sustainable practices in the hotel industry can substantially reduce its negative impact on the environment. By examining the definition and common sustainable practices adopted by hotels, assessing the environmental benefits resulting from these practices, and analyzing case studies of successful implementations, this paper will illustrate the positive implications of sustainability in the hospitality sector. In addition to the main hypothesis, two auxiliary hypotheses were also set: (h1) that the participation of hotel guests in interactive workshops "awakens" a sense of responsibility towards the environment and helps the sustainability of tourism, and (h2) which states that technology, energy-efficient solutions and sustainable practices contribute significantly to responsible guest behavior and sustainable development of tourism.

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.

3. Results and Discussion

According to Table 1, the majority of respondents (74.6%) support recycling workshops, while 20.6% have a neutral stance, likely due to a lack of experience. Only 1.6% oppose these initiatives, indicating broad recognition of their importance for environmental preservation. Similar attitudes among men and women highlight the need for further education to increase participation in sustainable practices.

Table 1: Workshops that allow individuals to physically sort recyclables

			Gender		Total
			Male	Female	
Organizing workshops that allow individuals to physically sort recyclables.	Tottaly agree	Count	44	48	92
		% of Total	17,5%	19,0%	36,5%
	Agree	Count	49	47	96
		% of Total	19,4%	18,7%	38,1%
	No opinion	Count	24	28	52
		% of Total	9,5%	11,1%	20,6%
	Disagree	Count	6	2	8
		% of Total	2,4%	0,8%	3,2%
	Tottaly disagree	Count	2	2	4
		% of Total	0,8%	0,8%	1,6%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

Table 2: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	2,508[a]	4	,643

Pearson's chi-square test indicates that there is no statistically significant difference in responses between genders, which may be due to a shared understanding of the importance of recycling for environmental conservation. These results confirm that men and women have similar opinions about the recycling workshop, likely due to comparable levels of awareness and education.

Table 3: Showing participants the difference between compostable, recyclable, and landfill materials

			Gender		Total
			Male	Female	
Showing participants the difference between compostable, recyclable, and landfill materials.	Tottaly agree	Count	74	63	137
		% of Total	29,4%	25,0%	54,4%
	Agree	Count	34	44	78
		% of Total	13,5%	17,5%	31,0%
	No opinion	Count	13	14	27
		% of Total	5,2%	5,6%	10,7%
	Disagree	Count	2	3	5
		% of Total	0,8%	1,2%	2,0%
	Tottaly disagree	Count	2	3	5
		% of Total	0,8%	1,2%	2,0%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that 54.4% of respondents fully support education on distinguishing materials for composting and recycling, likely due to growing awareness of proper waste management. Additionally, 31% agree with the initiative, while 10.7% remain neutral, possibly due to a lack of information. Only 2% completely disagree, indicating low resistance to these initiatives. Men (29.4%) and women (25%) show similar levels of full support, suggesting comparable environmental awareness between genders.

Table 4: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	2,587[a]	4	,629

Pearson's chi-square test shows no statistically significant difference between the responses of men and women, indicating a similar level of awareness and environmental consciousness. This suggests that gender does not play a decisive role in respondents' attitudes toward education on material separation.

Table 5: Implementation of color-coded bins that simplify waste sorting

			Gender		Total
			Male	Female	
Implementation of color-coded bins that simplify waste sorting.	Tottaly agree	Count	69	58	127
		% of Total	27,4%	23,0%	50,4%
	Agree	Count	40	44	84
		% of Total	15,9%	17,5%	33,3%
	No opinion	Count	14	17	31
		% of Total	5,6%	6,7%	12,3%
	Disagree	Count	1	4	5
		% of Total	0,4%	1,6%	2,0%
	Tottaly disagree	Count	1	4	5
		% of Total	0,4%	1,6%	2,0%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that 50.4% of respondents fully support the implementation of color-coded bins for waste sorting, while 33.3% agree, likely due to a recognized need for clearer waste organization in daily life. A neutral stance is held by 12.3%, possibly due to a lack of personal experience with this system, while only 4% do not support it or completely disagree, indicating minimal skepticism. Men (27.4%) and women (23%) share similar views, likely due to a common awareness of the environmental importance of this initiative.

Table 6: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	5,018[a]	4	,285

Pearson's chi-square test shows no statistically significant differences between the responses of men and women. This suggests that both genders share a similar perception of the implementation of waste sorting bins, likely due to a common understanding of the environmental benefits and the need for sustainable practices in daily life, which transcends gender differences in attitudes toward this initiative.

Table 7: Labeling and signage in waste disposal areas enhance recycling efforts by providing clear instructions on what can and cannot be recycled

			Gender		Total
			Male	Female	
Proper labeling and signage in waste disposal areas enhance recycling efforts by providing clear instructions on what can and cannot be recycled.	Tottaly agree	Count	72	57	129
		% of Total	28,6%	22,6%	51,2%
	Agree	Count	37	43	80
		% of Total	14,7%	17,1%	31,7%
	No opinion	Count	14	19	33
		% of Total	5,6%	7,5%	13,1%
	Disagree	Count	1	4	5
		% of Total	0,4%	1,6%	2,0%
	Tottaly disagree	Count	1	4	5
		% of Total	0,4%	1,6%	2,0%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that 51.2% of respondents fully support proper labeling of waste disposal areas, while 31.7% agree. A neutral opinion is held by 13.1%, while only 2% disagree and another 2% completely disagree. Men (28.6%) are slightly more likely to fully support this initiative compared to women (22.6%), which may suggest that men more often recognize the practical need for clear labeling to facilitate proper waste sorting. This trend could result from a greater male inclination toward organization and functionality, while women, although supportive of the initiative, may be more attuned to the emotional and social aspects of sustainability.

Table 8: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	6,536[a]	4	,163

Pearson's chi-square test shows no statistically significant differences in responses between men and women. These results indicate that gender does not significantly influence attitudes toward labeling waste disposal areas to improve recycling. Tables 1-8 support the sub-hypothesis (H1), which states that hotel guests' participation in interactive workshops fosters a sense of environmental responsibility and contributes to the sustainability of tourism.

Table 9: Use of technology such as mobile apps, to educate guests on local recycling guidelines, thus bridging the gap between knowledge and action

			Gender		Total
			Male	Female	
Use of technology such as mobile apps, to educate guests on local recycling guidelines, thus bridging the gap between knowledge and action.	Tottaly agree	Count	65	40	105
		% of Total	25,8%	15,9%	41,7%
	Agree	Count	40	54	94
		% of Total	15,9%	21,4%	37,3%
	No opinion	Count	19	20	39
		% of Total	7,5%	7,9%	15,5%
	Disagree	Count	1	10	11
		% of Total	0,4%	4,0%	4,4%
	Tottaly disagree	Count	0	3	3
		% of Total	0,0%	1,2%	1,2%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results in Table 9 show that 41.7% of respondents fully support the use of technology to educate guests about recycling, while 37.3% have a positive attitude, and 15.5% remain neutral. Only 1.2% oppose this initiative, indicating broad acceptance. Men (25.8%) are more likely to fully support this technology, while women (21.4%) more often express agreement, suggesting a more cautious stance. These differing perceptions between men and women may stem from their attitudes toward technology and its role in sustainability.

Table 10: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	18,412[a]	4	,001

Pearson's chi-square test shows a statistically significant difference between the responses of men and women. These results suggest that gender has a significant influence on attitudes toward using technology to educate guests about local recycling guidelines..

Table 11: Use of energy-efficient appliances as smart keys etc

			Gender		Total
			Male	Female	
Use of energy-efficient appliances as smart keys etc.	Tottaly agree	Count	53	58	111
		% of Total	21,0%	23,0%	44,0%
	Agree	Count	33	51	84
		% of Total	13,1%	20,2%	33,3%
	No opinion	Count	32	15	47
		% of Total	12,7%	6,0%	18,7%
	Disagree	Count	5	2	7
		% of Total	2,0%	0,8%	2,8%
	Tottaly disagree	Count	2	1	3
		% of Total	0,8%	0,4%	1,2%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that 44% of respondents fully support the use of energy-efficient devices, while 33.3% agree with this. 18.7% of respondents have a neutral stance, and only 1.2% oppose this initiative. Women are more likely to support the use of these devices, while men tend to take a neutral position. This pattern may be the result of a greater interest among women in ecological and energy-efficient options.

Table 12: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	11,835[a]	4	,019

The results of the Pearson Chi-square test show a statistically significant difference between genders in attitudes toward energy-efficient devices. This indicates that gender significantly influences the perception and support for the use of these technologies.

Table 13: Switching to a buffet during dining instead of the classic way of serving contributes to sustainable development

			Gender		Total
			Male	Female	
Switching to a buffet during dining instead of the classic way of serving contributes to sustainable development.	Tottaly agree	Count	78	48	126
		% of Total	31,0%	19,0%	50,0%
	Agree	Count	34	52	86
		% of Total	13,5%	20,6%	34,1%
	No opinion	Count	10	22	32
		% of Total	4,0%	8,7%	12,7%
	Disagree	Count	1	4	5
		% of Total	0,4%	1,6%	2,0%
	Tottaly disagree	Count	2	1	3
		% of Total	0,8%	0,4%	1,2%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that gender influences attitudes toward switching to a buffet-style system as a sustainable development measure. Men are more likely to fully support this change (31.0%) compared to women (19.0%), which may be related to a greater recognition of benefits such as waste reduction. Women are more likely to express agreement (20.6%) or a neutral stance (8.7%), indicating a more cautious approach. This pattern may result from different attitudes toward ecological changes and their practical challenges.

Table 14: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	17,529[a]	4	,002

The results of the Pearson Chi-square test indicate a statistically significant association between gender and attitudes toward switching to a buffet-style system. The low p-value (< 0.05) confirms that the differences in responses are not random, but significant. Tables 9-14 support our sub-hypothesis (h2), which asserts that technology, energy-efficient solutions, and sustainable practices significantly contribute to responsible guest behavior and sustainable tourism development.

Table 15: Loyalty programs might include benefits for guests who choose to participate in sustainability efforts during their stay, such as opting out of daily housekeeping or utilizing public transportation

			Gender		Total
			Male	Female	
Loyalty programs might include benefits for guests who choose to participate in sustainability efforts during their stay, such as	Tottaly agree	Count	77	55	132
		% of Total	30,6%	21,8%	52,4%
	Agree	Count	41	50	91
		% of Total	16,3%	19,8%	36,1%
	No opinion	Count	5	17	22

opting out of daily housekeeping or utilizing public transportation.		% of Total	2,0%	6,7%	8,7%
	Disagree	Count	0	3	3
		% of Total	0,0%	1,2%	1,2%
	Tottaly disagree	Count	2	2	4
		% of Total	0,8%	0,8%	1,6%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that the majority of respondents support a loyalty program promoting sustainability, with 52.4% fully agreeing and 36.1% agreeing to some extent. This support reflects a growing awareness of ecological issues and a desire for sustainable behavior. 8.7% have a neutral stance, while disagreement is minimal (2.8%). Men are more likely to express strong agreement (30.6%) compared to women (21.8%), which suggests different perceptions of the benefits of such programs, with men recognizing more practical advantages.

Table 16: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	14,087[a]	4	,007

The Pearson Chi-square test shows a statistically significant difference, suggesting that gender influences the perception of the topic. The different responses between men and women may result from varying attitudes or experiences, indicating that gender can shape how respondents perceive this issue.

Table 17: Give priority to local food and local producers

			Gender		Total
			Male	Female	
Give priority to local food and local producers.	Tottaly agree	Count	65	70	135
		% of Total	25,8%	27,8%	53,6%
	Agree	Count	45	41	86
		% of Total	17,9%	16,3%	34,1%
	No opinion	Count	13	12	25
		% of Total	5,2%	4,8%	9,9%
	Disagree	Count	1	2	3
		% of Total	0,4%	0,8%	1,2%
	Tottaly disagree	Count	1	2	3
		% of Total	0,4%	0,8%	1,2%
Total		Count	125	127	252
		% of Total	49,6%	50,4%	100,0%

The results show that 53.6% of respondents support prioritizing local food and producers, with women more likely to express strong support (27.8%) compared to men (25.8%). This trend may be linked to a greater emphasis among women on sustainability and community responsibility. The majority of respondents (34.1%) agree with the initiative, recognizing the value of promoting local resources. These data suggest a growing awareness of the importance of supporting local production, particularly among women.

Table 18: Pearson Chi-squere Test

	Value	df	Significance (p)
Pearson Chi-Square	1,062[a]	4	,900

The Pearson Chi-square test shows that there is no statistically significant difference in attitudes between male and female respondents. The p-value greater than 0.05 suggests that the distribution of responses is not significantly different by gender, indicating similar attitudes between both genders regarding the benefits of local food. This result may be due to broader societal awareness of the importance of sustainability, relevant to all groups.

The research confirms the main hypothesis (H) that the implementation of sustainable practices in the hotel industry reduces the negative environmental impact. This consensus among respondents supports the universal acceptance of sustainability in the industry.

4. Conclusion

The hotel industry's role in achieving tourism destination sustainability is fraught with challenges but is also ripe with opportunities for innovation and growth. The environmental impacts of hotel operations, particularly concerning energy consumption and waste management, necessitate urgent action. However, the emergence of best practices, such as eco-friendly initiatives and energy-efficient technologies, demonstrates the industry's potential to evolve toward more sustainable models. Furthermore, the influence of policy and regulation is crucial in shaping the industry's trajectory, offering frameworks and incentives that encourage sustainable practices. As the hotel industry continues to navigate these complex dynamics, it is imperative that stakeholders—ranging from government entities to hotel operators and consumers—collaborate to foster sustainable tourism destinations that benefit both current and future generations.

This research shows that the role of the hotel industry in sustainable tourism development is becoming crucial due to global challenges. Sustainable tourism involves balancing economic, ecological, and social aspects, aiming to reduce the negative impact on the environment and increase benefits for local communities. Although there are theories on sustainability, their implementation in tourism remains challenging, especially in the hotel industry. Implementing ecological practices requires investments in infrastructure and training, as well as overcoming cultural and organizational barriers. Achieving a balance between economic profitability and ecological responsibility presents a dilemma for hotel managers. Sustainable tourism requires the engagement of all sector stakeholders, including local communities and authorities. The research results show strong support for ecological initiatives such as recycling, education, and energy-efficient devices. Respondents consider it important to prioritize local food and producers, and the results indicate that men are slightly more inclined to support changes. Sustainability is becoming a key topic in tourism, with significant support from 220 respondents. Further development of sustainable policies in hotels and research into the long-term economic effects of these practices is recommended.

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19. Wang, J., Vo-Thanh, T., Gursoy, D., Dang-Van, T., Nguyen, N. (2024). Effects of hotels' green practices on consumer citizenship behavior. International Journal of Hospitality Management, 118, 103679, https://doi.org/10.1016/j.ijhm.2023.103679.
20. Wong, T. & Wickham, M. (2015). An examination of Marriott's entry into the Chinese hospitality industry: A Brand Equity perspective. Tourism Management, 48, 439-454, https://doi.org/10.1016/j.tourman.2014.12.014.
21. Xin, C., & Wang, Y. (2023). Green intellectual capital and green competitive advantage in hotels: The role of environmental product innovation and green transformational leadership. Journal of Hospitality and Tourism Management, 57, 148-157, https://doi.org/10.1016/j.jhtm.2023.10.001
22. Zhang, Q., Zhao, H., & Chen, Y. (2024). From science-policy interface to science-policy panel: The United Nations' strengthening of the sustainable life cycle management of chemicals. Circular Economy, 3(2), 100090, https://doi.org/10.1016/j.cec.2024.100090.

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

Title of Paper in Serbian

Authors' Name and Surname[1]*, Name and Surname[2], Name and Surname[3][in this stage leave it empty for the peer review purpose]

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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 thatwill 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

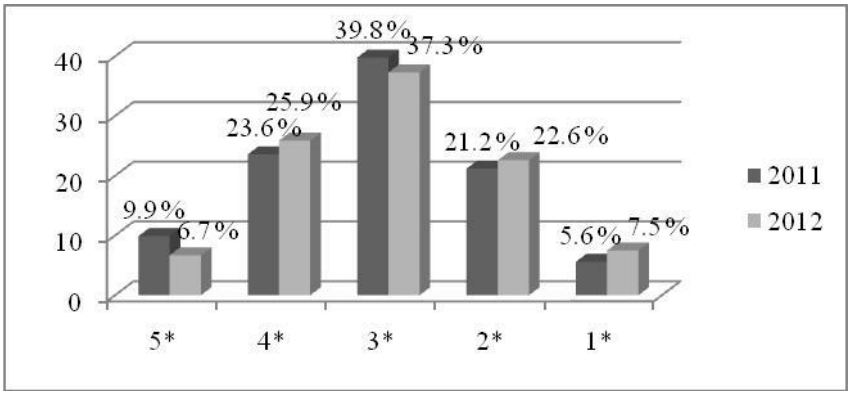
In the first line of the first page the title should be written in Serbian language (16 pt). Under the title of the paper the spaces for name(s) of the author and the names of the author's institutions should be indicated as specified and aforementioned in this Guideline. After the space for the institution 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.

Example: Barrows, C. & W. Powers, T. (2009). *Introduction to the Hospitality Industry.* 7th edition. Hoboken, New Jersey: John Wiley & Sons, Inc.

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.

A book with an editor for a collection of papers; proceedings:
If the book is a collection of papers on the appropriate topic, the authors should mention the editor of their work with the surname and first initial in parentheses as they add "edit" if the person is editor, or "Ed." as editor if the book is written in a foreign language.

Example: Đurković, M. (ed.) (2007). *Serbia 2000-2006: state, society, economy, Belgrade:* Institute for European Studies.

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

Newspaper article with the aforementioned author:
Example: Muscle, M. (days 1 February 2012). US Steel has reduced its losses. *Politika,* p. 11

Newspaper article with no author specified:
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Thesis in the printed version:
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Document or database from the Internet, the private or official web page for which we know the database author:
Example: Kraizer, S. (2012). Safe child. Retrieved on 29 October 2012, from http://www.safechild.org/

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

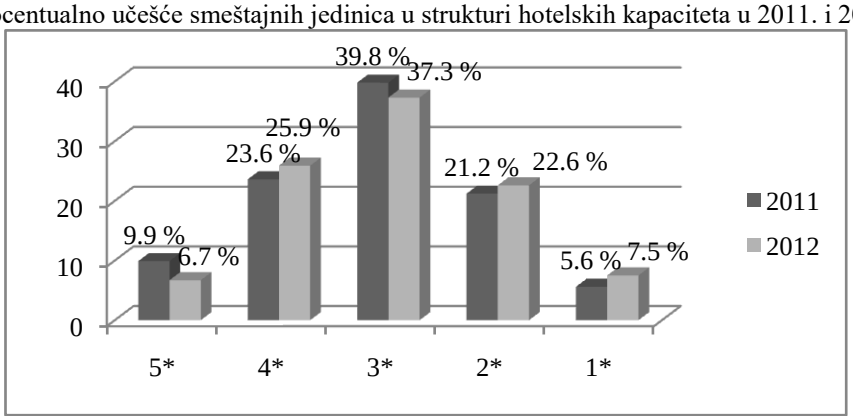
U prvom redu na prvoj strani treba napisati naslov rada na srpskom jeziku (16 pt). Ispod naslova rada treba ostaviti mesto za navođenje ime(na) autora, nazive institucija autora onako kako je naznačeno u ovom Obrascu. Nakon institucije poslednjeg autora, ostaviti jedan prazan red i u sledećem napisati 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).

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

4. Zaključak

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

Literatura

Prilikom navođenja literature, treba se pridržavati uputstva APA sistema navođenja literature. Za više informacija pogledajte *Publication Manual of the American Psychological Association* (6th ed.).

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Knjiga sa jednim autorom:
Primer: Hrabovski, Tomić, E. (2009). *Destinacije zdravstvenog turizma.* Novi Sad: Prometej.

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Kada imamo više autora navodimo ih sve, s tim što pre poslednjeg prezimena dodajemo i, odnosno &, ako imamo više od sedam autora, navodimo prvih šest, zatim pišemo pišemo tri tačke, i na kraju poslednjeg autora.

Primer: Barrows, C. W. & Powers, T. (2009). *Introduction to the Hospitality Industry*. 7th edition. Hoboken, New Jersey: John Wiley&Sons, Inc.

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:
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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:
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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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The Journal Committee strives to maintain the highest academic standards. The submitted papers should be original and unpublished until now. Also, it is forbidden that papers are in the process of reviewing in some other publication.

The papers would be subjected to check. The paper should fit the outlined academic and technical requirements.

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- Review paper;
- Scientific review; discussion.

Original unpublished professional paper:
- Original professional paper;
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- Book review.

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