Project Notes:

Project Title: Ecological Innovations in Sports Venues: A Robotic Revolution for Sustainable Waste Management in Sports
Name: Rishi Patel

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times, so set aside enough time in your schedule.

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
Sports Stadiums' Environmental Impact	General Article	https://knowledge.wharton.upenn.edu/article/reducing-sports-impact-environment/	8/20/2023
Energy-Saving Strategies	Journal Article	https://www.proquest.com/earthatmosphericaquatic/docview/2577547275/EE7732DC7B5E42ECPQ/3?accountid=29120	9/21/2023

Literature Search Parameters:

These searches were performed between (Start Date of reading) and XX/XX/2019.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
WPI Library Search	Environmental, Energy, Sustainability	This search found databases related to my topic of study for my STEM project. The databases that I found with this search helped me find useful articles that I could do further research. Some of the databases include Scopus, Gale, ScienceDirect, and GreenFILE.
Scopus	Waste management, Sustainability, Stadiums/Venues, Sports	This search found many journal articles that were useful for my research. One of the journal articles that I have logged into my project notes was found in this literature search.
Gale OneFile: Environmental Studies and Policy	Waste management, Sustainability, Stadiums/Venues, Sports	This search found many journal articles, but none that were closely related to my project and my research needs.

Tags:

Tag Name	
#stadiums	#sustainability
#recycling	#sustainabledesign
#reduceGHG	#wastemanagementstrategies
#wastemanagement	#reducewaste

Article #1 Notes: Title

Article notes should be on separate sheets

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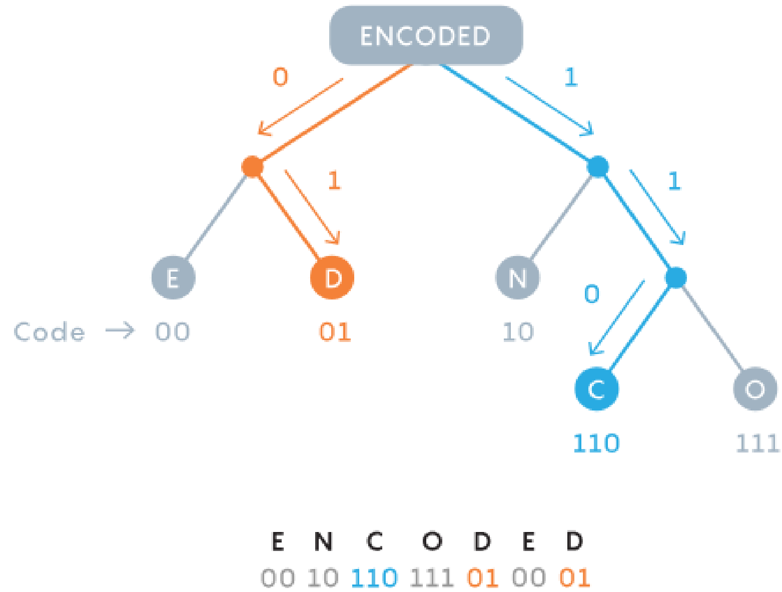
Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	
Cited references to follow up on	
Follow up Questions	

Article #1 Notes: How Lossless Data Compression Works

Article notes should be on separate sheets

Date and Time: 7/10/2023

Source Title	How Lossless Data Compression Works
Source citation (APA Format)	Litchtman, E. (2023, May 31). How lossless data compression works. *Quanta Magazine.* https://www.quantamagazine.org/how-lossless-data-compression-works-20230531/
Original URL	https://www.quantamagazine.org/how-lossless-data-compression-works-20230531/
Source type	Science magazine
Keywords	Data, compression, internet
#Tags	#datacompression #computers #cryptography
Summary of key points + notes (include methodology)	Recently, researchers have been investigating ways to compress the enormous amount of data transmitted on the internet every day, exploring both lossy and lossless compression techniques. Lossy methods purposefully exclude redundant information, such as Google's plan to omit image details and rely on artificial intelligence to fill in the blanks. Lossless approaches, which retain all data that is being compressed from the start, are already quite effective and power various innovations like the PHG image standard and the PKZip software. Robert Fano created a technique that uses codes of various lengths without requiring spaces between them, ultimately laying the groundwork of efficient and effective lossless data compression. His student, David Huffman, refined the technique by giving longer codes to the least commonly used characters. Now that we have the ability to accommodate billions of gigabytes of data thanks to Huffman, his technique is widely used today and has revolutionized lossless compression. When it comes to data compression, each bit that is saved makes a significant difference when scaled up to handle the billions of gigabytes of data on the internet worldwide.
Research Question/Problem/ Need	How can data be compressed more efficiently and effectively?

Important Figures	
VOCAB: (w/definition)	ubiquitous: present, appearing, or found everywhere. lossy: (of data compression) in which unnecessary information is discarded.
Cited references to follow up on	none
Follow up Questions	- How does lossy compression differ from lossless compression, and what are the main advantages and disadvantages of each approach? - What is the significance of Robert Fano's challenge to his students in the context of data compression, and how did it lead to the development of efficient compression algorithms? - How can data compression be more efficient? (helped by chatGPT)

Article #2 Notes: How to Store Renewable Energy

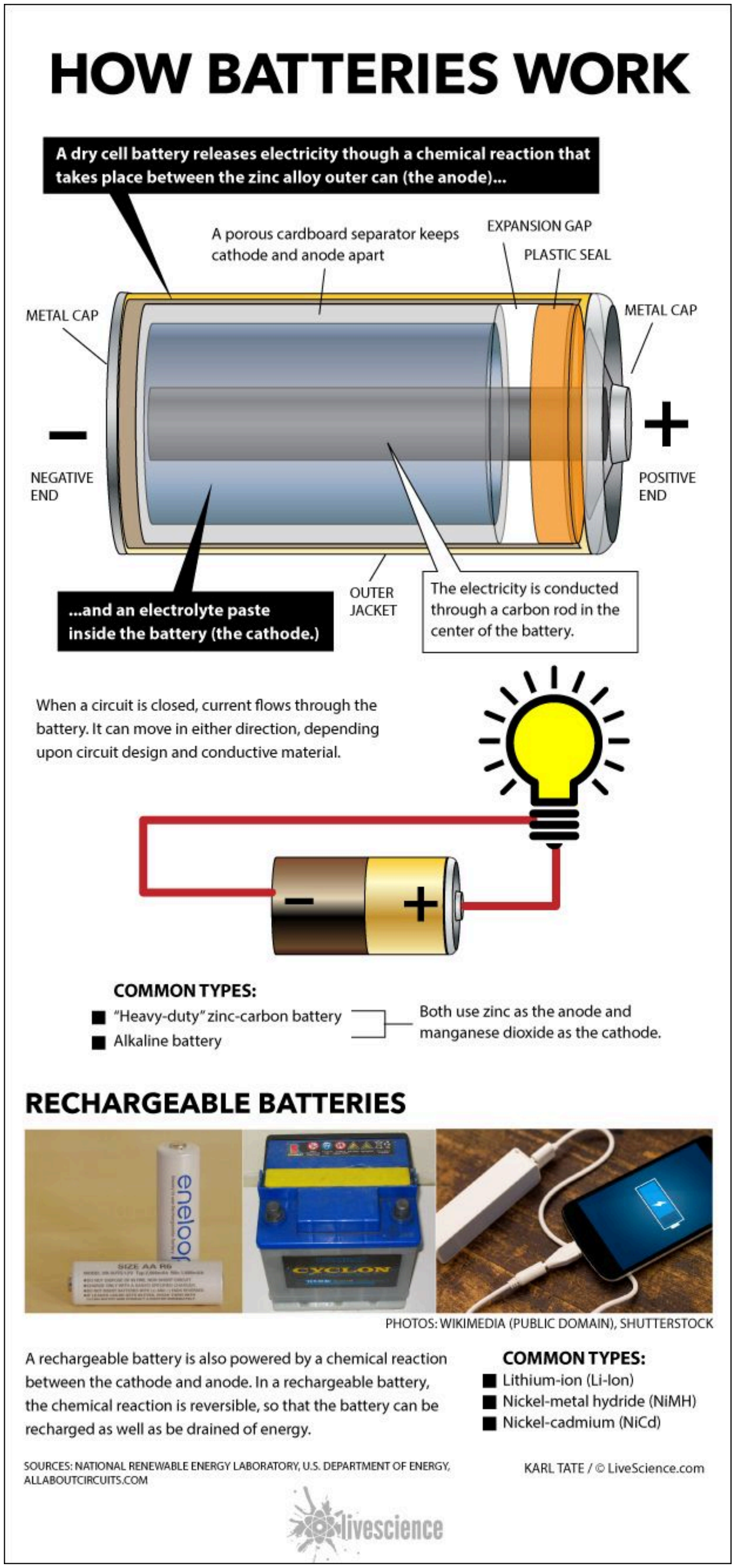
Article notes should be on separate sheets

Date and Time: 7/27/2023

Source Title	How to Store Renewable Energy
Source citation (APA Format)	Pester, P. (2022, March 15). How to store renewable energy. *LiveScience*. https://www.livescience.com/renewable-energy-storage
Original URL	https://www.livescience.com/renewable-energy-storage
Source type	Science magazine
Keywords	renewable-energy storage, fossil fuels, greenhouse gasses, climate change
#Tags	#energystorage #renewableenergy #batteries
Summary of key points + notes (include methodology)	Occurring most prominently in the last 40 years, climate change has caused many issues on our earth that can be prevented. The fossil fuels we humans burn on an everyday basis, which emit massive amounts of carbon into our atmosphere, is the major cause of climate change in our world today. For that reason, renewable energy storage is essential for reducing humanity's reliance on fossil fuels. While solar panels and wind turbines are common sources of renewable energy, their output can be inconsistent due to a lack of sun for solar panels and a lack of wind for the turbines. To resolve this issue, scientists and engineers have been exploring many different energy storage methods, including six major storage methods: batteries, pumped hydro energy storage, pumped thermal electricity storage, gravity energy storage, compressed air energy storage, and hydrogen storage. Starting with batteries, although lithium-ion batteries are frequently used for energy storage, they have significant limitations, such as costly manufacturing and efficiency decrease over time. With pumped hydro energy storage, electricity is stored using two water reservoirs. Water is pumped to a higher reservoir during surplus energy and released to generate electricity when needed. It has approximately 75% to 85% efficiency. Next, in the pumped thermal electricity storage method, gravel or other heat-retaining material is heated with electricity to produce electricity when required. Between 50% and 70% efficiency is expected. Moving on to gravity energy storage, these systems use electricity to lift heavy weights, which are then released when energy is needed, usually being about 80% to 90% efficient. With 70% to 89% efficiency, compressed air energy storage uses gas turbines which are powered by air that is pumped into an underground chamber to build pressure before being discharged. Lastly, hydrogen storage converts electricity into hydrogen through a process known as electrolysis, and the hydrogen can then be used as fuel to generate electricity or power

	hydrogen vehicles with 35% to 55% efficiency. Every technique has benefits and drawbacks, and continuing research strives to advance energy storage methods to enable a future of sustainable energy.
Research Question/Problem/ Need	What are some efficient ways that renewable energy can be stored?

Important Figures



- This graphic shows how batteries work

VOCAB: (w/definition)	electrode: a conductor through which electricity enters or leaves an object, substance, or region. anode: the positively charged electrode by which the electrons leave a device. electrolysis: the process of using electricity to split water into hydrogen and oxygen
Cited references to follow up on	Advanced Rail Energy Storage, "ARES Nevada Project," 2022. https://aresnorthamerica.com/nevada-project/ Alexandra Zablocki, Environmental and Energy Study Institute, "Energy Storage (2019)," Feb. 22, 2019. https://www.eesi.org/papers/view/energy-storage-2019 Antoine Koen and Pau Farres Antunez, The Conversation, "How heat can be used to store renewable energy," Feb. 25, 2020. https://theconversation.com/how-heat-can-be-used-to-store-renewable-energy-130549 Blakers et al. "A review of pumped hydro energy storage," Progress in Energy, Volume 3, March 25, 2021. https://iopscience.iop.org/article/10.1088/2516-1083/abeb5b Clean Energy Institute, University of Washington, "Lithium-ion battery," 2020. https://www.cei.washington.edu/education/science-of-solar/battery-technology/ Davenne, T. R. and Peters, B. M. "An analysis of pumped thermal energy storage with de-coupled thermal stores," Frontiers in Energy Research, Volume 8, Aug. 11, 2020. https://www.frontiersin.org/articles/10.3389/fenrg.2020.00160/ Department of Mechanical & Aerospace Engineering, University of Strathclyde, "Seawater pumped hydro storage." http://www.esru.strath.ac.uk/EandE/Web_sites/17-18/cumbrae/Seawater%20pumped%20hydro.html Elizabeth Palermo, Live Science, "How Do Batteries Work?" April 29, 2015. https://www.livescience.com/50657-how-batteries-work.html Gravitricity, "Fast, long-life energy storage." https://gravitricity.com/technology/ Jillian Ambrose, The Guardian, "How UK's disused mine shafts could be used to store renewable energy," Mon. 21, 2019. https://www.theguardian.com/environment/2019/oct/21/how-uks-disused-mine-shafts-plan-to-store-renewable-energy Jim Park, Clayton Ashley and Dave Brody, Live Science, "Renewable Energy Rides the Rails to More Efficient Power Storage," Feb. 07, 2014. https://www.livescience.com/43211-renewable-energy-rides-the-rails-to-more-efficient-power-storage.html

	King et al. "Overview of current compressed air energy storage projects and analysis of the potential underground storage capacity in India and the UK," Renewable and Sustainable Energy Reviews, Volume 139, April 2021. https://www.sciencedirect.com/science/article/pii/S1364032121000022 Michael Schirber, Live Science, "How Compressed Air Could Power the Future," June 04, 2008. https://www.livescience.com/4955-compressed-air-power-future.html Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, "How Does a Lithium-ion Battery Work?" Sep. 14, 2017. https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, "Hydrogen Production: Electrolysis." https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis Steinmann, W. D. "Thermo-mechanical concepts for bulk energy storage," Renewable and Sustainable Energy Reviews, Volume 75, Aug. 2017. https://www.sciencedirect.com/science/article/pii/S1364032116307341?via%3Dihub World Energy Council, "Five Steps To Energy Storage: Innovation Insights Brief," 2020. https://www.worldenergy.org/assets/downloads/Five_steps_to_energy_storage_v301.pdf
Follow up Questions	- How might these renewable energy storage methods impact the transition away from fossil fuels and the reduction of greenhouse gas emissions? - Are there any ongoing developments or research initiatives in the field of renewable energy storage mentioned in the article? - What is gravity energy storage, and how does it utilize gravity to store and release energy? Are there any real-world applications of this technology? (helped by chatGPT)

Article #3 Notes: This moss survived 165 million years — and now it's under threat from climate change

Article notes should be on separate sheets

Date and Time: 8/8/2023

Source Title	This moss survived 165 million years — and now it's under threat from climate change
Source citation (APA Format)	Coleman, J. (2023, August 9). This Moss survived 165 million years - and now it's under threat from climate change. *Nature News.* https://www.nature.com/articles/d41586-023-02514-8
Original URL	https://www.nature.com/articles/d41586-023-02514-8
Source type	Science article
Keywords	Moss, Takakia, T. lepidozioides, T. ceratophylla
#Tags	#plantsciences #evolution #DNAsequencing #climatechange
Summary of key points + notes (include methodology)	Around 165 million years ago, beneath the presence of dinosaurs, mossy vegetation lived, and as the collision of the Indian and Asian land masses formed the Himalayas 65 million years ago, these plants, now identified as the ancient genus Takakia, adapted to the high-altitude Tibetan plateau. Takakia is one of the oldest remaining plant genera on Earth today, however, it is currently declining in population, most likely as a result of climate change. Comprising two species, T. ceratophylla and T. lepidozioides, found together on the Tibetan plateau, the mosses have evolved rapidly, exhibiting unique characteristics, including a high number of genes aiding survival in harsh environments. The species' loss, which has been measured at 1.6% annually over the past ten years, coincides with an increase in temperature, however, it is possible that other environmental variables could also be to blame. With that being said, climate change has negatively affected our beautiful Earth for too long now. To prevent this detrimental change from continuing to destroy our Earth, we must attack the root cause of the issue, which happens to be the emitting of greenhouse gasses into our Earth's atmosphere. Greenhouse gases are emitted as a result of the burning of fossil fuels. With renewable energy sources now available, it can be used as a substitute for fossil fuels, ultimately reducing the greenhouse gasses in the atmosphere, which would slow down climate change, or potentially even stop it. As climate change persistently hurts the Earth, it is essential that we stop it from happening before we lose everything that our precious Earth has to offer.
Research Question/Problem/ Need	Why is the moss species, Takakia, in danger of becoming extinct and why are Takakia beneficial to the Earth?

Important Figures	none
VOCAB: (w/definition)	dispersal: the action or process of distributing things or people over a wide area.
Cited references to follow up on	Hu, R. et al. Cell https://doi.org/10.1016/j.cell.2023.07.003 (2023).
Follow up Questions	- What are some ways we can preserve and grow more moss? - What specific evidence suggests that the decline in the population of Takakia mosses is most likely due to climate change, and are there other environmental factors that could be contributing to this decline? - What are some of the potential consequences of the decline in the Takakia moss population for the ecosystems in which they are found, and for other species that may rely on them? (helped by chatGPT)

Article #4 Notes: Aiming Toward a Sustainable Future for Stadiums

Article notes should be on separate sheets

Date and Time: 8/20/2023 10:06 pm

Source Title	AIMING TOWARD A SUSTAINABLE FUTURE FOR STADIUMS
Source citation (APA Format)	Publisher. (2021, August 11). Aiming toward a sustainable future for stadiums. *Sports Planning Guide*. https://sportsplanningguide.com/aiming-toward-a-sustainable-future-for-stadiums/
Original URL	https://sportsplanningguide.com/aiming-toward-a-sustainable-future-for-stadiums/
Source type	Sports news site
Keywords	Sports stadium, eco-friendly, renewable energy, carbon footprint
#Tags	#sportsstadiums #environmentalimpact #carbonfootprint #sustainablepractices #energyefficiency #waterconservation #eco-friendlyinitiatives
Summary of key points + notes (include methodology)	Sports stadiums and facilities historically have had a detrimental impact on the environment causing issues such as waste management, energy consumption, and air pollution, with fans of major sports games creating carbon footprints much higher than day-to-day activities. However, as of recently, many sports stadiums, such as AT&T and Mercedes-Benz Stadiums, have created eco-friendly stadiums through their additions of renewable energy, LEED certifications, rainwater collection, and LED lighting to reduce their carbon footprint and promote the idea of saving our environment.
Research Question/Problem/ Need	What steps is the sports industry making in order to make sports stadiums and facilities more environmentally friendly and sustainable?
Important Figures	none
VOCAB: (w/definition)	Eco-consciousness: a state of mind where you have an innate understanding of your role as a human being on Earth. PHA (polyhydroxyalkanoate): intracellular microbial polyesters synthesized by many species of Bacteria and Archaea, generally under nutrient limitation and excess of carbon source as storage granules of energy and also conferring stress resistance to prokaryotes.
Cited references to follow up on	none

Follow up Questions	- How have newer sports stadiums incorporated sustainability measures, such as renewable energy sources, water-saving technologies, and waste reduction strategies, to address their environmental impacts? - What initiatives and strategies can mid-to small-sized sporting facilities adopt to reduce environmental impacts, especially when financial constraints limit their ability to invest in extensive infrastructure changes? - In what other ways are stadiums leaving a carbon footprint and how can those issues be solved to mitigate their carbon footprint?

Article #5 Notes: Reducing Sports' Impact on the Environment

Article notes should be on separate sheets

Date and Time: 8/20/2023 10:40 pm

Source Title	Reducing Sports' Impact on the Environment
Source citation (APA Format)	Reducing Sports' Impact on the Environment. (n.d.). *Knowledge at Wharton.* Retrieved September 27, 2023, from https://knowledge.wharton.upenn.edu/article/reducing-sports-impact-environment/
Original URL	https://knowledge.wharton.upenn.edu/article/reducing-sports-impact-environment/
Source type	Journal article
Keywords	Sports, climate impacts, greenhouse gas, energy, waste
#Tags	#greensportsmovement #sportsindustrysustainability #energyefficiency #wastereduction
Summary of key points + notes (include methodology)	A conference discussing greening the sports industry investigated the difficulties of accurately assessing the environmental impact of making sports stadiums more energy efficient. Even though this process is in its early stages, it has gained traction due to the efforts to gather information on energy, waste, and water usage from various sports arenas. Despite the fact that sporting events have a relatively tiny environmental impact in comparison to big polluters like coal power plants, the movement is a small step in the right direction that aids in increasing public awareness, influencing fan behavior, and spreading environmentally conscious messages to a wide audience.
Research Question/Problem/ Need	How can the environmental impact of making sports venues more environmentally friendly be accurately measured and assessed?
Important Figures	none
VOCAB: (w/definition)	Biodiversity: the variety of life in the world or in a particular habitat or ecosystem. Procurement: the action of obtaining or procuring something. Mitigated: make less severe, serious, or painful.
Cited references to follow up on	none
Follow up Questions	- What strategies can organizations use to further spread their message to fans and promote environmental sustainability in society?

	- What are the challenges to implementing sustainable practices into the large stadiums around the world? - How can standardized measurements be developed to precisely assess and compare the environmental impact of sporting arenas and facilities across various geographical areas?

Article #6 Notes: Preventing antisocial robots: A pathway to artificial empathy

Notes:

Section 1: Introduction
- AI's growing role in various aspects of society
- The unpredictability of AI behavior and the potential for disastrous outcomes
- There are many challenges in understanding and explaining AI solutions

Section 2: Alignment of AI
- The importance of aligning AI's goals and behaviors with human values
- Focus on value specification and avoiding negative incentives
- There is a scarcity of technical solutions for alignment

Section 3: Behavior Toward Humans
- Addressing AI behavior through dilemmas and ethical solutions
- The need for empathy in AI
- Limitations of existing approaches to artificial empathy

Section 4: The Role of Vulnerability
- Vulnerability as a prerequisite for developing artificial proxies for empathy
- Creating proxies for feelings like suffering
- Using a vulnerable body to model empathy

Section 5: Developing AI with Proxies for Feelings
- The concept of a "feeling machine"
- The role of a vulnerable body in AI
- Incorporating physical vulnerability into AI reinforcement

Section 6: Training and Stages for Empathic AI
- A staged approach to developing empathic AI
- Stage 1: Navigating environments, seeking rewards, and avoiding harm.
- Stage 2: Developing predictive models of others' homeostatic states.
- Stage 3: Mapping perceived/inferred states of others to the AI's body.

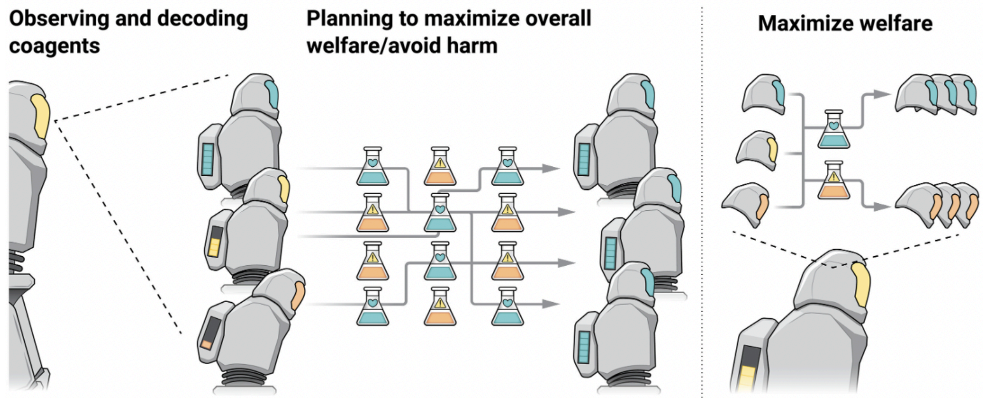
Section 7: Leveraging AI's Scalable Power
- Using AI's scalability to overcome limitations of human empathy
- The potential for AI to make compassionate, intelligent, and cooperative decisions
- The role of empathy in facilitating communication and group behavior

Section 8: Challenges and Ethical Considerations
- Challenges in ensuring that empathic AI does not choose harmful solutions
- The issue of trust in AI with intelligence beyond human capabilities
- Emphasizing the importance of affective empathy and the role of vulnerability

Section 9: Conclusion and Future Directions
- The importance of developing empathic AI to align with human values
- A potential path from vulnerable AI to affective empathy
- The potential for AI to be a powerful ally in human affairs

Date and Time: 8/29/2023 12:02 pm

Source Title	Preventing antisocial robots: A pathway to artificial empathy
Source citation (APA Format)	Christov-Moore, L., Reggente, N., Vaccaro, A., Schoeller, F., Pluimer, B., Douglas, P. K., Iacoboni, M., Man, K., Damasio, A., & Kaplan, J. T. (2023). Preventing antisocial robots: A pathway to artificial empathy. *Science Robotics*, *8*(80), eabq3658. https://doi.org/10.1126/scirobotics.abq3658
Original URL	https://www.science.org/doi/10.1126/scirobotics.abq3658
Source type	Journal article
Keywords	alignment, feeling, empathy, AI, AI alignment, AI behavior
#Tags	#artificialintelligence #AIalignment #AIbehavior #empathyinAI #AIethics #machinelearning
Summary of key points + notes (include methodology)	The journal article discusses the critical challenge of aligning artificial intelligence (AI) systems with human values and behavior, particularly in the context of empathy. It emphasizes that AI should not only decode human emotions but also exhibit prosocial behavior akin to empathy. The authors propose an approach rooted in the principle of maintaining physical integrity, similar to homeostasis, as a basis for developing AI empathy. This approach involves three key stages: 1) AI navigating an environment to optimize integrity, 2) developing predictive models of other agents' internal states, and 3) mapping others' bodily and affective states to its own representation, thus fostering an artificial proxy for empathic concern. The article doesn't focus on traditional research methodology but rather presents a conceptual framework for aligning AI behavior with human values. It draws from various fields, including neuroscience, to propose that AI's development of empathy-like behavior may require a form of vulnerability and homeostasis. The approach is outlined in stages, emphasizing AI's ability to model and predict the internal states of others, and it underlines the importance of multiple time scales in training AI. The article doesn't provide specific experimental data or empirical evidence but rather lays the foundation for future research in AI alignment and empathy. (helped by chatGPT)
Research Question/Problem/ Need	Through the powers of AI, can robots be designed and programmed to have empathy?

Important Figures	
VOCAB: (w/definition)	propositional: relating to, consisting of, or based on propositions. neocortex: comprises the largest part of the cerebral cortex and makes up approximately half the volume of the human brain. counterfactual: relating to or expressing what has not happened or is not the case. homeostasis: the tendency toward a relatively stable equilibrium between interdependent elements, especially as maintained by physiological processes. dimensionality: the quality of having many different features or qualities, especially in a way that makes something seem real, rather than being too simple.
Cited references to follow up on	T. L. Friedman, *Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations* (Picador, 2017), pp. 38–39. J. Taylor, E. Yudkowsky, P. LaVictoire, A. Critch, Alignment for advanced machine learning systems, in Ethics of Artificial Intelligence (Oxford Univ. Press, 2020), pp 342–382. A. B. Arrieta, N. Díaz-Rodríguez, J. Del Ser, A. Bennetot, S. Tabik, A. Barbado, S. Garcia, S. Gil-Lopez, D. Molina, R. Benjamins, R. Chatila, F. Herrera, Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. *Inf. Fusion* **58**, 82–115 (2020). N. Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford Univ. Press, 2014). H. Yu, Z. Shen, C. Miao, C. Leung, V. R. Lesser, Q. Yang, Building ethics into artificial intelligence, in *IJCAI International Joint Conference on Artificial Intelligence* (IJCAI, 2018), pp. 5527–5533. S. D. Preston, F. B. M. de Waal, Empathy: Its ultimate and proximate bases. *Behav. Brain Sci.* **25**, 1–20 (2002).

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F. Schoeller, M. Miller, R. Salomon, K. J. Friston, Trust as extended control: Human-machine interactions as active inference. *Front. Syst. Neurosci.* **15**, 669810 (2021).

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	R. T. Azevedo, E. Macaluso, A. Avenanti, V. Santangelo, V. Cazzato, S. M. Aglioti, Their pain is not our pain: Brain and autonomic correlates of empathic resonance with the pain of same and different race individuals. *Hum. Brain Mapp.* **34**, 3168–3181 (2013). P. Bloom, *Against Empathy: The Case for Rational Compassion* (Ecco, ed. 1, 2016). R. I. M. Dunbar, Coevolution of neocortical size, group size and language in humans. *Behav. Brain Sci.* **16**, 681–694 (1993). D. Gaddy, D. Klein. Pre-Learning Environment Representations for Data-Efficient Neural Instruction Following, in *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics* (Association for Computational Linguistics, 2019), pp. 1946–1956. K. Driessens, S. Džeroski, Integrating guidance into relational reinforcement learning. *Mach. Learn.* **57**, 271–304 (2004). S. M. Omohundro, The basic AI drives, in *Artificial General Intelligence 2008: Proceedings of the First AGI Conference*, P. Wang, B. Goertzel, S. Franklin, Eds., (IOS, 2008), vol. 171 of Frontiers in Artificial Intelligence and Applications, pp. 483–492.
Follow up Questions	- Can AI truly develop a form of empathy that mirrors human emotional understanding, and to what extent is it achievable? - How can we ensure that AI systems aligned with empathy do not exhibit biases similar to human empathy, which can lead to unfair or unjust outcomes? - With the current AI models we have, how can we improve them so that they don’t exhibit bias, specifically racial bias? - How might AI's ability to develop empathy affect human-AI interactions, and what implications does this have for society?

Article #7 Notes: Research on energy-saving strategies of college stadiums and sports venues under the concept of low carbon development

Date and Time: 9/21/2023 4:27 pm

Introduction:

- Carbon emissions are causing serious climate problems in China more than ever
  - Humans health as risk
- Concept of low carbon will have a profound impact and change the world
- Make low carbon normal in modern society
- Lots of college university sports venues in China
  - They use lots of energy
  - How to make them eco-friendly is a big question

Significance:

- More than half of sports venues in China are concentrated in the education system
  - But these venues ae not used effeciently, as they are only used by university, not open to society
- Colleges and universities should focus more on
  - low-carbon ideas that they can implement in the design of the stadiums
  - Put low-carbon, green and energy saving through the whole process and all aspects of the design, construction, operation and management of sports venues
  - Improve the utilization rate
  - Be energy efficient

LOW-CARBON ENERGY-SAVING STRATEGIES FOR COLLEGE STADIUMS AND SPORTS VENUES:

- 3.1 Integration of design with campus environment
  - Design a buidling that achieves harmony and unity by avoiding environmental damage
- 3.2 Targeted application of energy-saving and low-carbon materials and technologies
  - More than 80% of maintenance funds for college stadiums rely on state approval
  - In the application of energy-saving and low-carbon technologies for large stadiums, colleges and universities should exercise caution and prioritize economy, practicality, and effectiveness
    - May not be the best choice because of high construction and maintenance costs
  - Passive energy-saving technologies, such as improved ventilation design, can reduce the need for central air conditioning and lower energy consumption, relieving financial pressures on universities
  - use of transparent skylights in gymnasiums can significantly reduce the energy consumption of lighting equipment, utilizing natural lighting and ventilation
- 3.3 Focus on renovating existing stadiums and sports venues
  - Old stadiums need to be renovated with energy-saving renovations

        - take the initiative to invite relevant experts and institutions to study and comprehensively analyze the energy consumption of old venues, find the main reasons for high energy consumption, and at the same time learn from the renovation experience of similar venues to develop targeted energy-saving renovation plans
    - 3.4 Strengthen the training and management of relevant personnel
        - Staff and all personnel should be educared on low carbon
        - They should be rasing awareness of energy-saving
        - They should have a reward or punish system that is managed by the personnel
    - 3.5 Develop standardized rules and regulations
        - Colleges and universities should develop various systems and norms for energy saving and green operation of stadiums
    - 3.6 Promote the energy-savung utilization with green sharing strategy
        - Many colleges have theirt own heated pools that aren't utilzed efficiently whatsoever throughout all the season of the year
            - These pools waste a lot of water, electricity, etc.
        - In this case, the integration of shared stadiums resources can kill two birds with one stone. In the case of colleges and universities with indoor heated swimming pools, for example, if we can open shared venues and courses to students of neighboring colleges and universities

Conclusion:

- the beginning of the planning project of stadiums and sports venues, they should plan in advance, organize sufficient demonstration and analysis, and scientifically and reasonably integrate green ecological and energysaving technology elements into the architectural design
- passive energy-saving design should also be adapted to local conditions

Source Title	Research on energy-saving strategies of college stadiums and sports venues under the concept of low carbon development
Source citation (APA Format)	Ke, Y. (2021). Research on energy-saving strategies of college stadiums and sports venues under the concept of low carbon development. *E3S Web of Conferences, 275, 02007*. https://www.e3s-conferences.org/articles/e3sconf/pdf/2021/51/e3sconf_eilcd2021_02007.pdf
Original URL	https://www.proquest.com/earthatmosphericaquatic/docview/2577547275/EE7732DC7B5E42ECPQ/3?accountid=29120
Source type	Journal article
Keywords	Energy-saving, green, climate change, sports venues
#Tags	#3.3 #energysavingtechnology #carbonemissions #GHG #china
Summary of key points + notes (include methodology)	Carbon emissions are causing serious climate problems in China more than ever. The carbon emissions are putting human health at risk. With there being lots of

college and university sports venues in China, and they use lots of energy, how to make them eco-friendly is a big question. So, colleges and universities should focus more on low-carbon ideas that they can implement in the design of the stadiums, put low-carbon, green, and energy saving throughout the whole process and all aspects of the design, construction, operation, and management of sports venues, improve the utilization rate, and be more energy efficient. The six methods that the article brought up were: integration of design with the campus environment, targeted application of energy-saving and low-carbon materials and technologies, focus on renovating existing stadiums and sports venues, strengthening the training and management of relevant personnel, develop standardized rules and regulations, and promote the energy-saving utilization with green sharing strategy. In conclusion, at the beginning of the planning project of stadiums and sports venues, they should plan in advance, organize sufficient demonstration and analysis, and scientifically and reasonably integrate green ecological and energy-saving technology elements into the architectural design.

Research Question/Problem/ Need

What strategies can colleges and universities use to save more energy?

Important Figures

Table 1. Research information of natatoriums in Hongshan University City in Wuhan

Affiliation	Swimming pool	Pool specification	Open season
South Central University for Nationalities	10 lane pool with constant temperature	Size: 25m*50m Depth: 2.0m	Summer, Fall and Winter
China University of Geosciences	10 lane pool with constant temperature	Size: 25m*50m Depth: 2.0m	open year-round
Wuhan University of Technology	A 10 lane competition pool and a 4 lane training pool with constant temperature	Competition pool size: 25m*50m Depth: 2.0m Training pool size: 10m*50m Depth: 1.8m	open year-round
Huazhong Agricultural University	8 lane pool with constant temperature	Size: 21m*50m Depth: 2.0m	open year-round
Wuhan Sports University	A 8 lane competition pool and a 10 lane training pool with constant temperature	Competition pool size: 21m*50m Depth: 2.0m Training pool size: 25m*25m Depth: 1.2m	open year-round

Table 2. Research information of universities with natatorium and its neighboring universities

University	Neighboring Universities (Straight-line distance)
South Central University for Nationalities	Zhongnan University of Economics and Law (0.2km), Wuhan Textile University (0.4km), Hubei Science and Technology College (1.1km), Wuhan Vocational and Technical College (1.3km)
China University of Geosciences	Huazhong University of Science and Technology (0.5km), Wuhan Institute of Technology (1.8km)
Wuhan University of Technology	Wuhan University of Science and Technology (1.3km), Hubei Water Resources Technical College (1.4km), Wuchang Shouyi University (2.1km), Central China Normal University (2.2km)
Huazhong Agricultural University	Hubei Vocational College Of Bio-Technology (1.7km), Zhongnan University of Economics and Law (1.6km), Hubei Vocational College of Railway Transportation (1.9km)
Wuhan Sports University	Wuhan Electric Power Technical College (1.1km), Wuhan University (1.1km), Central China Normal University (1.2km)，Wuhan Social Work Professional College (1.3km)

3.6

- Many colleges have their own heated pools that aren’t utilized efficiently whatsoever throughout the season of the year
    - These pools waste a lot of water, electricity, etc.
- In this case, the integration of shared stadium resources can kill two birds with one stone. In the case of colleges and universities with indoor heated

	swimming pools, for example, if we can open shared venues and courses to students of neighboring colleges and universities
VOCAB: (w/definition)	Natatoriums: a swimming pool, especially one that is indoors. Adequate: satisfactory or acceptable in quality or quantity. Conducive: making a certain situation or outcome likely or possible. Ventilation: the provision of fresh air to a room, building, etc.
Cited references to follow up on	1. https://www.yangtse.com/content/960174.html 2. https://www.sohu.com/a/452600818_583687 3. Xiena."On the enterprise management policy of college stadiums" Contemporary Economics .10 (2013): 42-43. 4. "The green concept of Olympic venues." China Construction.07(2008):14-19 5. "Highlighting the focus of energy conservation Strengthening energy-saving renovation Efforts to create a demonstration of energy conservation in sports venues." China Organ Logistics.08 (2016): 23 6. Bi Changquan, et al. "Research on energy-saving strategies for university libraries in the low-carbon era." Science and Technology Information .36 (2012): 34
Follow up Questions	- How can these sustainability strategies be implemented? - Since this article is written focused on China, how do these ideas pertain to the USA? - What energy systems in the stadiums are so unsustainable?

Article #8 Notes: Achieving Sustainability beyond Zero Waste: A Case Study from a College Football Stadium

Date and Time: 10/1/2023 7:07 pm

Introduction:

- fan travel to the event contributed the most to the overall carbon footprint. Collins, Jones, and Munday found that the second most significant contribution came from food and drink.
- Sustainability initiatives are increasing in athletic venues, with leagues adopting measures such as energy and water conservation, recycling, renewable energy, and LEED construction.
- Sporting events provide an opportunity to engage a diverse audience in sustainability efforts and raise awareness at a low cost.
- Academic research on greening sporting events has grown but lacks a detailed exploration of technical aspects, waste management, and operational issues.
- The concept of zero waste, grounded in ecological theory, aims to eliminate waste generation entirely during production and consumption.
- Zero waste encourages creative design innovations and aligns with ethical, economical, and efficient principles.
- Most organizations aim to recycle or compost 90% of the waste stream, considering it the most sustainable option.
- Quantitative evaluation is crucial to assess alternative waste management options' impact on metrics like GHG emissions and ecotoxicity.
- Achieving 90% waste diversion involves complex changes in supply chains, coordination, and investment in waste infrastructure.
- The study at Ohio State University achieved diversion rates close to 90%, showcasing feasibility.
- Systematic waste stream inventory is essential for forecasting, identifying source reduction opportunities, and replacing non-recyclable materials.
- The research objectives include waste characterization, quantifying energy and GHGs, identifying waste strategies, and assessing GHG and energy reductions.
- The study aims to evaluate waste generation and management for stadium operations in the 2014 season.
- Previous research suggests that recycling is effective in reducing GHG emissions, and replacing petroleum-based plastics with compostable materials can aid in achieving zero waste.
- An audit at the University of Missouri in 2014 focused on waste from Memorial Stadium/Faurot Field, estimating recyclables, compostables, and other materials.
- The study quantified GHGs and net energy use associated with alternative disposal options using the WARM model.
- Recommendations are provided for MU's Intercollegiate Athletics Department and the City of Columbia's waste management system.

Methods:

- Study takes place in Columbia, Missouri at Memorial Stadium/Faurot Field on the campus of the University of Missouri

2.1 Site Description:

- Memorial Stadium/Faurot Field is on the University of Missouri campus, expanded to hold 71,168 fans, with expected future seating expansions.
- Three seating categories with unique food service options: general stadium seating with vendor food, all-you-care-to-eat box seating, and à la carte box seating.
- Limited recycling infrastructure, no compost collection.
- Sustainability Office presence with student volunteers to encourage recycling.

2.2 Data Collection Description

2.2.1 Pre-Consumer and Unsold Waste

- Food preparation for box seating occurs at Mizzou Arena.
- Waste categorized as "pre-consumer and un-sold" collected before and after games.
- Categories include Food Waste (subcategorized), Recyclables (aluminum, PET, HDPE, glass), other plastics (PVC, LDPE, PP, PS; #3-6), nonfood compostable waste (corrugated cardboard, mixed paper), and landfill waste.
- Data utilized from the City of Columbia regarding trash collected from Mizzou Arena.

2.2.2 Seating Options and Waste Collection within Memorial Stadium

- The sampling strategy used due to the large volume of trash from the Stadium.
- Bag counts from various locations: East chute, West chute, Main roll-off, Hearnes roll-off, and post-game collections.
- Premium seating areas have distinct waste characteristics.
- Bag counts on game day performed to assess waste composition.

2.3 GHG and Energy Use Evaluation of Alternative Waste Management Scenarios

- The EPA's WARM model is used to calculate life cycle GHG emissions and energy for waste management scenarios.
- Scenarios include recycling, composting, source reduction, and materials replacement.
- GHG and energy estimates based on waste materials and transportation distances.

2.4 Waste Management Scenario Descriptions

- Eleven scenarios were developed to evaluate GHG emissions and energy use for various waste management options.
- Scenarios involve recycling, composting, source reduction, and materials replacement.
- Assumptions about avoiding food waste and materials replacement are considered in some scenarios.

Results:

3.1. Waste Audit Results

3.1.1. Pre-Consumer and Unsold Waste

- Total pre-consumer and unsold waste: 29.64 mt
- 96% of audited waste was food waste, with 71.2% being edible and 25% inedible.
- Largest food waste categories: fruit and grain-based products (4.17 mt and 4.14 mt)
- Beef accounted for 1.63 mt.
- Recyclables not individually weighed; aluminum (1/3) and mixed plastics (2/3) allocation.
- "Other" food waste mainly consisted of gravy and barbeque sauce.

3.1.2. Waste Collection within Memorial Stadium/Faurot Field

- Separation and audit of 55 bags within the stadium.
- Collection time had no significant impact on bag weight percentages.
- Location also showed no significant difference in waste category percentages.
- Overall waste categories: recyclables (43.2%), food waste (24.2%), landfill waste excluding #3–6 plastic (23.3%).
- Major food waste sub-categories: dairy (6.9%), grain-based foods (5.6%), fruits (3.2%), "other meats" (3.1%), and vegetables (3.0%).

3.1.3. Total Waste

- Food waste was the largest waste category at 69% of the total weight.
- Inedible food waste: 7.2 mt, all other food waste was edible.

3.2. WARM Scenario Analysis Results

- The base case involved landfilling all audited waste, resulting in 11.1 mt of CO2e and 3.45 GJ of net energy.
- Recycling and source reduction of food waste were the most effective approaches for reducing GHG emissions and energy use.
- Recycling of corrugated cardboard and mixed paper led to the largest GHG savings (25.4 mt GHGs and 243.7 GJ energy savings).
- Source reduction of edible food waste achieved the most significant GHG reduction (103.1 mt) and energy savings (448.5 GJ).
- Scenario 5a, focusing on avoiding edible food waste, achieved substantial GHG (114.8 mt) and energy (448.8 GJ) savings.
- Scenario 1, recycling of all recyclables, resulted in 24.7 mt CO2e reduction and 243.8 GJ energy savings.
- Scenario 2a, recycling recyclables and composting all food waste, achieved GHG (41.4 mt) and energy (224.5 GJ) reductions.
- Scenario 5b, similar to 2a but avoiding edible food waste, saw GHG and energy reductions of 143 mt CO2e and 688 GJ.
- Scenario 2b, composting paper and cardboard along with food waste, reduced GHG by 23.5 mt CO2e and had a net energy balance of -256.7 GJ.
- Scenario 5c, like 2b but avoiding edible food waste, had GHG and energy reductions of -125.3 mt CO2e and -582.6 GJ.
- Scenario 3, recycling recyclables, composting food waste, and replacing non-recyclables with PLA materials, reduced GHG by 42.4 mt CO2e and energy use by -224.2 GJ.
- Scenario 5d, similar to 3 but avoiding edible food waste, achieved the largest GHG reduction (144.1 mt CO2e) and significant energy savings (-688.0 GJ).
- Scenarios 4 and 5e, replacing non-recyclables with PLA and avoiding edible food waste, resulted in GHG savings (-18.1 mt CO2e and -101.3 mt CO2e) and energy savings (-24.7 GJ and 444.2 GJ), respectively.
- Scenarios 3, 4, 5d, and 5e would achieve zero waste goals, while 2a and 2b would achieve 88% materials diversion from the landfill. Scenario 5b would divert 74% of waste.

Discussion:

- Managers should incorporate waste mitigation strategies in sustainability and zero waste approaches.
- Source reduction of food waste is the most effective in reducing GHG emissions and energy consumption.
- Avoiding food waste is more ecologically beneficial than producing biogas from it.
- Reducing the wastage of animal-based foods, especially beef, can significantly cut GHG emissions and energy use.
- Challenges include predicting food demand due to varying factors and aversion to running out of food.
- Improving the predictability of food demand can reduce costs and motivate sustainability efforts.
- Substituting high-impact foods with lower-impact options can reduce GHG and energy use.
- Some scenarios focusing on source reduction may not achieve zero waste goals, suggesting the need for overall waste reduction.
- Proper sorting of recyclables is essential, and engaging fans is a challenge.
- Strategies like bin guards and public relations campaigns can improve recycling rates.
- Redesigning non-recyclable and non-compostable novelty items may streamline waste streams.
- Outside materials introduced by fans pose challenges to waste management.
- Sampling and estimation efforts were made to assess waste categories, acknowledging potential imperfections.
- Recycling aluminum provides significant GHG and energy savings.
- Improvements in the audit approach include employing more people and obtaining detailed inventory data.
- Expanding the concept of sustainability to include life-cycle GHG emissions in materials can motivate greener events.
- Policy measures like carbon taxes could incentivize materials with lower GHG emissions.
- Venue managers should consider waste prevention rather than just management.

Conclusions:

- The study outlines a sampling approach for auditing waste from a large football venue during a seven-game season.
- Due to the volume of waste generated during such events, practicality necessitates the use of sampling methods.
- The key findings emphasize that source reduction of food waste, even with some landfill waste, can achieve greater reductions in GHG emissions and energy use compared to achieving zero waste through recycling and composting.
- Sensitivity analyses confirm the benefits of source reduction.
- Maximizing GHG emissions and energy use savings is achieved through source reduction of food waste and improving fan sorting of recyclables.
- Achieving zero waste doesn't always correspond to the largest reductions in GHG emissions and energy use.
- Recycling is found to be more environmentally friendly than composting biodegradable polymers, but challenges exist in areas lacking composting facilities.
- The study offers a nuanced perspective on sustainability in sporting events, highlighting the potential for waste reduction and food waste reduction to yield greater GHG and energy savings.

- Further research is needed to develop decision support tools and operational guidelines for event managers to implement these sustainability strategies, requiring collaboration across various disciplines.

Source Title	Achieving Sustainability beyond Zero Waste: A Case Study from a College Football Stadium
Source citation (APA Format)	Costello, C., McGarvey, R. G., & Birisci, E. (2017). Achieving Sustainability beyond Zero Waste: A Case Study from a College Football Stadium. *Sustainability*, *9*(7), 1236. https://doi.org/10.3390/su9071236
Original URL	https://www.mdpi.com/2071-1050/9/7/1236
Source type	Journal article
Keywords	zero waste; green events; waste management; sustainability; food waste; compost; athletics
#Tags	#introduction #GHG #wastemanagementstrategies
Summary of key points + notes (include methodology)	This study focused on waste management at a large college football stadium–University of Missouri in Columbia, Missouri–in 2014 and assessed the associated greenhouse gas emissions (GHG) and energy use. It found that the zero-waste waste management strategy is not the most effective way to reduce GHG emissions and energy use. Instead, the most effective strategies are eliminating food waste, through a method known as source reduction, and improving recycling. The researchers audited the waste generated at the stadium and used the Waste Reduction Model (WARM) to evaluate eleven waste management strategies. They categorized the waste into pre-consumer and unsold food waste, off-site food preparation waste, and waste generated inside the stadium. The study looked at different scenarios, including those that achieve zero-waste compliance and those that don't. The findings highlight the importance of reducing the amount of edible food waste and encouraging recycling to achieve a reduction in GHG emissions and energy use. While these strategies have now been proven to work, the challenges lie in predicting food demand to decrease edible food waste and influencing customer behavior so that they recycle the right way.
Research Question/Problem/ Need	How can sustainability be achieved in sports venues by effectively managing waste, and what are the associated environmental and operational considerations?

Important Figures

Table 1. Total waste estimated corresponding to football game days.

Game and Game Date	Pre-Consumer and Unsold Waste (mt) [1]	Post-Consumer Waste (mt) [2]	Game Day Attendance
South Dakota 30 August 2014	6.73	2.72	60,589
Central Florida 13 September 2014	3.41	1.90	60,348
Indiana 20 September 2014	2.86	2.31	66,455
Georgia 11 October 2014	4.16	2.64	71,168
Vanderbilt 25 October 2014	3.13	3.27	65,264
Kentucky 1 November 2014	8.45	2.14	62,004
Arkansas 28 November 2014	0.84	2.67	71,168
TOTAL	29.58	17.65	

Notes: [1] These totals are derived from waste audits associated with the food preparation and post-game disposal that occurs at the Mizzou Arena; [2] These totals are derived from waste audits associated with waste occurring on game day that is generated within the Stadium.

Table 2. Dates and description of waste audit activities completed at home games over the season.

Date	Trash Collection Point	Activity
30 August 2014	NA	None
13 September 2014	East & West Chutes, Main and Hearnes	Bag counts recorded (pre-kick off to end of game)
20 September 2014	East & West Chutes, Main and Hearnes, and post-game Can-do crew collections	Bag counts recorded (pre-kick off to end of Can-do crew shift)
11 October 2014	East & West Chutes	Audit of collected bags: East Chute (12 bags), West Chute (10 bags)
25 October 2014	Main and Hearnes	Audit of collected bags: 15 bags
1 November 2014	Can-do Crew	Audit of collected bags: 17 bags
28 November 2014	NA	None

Table 3. Bag count data from 20 September 2014, Missouri vs. Indiana.

Location	East Chute	West Chute	Main and Hearnes	Can-Do Crew
Bag count	73	65	390	53

Table 4. Average bag weight at each trash collection location.

Location	East Chute	West Chute	Main and Hearnes	Can-Do Crew
Average bag weight (kg)	2.30	3.31	4.50	3.26

Table 5. Summary of waste management scenarios, represented by percent weight of materials generated over the 2014 football season. The total estimated weight of waste is provided in Table 1.

Material	1	2a	2b	3 *	4 *	5a		5b		5c		5d *		5e *	
						E	I	E	I	E	I	E	I	E	I
	Percent of total weight														
Aluminum Cans	1.2	1.2	1.2	1.2		1.2		1.2		1.2		1.2			
Glass	2.8	2.8	2.8	2.8		2.8		2.8		2.8		2.8			
LDPE	4.0	4.0	4.0			4.0		4.0		4.0					
PP	4.0	4.0	4.0			4.0		4.0		4.0					
PS	4.0	4.0	4.0			4.0		4.0		4.0					
Corrugated Containers	7.9	7.9		7.9		7.9		7.9				7.9			
Food Waste (non-meat)	5.1	5.1	5.1	5.1	5.1	5.1		5.1		5.1		5.1		5.1	
Beef	5.7	5.7	5.7	5.7	5.7	5.7		5.7		5.7		5.7		5.7	
Poultry/Pork	10.3	10.3	10.3	10.3	10.3	10.3		10.3		10.3		10.3		10.3	
Bread	13.4	13.4	13.4	13.4	13.4	13.4		13.4		13.4		13.4		13.4	
Fruits and Vegetables	30.7	30.7	30.7	30.7	30.7	15.5	15.1	15.5	15.1	15.5	15.1	15.5	15.1	15.5	15.1
Dairy Products	4.2	4.2	4.2	4.2	4.2	4.2		4.2		4.2		4.2		4.2	
Mixed Paper (general)	4.3	4.3		4.3		4.3		4.3				4.3			
Mixed Plastics	2.4	2.4	2.4	2.4		2.4		2.4		2.4		2.4			
Mixed Organic			12.1		12.1					12.1				12.1	
PLA				12.0	18.4							12.0		18.4	
Waste management category key:						landfill		recycle		compost		source reduction			

Notes: * Indicates that the scenario would achieve > 90% diversion of waste from the landfill. "E" is an abbreviation for edible. "I" is an abbreviation for inedible. Sums of percentages may not equal 100% due to rounding.

Table 6. Pre-consumer and un-sold food waste audited from Mizzou Arena.

Waste Category	Total Waste	Landfill	Recycling	Inedible Food Waste	Edible Food Waste	Total Food Waste
Total weight audited (kg)	187.7	6.64	0.45	47.0	133.6	180.6
Percentage by category (%)	100	3.54	0.24	25.0	71.2	96.2

Table 7. Percentage of waste by category observed in post-consumer waste collected at Memorial Stadium over the season.

Waste Category	Food Waste	Recyclables	Landfill #3–#6 Plastic	Landfill Waste
Overall percentage in each waste category	24.2	43.2	8.8	23.8

Table 8. Percentage of the total weight observed by recyclable subcategories in post-consumer waste collected at Memorial Stadium over the season.

Waste Category	Plastic #1 &2	Aluminum	Glass	Corrugated Cardboard and Mixed Paper
Overall percentage in each recyclables sub-category	6.1	3.1	7.5	26.6

able 9. Percentage of the total weight observed by food subcategories in ost-consumer waste collected at Memorial Stadium over the season.

Waste Category	Grain-Based Foods	Beef	Other Meats	Dairy	Fruits	Vegetables	Other
Percentage in each food waste sub-category	5.6	1.1	3.1	6.9	3.2	3.0	1.3

Figure 5. Greenhouse gas emissions estimated for each waste management scenario modeled in Waste Reduction Model (WARM). Note that if all of the inedible food waste was also assumed to be source reduced WARM estimates an additional greenhouse gas (GHG) reduction of 5 mt CO_2e. "+" Indicates 88% waste diversion from the landfill and "*" Indicates 100% waste diversion from the landfill.

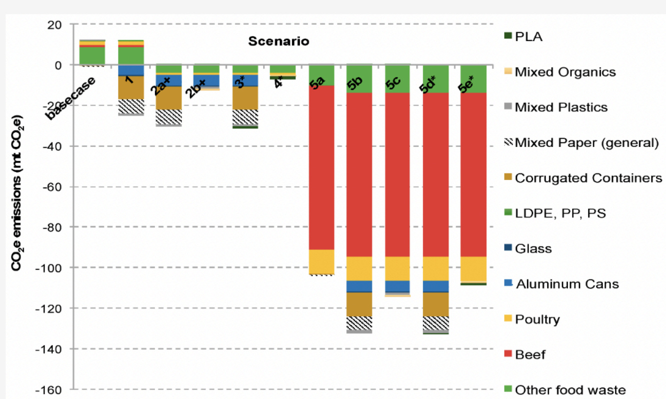
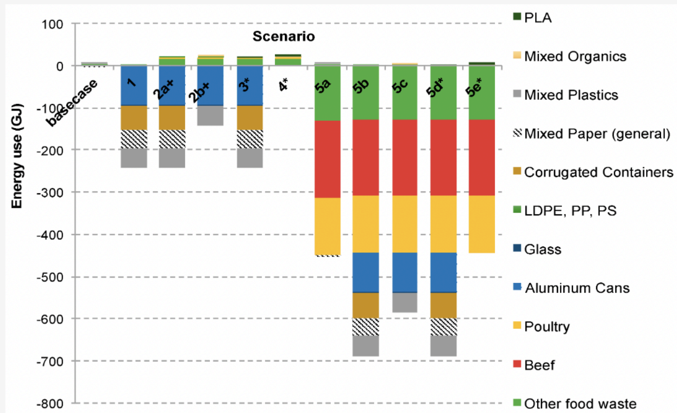


Figure 6. Energy use estimated for each waste management scenario. Note that if all of the inedible food waste was also assumed to be source reduced WARM estimates an additional energy savings of 77.4 GJ. "+" Indicates 88% waste diversion from the landfill and "*" Indicates 100% waste diversion from the landfill.



VOCAB: (w/definition)

ecotoxicity: the capability of a compound or any physical agent to show the harmful effect on both environment and organisms.

eutrophication: occurs when the environment becomes enriched with nutrients, increasing the amount of plant and algae growth to estuaries and coastal waters.

receptacles: an object or space used to contain something.

polymer: any of a class of natural or synthetic substances composed of very large molecules, called macromolecules, which are multiples of simpler chemical units called monomers.

aversion: a strong dislike or disinclination.

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Follow up Questions	- How might these research findings change the way sporting events approach sustainability, and what are the practical implications for event managers and stakeholders? - What further research is needed to expand on the findings of this study, and how can it help event managers achieve potential GHG and energy savings in waste management? - What are the environmental implications of recycling versus composting biodegradable polymers, and what challenges exist in implementing composting strategies for biopolymers? (helped by chatGPT)

Article #9 Notes: Environmental Sustainability in Stadium Design and Construction: A Systematic Literature Review

Date and Time: 10/9/2023 6:32 pm

Introduction:

- The study begins by highlighting the significance of mega-events like the Olympics and FIFA World Cup, which have a substantial impact on host cities and involve the construction of large stadiums.
- It points out that these stadiums often contribute to negative environmental impacts and can become financial burdens after the events.
- The study emphasizes the need to address the environmental performance of stadium infrastructure, considering sustainability categories like materials, energy, water, and light.
- It mentions that the goal should be to make large stadiums environmentally sustainable while also benefiting the community.
- The originality of the study lies in its focus on sustainability in mega-event infrastructure, which is less explored in academic literature, especially concerning stadiums.
- It mentions that the adoption of green building methods in stadium design and construction lags behind other building types.
- The study highlights the emergence of environmental sustainability initiatives and technologies in stadium design and construction.
- It emphasizes the significance of understanding the environmental sustainability of large stadium life cycles and integrating sustainable features during design and construction.
- The paper's objective is to review recent developments in the design and construction of large sports venues, focusing on their environmental sustainability.
- The authors pose four questions to guide the review, including what defines an 'Environmentally Sustainable Stadium' (ESS), major drivers for ESS outcomes, resource-saving measures in stadium design, and the use of environmental sustainability assessment tools and certification systems.
- The study presents findings from the review, including the definition of an ESS, drivers for ESS design, common resource-saving areas, and the application of environmental sustainability assessment tools and certification systems.
- The review sets a foundation for future research in environmentally sustainable stadiums.

Materials and Methods:

- Systematic Literature Review (SLR) is a comprehensive and structured approach used to gather and analyze relevant research on a specific topic.
- The SLR aims to reveal areas where knowledge is lacking and guide future research.
- Potential limitations and challenges of SLRs include the risk of bias, excluding grey literature, and limited database sources.
- To overcome these limitations, electronic databases were used for searching, and management products such as Endnote, Covidence, and NVivo were utilized to organize and analyze data.
- The SLR was conducted by a team with mixed methodological expertise.

- The SLR followed a protocol with two main steps: SLR protocol development and SLR execution.
- The protocol development included defining the purpose, formulating research questions, selecting keywords, and choosing databases.
- The PRISMA (Preferred Items for Systematic Review Recommendations) protocol was adopted for conducting the SLR.
- The primary research question addressed in the study is, "How are large stadiums currently being designed and constructed for environmental sustainability?"
- Keywords, search strings, and search strategies were developed to identify relevant literature.
- Multiple databases, including Scopus, Web of Science, ProQuest, Sage, Ebsco, Ovid, Informit, and Wiley Online, were selected for data collection.
- Papers were limited to those published in the last five years (2017–2021) to focus on recent developments in stadium sustainability.
- Inclusion and exclusion criteria were used to screen and select relevant papers.
- A total of 18 papers were reviewed and included in the study.
- Thematic analysis was conducted using NVivo software to analyze the content of the selected papers, with a focus on addressing the research questions

Results:

3.1. Descriptive Analysis:

- The study examined 18 academic literature papers from various sources
- It presents the journals in which the articles were published and their frequencies, with "sustainability" having the highest number of publications.
- There has been a consistent increase in the number of articles published since 2018, indicating a growing trend in environmentally sustainable stadium design and construction.

3.1.2. Overview of Paper Contents:

- Research methods used are almost equally distributed; 50% use quantitative research methods, 8 use qualitative research methods, and 1 use both
- Some papers focus on existing stadiums while others examine newly constructed ones

3.2. Thematic Analysis:

- The study addresses the lack of a comprehensive definition for environmentally sustainable stadiums (ESS)
- It proposes a definition for ESS: minimal resource consumption and environmental damage reversal

3.2.2. ESS Drivers:

- Major drivers for ESS include initiatives and requirements for sports organizations like UEFA, FIFA, and the IOC
- National and local sustainability goals and policies also play a role

3.2.3. ESS Resource-Saving Measures in Design and Construction:

- Various engineering features and initiatives are discussed to improve energy efficiency, reduce material usage, control lighting pollution, and optimize water management in stadium construction.

3.2.4. ESS Assessment Tools and Certification Systems:

- There is a lack of strict regulatory structures and certification systems for large stadiums.

- FIFA has made green building certification mandatory for all World Cup stadiums, which has led to increased efforts in designing environmentally sustainable stadiums.

Discussion:

4.1. Improving Environmental Sustainability for Large Stadiums:

- Large stadiums have a significant environmental footprint.
- They can serve as platforms for raising awareness and promoting design innovations.

4.2. Incorporating Macro-Sustainability Categories in ESS:

- Focus areas include energy, materials, and water conservation.
- Limited attention to noise pollution and indoor air quality.

4.3. Prioritizing Sustainability Governance, Certification, and Tools:

- Few papers document green-certified stadiums.
- Stadiums lack specific green certification systems.
- Calls for regulatory structures to enforce environmental standards.

4.4. Considering Stadium 'Whole of Life' Performance:

- Emphasizes environmental sustainability across all stadium lifecycle phases.
- Highlights the importance of planning, market analysis, and post-event utilization.

4.5. Documenting Academic Information for Capacity Building and Research:

- Lack of documented industry-leading practices hampers capacity building.
- Emphasizes the need for documentation of current best practices.

Limitations of the Study and Implications of Future Research:

- The study provides references for stadium design and construction but doesn't include grey literature (industry reports, books, etc.).
- Future studies should consider industry-based research to bridge the gap with emerging technology.
- Focus of this SLR is on the design and construction phases, future studies should explore the operation and demolition phases.
- This SLR primarily covers large stadiums for mega-events; future studies should examine smaller stadiums and other sports facilities.
- Proposed future research directions include:
    - Prioritizing less-studied areas like noise and light pollution, and indoor air quality.
    - Clarifying ESS features and characteristics, emphasizing stadiums as community infrastructure.
    - Developing a framework/guideline for applying green certification systems and sustainability tools in stadiums.

Conclusions:

- This systematic review summarizes stadium design and construction methods for improved environmental sustainability.
- Energy and materials are the primary sustainability focus in stadium design.
- Mega-events and sustainability goals drive stadium sustainability efforts.
- Green-certified stadiums are on the rise, but there's room for growth.
- Future stadiums should prioritize fan experience, community, and environmental contributions.
- A baseline for future progress is established.
- Areas for future research, like water use, are highlighted.

- A checklist aims to advance stadium sustainability and community integration.
- The findings benefit academics and practitioners involved in environmentally sustainable stadium design and construction.

Source Title	Environmental Sustainability in Stadium Design and Construction: A Systematic Literature Review
Source citation (APA Format)	Francis, A. E., Webb, M., Desha, C., Rundle-Thiele, S., & Caldera, S. (2023). Environmental Sustainability in Stadium Design and Construction: A Systematic Literature Review. *Sustainability*, *15*(8), 6896. https://doi.org/10.3390/su15086896
Original URL	https://www.mdpi.com/2071-1050/15/8/6896
Source type	Journal article
Keywords	Environmentally Sustainable Stadium (ESS); mega-events; stadiums; environmental sustainability; design; construction; systematic literature review
#Tags	#stadiums #sustainability #construction #sustainabledesign #mega-events #GHG
Summary of key points + notes (include methodology)	This journal article presents a systematic literature review (SLR) focused on environmental sustainability in large stadium design and construction. It finds 159 articles and narrows them down to just 18 to assess the current knowledge in this field. It uses the 18 articles to identify key findings and trends in the types of research in this field. The study discusses the importance of addressing environmental sustainability in these large stadiums because of the amount of resources they use and the environmental impacts they cause as a result. It also calls attention to the need for more research in areas like noise pollution, light pollution, and indoor air quality. It concludes by imagining the stadiums in the next generation that will prioritize fan experiences and environmental health. Lastly, it provides a checklist to guide the construction and design of future stadiums so that they can be environmentally sustainable.
Research Question/Problem/ Need	How are large stadiums currently being designed and constructed for environmental sustainability, and how can they be improved?

Important Figures

Table 2. Inclusion and exclusion criteria used in screening papers.

Inclusion Criteria	Exclusion Criteria
• Keywords used in search strings should exist in the title, keywords or abstract section of the paper. • Peer-reviewed journals only • Published between 1 January 2017 and 11 October 2021 • Papers that focus on large/commercial sporting venues • Papers that have original information and an actual experimental study • Papers that focus on environmental sustainability • Papers that focus on environmental sustainability features included in the design or construction phase of a stadium • Papers written in English	• Grey literature including books, book sections, trade journals, industry reports, conference proceedings, dissertations, thesis, newspaper and magazine articles and other review papers • Published prior to 2017 • Papers that are not accessible online • Papers on other types of sports facilities such as community/university stadiums and gymnasiums, hockey rings, golf courses etc. • Papers only with general descriptions • Papers focus only on social and/or economic sustainability • Papers that feature environmental sustainability only in the operational or demolishing phase of stadium • Papers written in any language other than English

Table 3. Papers reviewed in this SLR.

Paper Title	Reference
A thin line between a sport mega-event and a mega-construction project: the 2018 Winter Olympic Games in PyeongChang and its event-led development	[4]
Analysis of the influence of cooling jets on the wind and thermal environment in football stadiums in hot climates	[14]
CFD optimisation of a stadium roof geometry: a qualitative study to improve the wind microenvironment	[28]
Challenges and key factors in planning legacies of mega sporting events: Lessons learned from London, Sochi, and Rio de Janeiro	[29]
Circular economy application for a Green Stadium construction towards sustainable FIFA world cup Qatar 2022	[30]
Climate vulnerability as a catalyst for early stadium replacement	[31]
Construction of the Evaluation System of Sustainable Utilization of Large Stadiums Based on the AHP Method	[12]
Environmental management of sport events: a focus on European professional football	[32]
Examination of sustainable features of stadiums as an integral part of sustainable urban development: the case of Turkey	[6]
How circular design can contribute to social sustainability and legacy of the FIFA World Cup Qatar 2022™? The case of innovative shipping container stadium	[33]
Investigating alternative development strategies for sport arenas based on active and passive systems	[34]
Modern Stadium Design: an adaptive renovation or urban renewal.	[35]
Research on the Indoor Physical Characteristic of the Ceiling of China National Aquatics Center under the Demand of Olympic Games	[15]
Reusing Stadiums for a Greener Future: The Circular Design Potential of Football Architecture	[36]
Rwanda Cricket Stadium: Seismically stabilised tile vaults	[37]
The Object-Oriented Politics of Stadium Sustainability: A Case Study of SC Freiburg	[38]
Using Simulation-Based Modeling to Evaluate Light Trespass in the Design Stage of Sports Facilities	[39]
Water savings and reduction of costs through the use of a dual water supply system in a sports facility	[40]

- All of the papers above are potential papers that I could read for further research

Table 4. State and end use of stadiums internationally.

Stadium	Place	Climate Properties (Köppen Climate Classification) (Main Climate, Precipitation, Temperature)	Type	End Use	Reference
Education City Stadium	Al Rayyan, Qatar	Arid, Desert, hot arid (BWh)	New	FIFA World Cup	[30,33]
National Aquatics Center, China	Beijing, China	Snow, Desert, Hot summer (DWa)	Existing	Olympics	[15]
M City stadium and K city stadium	Korea	Snow, winter dry, hot summer (Dwa)	New	NA	[39]
Globe Life Field in Arlington, Texas; Oakland Ballpark in Oakland, California; and Marlins Park in Miami, Florida	US	Warm temperate, fully humid, hot summer (Cfa) Warm temperate, summer dry, warm summer (Csb) and Equatorial, monsoonal (Am)	New	Professional sports stadiums in the US	[31]
Six stadiums in Europe—three stadiums in Italy and one each from Spain, Romania and Sweden	Europe	Warm temperate, summer dry, hot summer (Csa)—Italy Warm temperate, summer dry, hot summer (Csa)—Spain Warm temperate, fully humid, hot summer (Cfa)—Romania Snow, fully humid, warm summer (Dfb)—Sweden	Existing	European professional football league	[32]
Stadium in Poland	Poland	Warm temperate, fully humid, warm summer (Cfb)	Existing	Euro 2012	[40]
SC Freiburg's Stadium	Freiburg, Germany	Warm temperate, fully humid, warm summer (Cfb)	New	Bundesliga—German Football League	[38]
Olympic venues in PyeongChang	PyeongChang, South Korea	Snow, winter dry, hot summer (Dwa) and Snow, winter dry, warm summer (Dwb)	Existing	Olympics	[4]
Bengbu Sports Center	Anhui, China	Warm temperate, winter dry, hot summer (Cwa)	Existing	Anhui Provincial Games	[12]
Stadiums from London, Sochi, and Rio de Janeiro	London, Sochi, Rio de Janeiro	Warm temperate, fully humid, warm summer (Cfb) Warm temperate, fully humid, hot summer (Cfa) Equatorial, monsoonal (Am)	Existing	FIFA World Cup and Olympics	[29]
Z stadium	Zhoushan, China	Warm temperate, fully humid, hot summer (Cfa)	Existing	NA	[35]
Dacia Arena football stadium	Udine, Italy	Warm temperate, fully humid, hot summer (Cfa)	Existing	NA	[34]
Rwanda Cricket Stadium	Kigali, Rwanda	Equatorial, winter dry (Aw)	New	NA	[37]
Tynecastle Park and Stadio Flamino	Edinburgh, Rome	Warm temperate, fully humid, warm summer (Cfb) Warm temperate, summer dry, hot summer (Csa)	Existing	European professional football leagues	[36]
2D design stadium	NA	Arid, Desert, hot arid (BWh)	New	Based on FIFA World Cup requirements for international games	[28]
Case study stadium	Qatar	Arid, Desert, hot arid (BWh)	Existing	FIFA World Cup	[14]
20 Stadiums in Turkey	Turkey	Warm temperate, summer dry, warm summer (Csb) Warm temperate, summer dry, cool summer (Csc)	Existing	Euro 2020 and Olympics	[6]

Table 4. *Cont.*

- These tables display all the places and stadiums that have been studied for their environmental sustainibility and how to improve it

Table 6. Environmental sustainability initiatives experimented recently in large stadiums that are found in the literature.

Engineering Feature	Initiative and Method	Effects on Environmental Sustainability	References
Energy	Dacia arena football stadium (Italy): Use of passive methods to reduce energy use ▪ Comparison of active and passive strategies. ▪ Building-integrated photovoltaic plant and cool surface treatment to increase solar reflectance.	▪ Passive approach: application of highly reflective coating. Reduced environmental impacts, and cheaper. ▪ Reduced emissions approx. 100 kg CO_2-eq/m^2 (passive scenario), 1500 kgCO_2-eq/m^2 (active scenario).	[34]
	National Aquatics Centre (China) Use of roof shielding material to improve thermal comfort ▪ PVC film-based black coated fabric as a shielding material in the cavity of ethylene tetrafluoroethylene (ETFE) air pillow ceiling system. ▪ To reduce the transmission of sunlight and to maintain a lower indoor temperature and thereby to reduce energy usage.	▪ Shielding material: blocked more than 98% of the solar radiation. Reduced the heat gain of the facility. Kept the temperature of the playing field almost stable, varying only about 1 °C. ▪ Made the ceiling resistant to condensation through minimising the temperature difference between lower surface of the ceiling and the indoor temperature.	[15]
	Case Study Stadium model (Qatar) Use of cooling jets to optimise aero-thermal comfort ▪ Cooling jets with different supply velocities, supply temperatures and located at different positions to optimise the aero-thermal conditions.	▪ Maintained the spectator tiers at an average temperature of 22 °C. ▪ Reduced the maximum predicted percentage of dissatisfied thermal comfort: 100% to 63% and 19% for the pitch and tiers, respectively.	[14]

Table 6. *Cont.*

Engineering Feature	Initiative and Method	Effects on Environmental Sustainability	References
	2D Stadium Model (based on FIFA's requirements for international games) Optimisation of roof geometry for maximum wind comfort ▪ Optimisation of roof height, width and length, using coupled computational fluid dynamics (CFD) and response surface methodology (RSM) to increase wind comfort.	▪ Maximum velocity reduction of 26.5%, 15.4% and 25.9% (symmetric case) and 76.5%, 62.7% and 55.6% (asymmetric case) in the front and back spectator tiers and the pitch area, respectively. ▪ Optimal symmetric roof design scenario: roof height is reduced by 57% and the roof radius increased by 835% relative to the initial one; maximum velocity reduction of up to 26.5% for the front spectator tiers.	[28]
Material	Education City Stadium (Qatar) Cyclopean concrete method to reduce material usage and minimise waste ▪ Use of site excavated boulders in the concrete mix to cast the under-raft foundation. ▪ Low-cost alternative material from existing waste products with less environmental impacts but with similar quality of conventional concrete.	▪ Reduction in raw materials consumption: disposal of 6500 m^3 of the site excavated boulders into landfills was avoided. ▪ 32.2% reduction in greenhouse gas emissions ▪ Saved USD 535,159 which is equivalent to a 32% reduction in the total cost.	[30]
	Rwanda Cricket Stadium (Rwanda) Use of soil-cement tiles and thin tile vaulting to minimise waste and CO_2 emissions and for rapid construction ▪ Mediterranean thin-tile masonry with geogrid between layers. ▪ Compressed soil-cement tiles made from site-excavated earth used to make vaults. ▪ Low carbon, agro-waste-fired, locally made bricks, to define edges and spaces. Clay tiles, broken granite, and slate for flooring. Plywood rectangles from tile-making for countertops. Material from the vault guide work for joinery and doors.	▪ Saved approx. 41 tons of CO_2 emissions by using bio-waste fired modern bricks instead of traditional Rwandan bricks. ▪ Saved 4 tons of CO_2 emissions by using bio-waste-fired clay floor tiles instead of typical ceramic tiles ▪ Economic and fast building technique with minimum materials and skilled labour.	[37]
Water	Euro 2012 facility (Poland) Use of a dual water supply system ▪ Rainwater harvesting system (non-potable water requirements) and public water network (potable water requirements) to meet water needs for 3 years.	▪ Rainwater harvesting system covered 70% of the total water consumption in the facility in 2014, 51% in 2015 and 54% in 2016. ▪ Cost savings of approx. PLN 50,000 (EUR 11,225.90) ▪ Annual water cost reduction: 41%, 39% and 33% in 2014, 2015 and 2016, respectively.	[40]

Table 6. *Cont.*

Engineering Feature	Initiative and Method	Effects on Environmental Sustainability	References
Lighting	M City Stadium and K City Stadium (Korea) Prediction of light pollution and design strategies to reduce light trespass ▪ Light pollution prediction technique for the planning phase using computer simulations; Sketch up, AGi32 and The Relux Program were proposed. ▪ Improvement plans were proposed to reduce light pollution by changing the angle and amount of light.	▪ Alternative designs reduced the horizontal and vertical illuminances by 74.5% and 72.2%, respectively, in M city stadium and 30% and 30.6% in K city stadium.	[39]

- This table describes some initiatives and methods that could be implemented in stadiums and then displays the effects of the initiatives

- The figure below identifies the gaps in their study

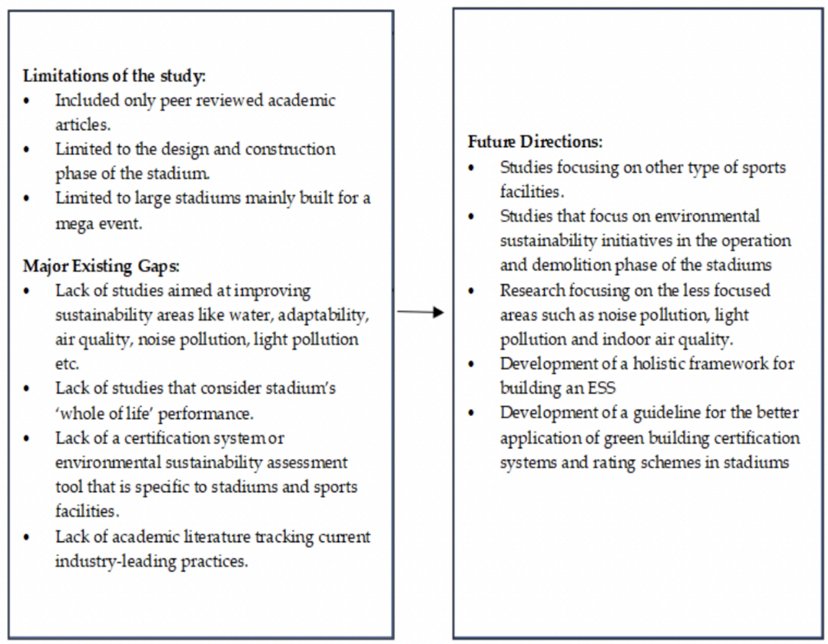

Figure 8. Existing gaps and future research directions.

VOCAB: (w/definition)

revitalization: the action of imbuing something with new life and vitality.

demountable: able to be dismantled or removed from its setting and readily reassembled or repositioned.

candidacy: the fact or condition of being considered for a particular position or status, especially in an election.

retrofit: an act of adding a component or accessory to something that did not have it when manufactured.

	nodes: a point at which lines or pathways intersect or branch; a central or connecting point.
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Follow up Questions	- How might the findings and recommendations be applied to smaller-scale sports facilities or stadiums in different parts of the world? - The article mentions the importance of going beyond reducing environmental impacts and making positive contributions to the environment and community. How can stadiums achieve this? - How practical is the checklist that the author created? What are some improvements or additions that could be made to the checklist to make it better? - How should we envision the stadiums of the future in terms of their designs and constructions based on this article?

Article #10 Notes: Global Garbage Problem - Addressing Waste Management Woes in Stadiums

Date and Time: 10/15/2023 2:08 pm

Introduction:
- With so many fans at games, various fan activities occur, including eating, drinking, and littering.
- The sports industry generates a significant amount of waste annually, with major leagues like the NFL, MLB, NBA, and NHL accumulating more than 1,000 tons of garbage per season.
- A minimal fraction of this waste is recycled or properly disposed of.
- The impact of stadium waste on local energy and the environment is substantial.
- The rise in sports' popularity has led to the construction of new stadiums, further exacerbating waste-related issues.
- Waste Management (WM) estimates that major leagues contribute around 35,000 metric tons of carbon dioxide (CO2) annually due to fan waste.

Methodology:
- The study utilized secondary data from diverse sources, including reports from organizations like the World Bank, FIFA, and LEED.
- Data collection involved accessing a range of materials, including books, journals, research articles, and web resources.
- The primary objective was to analyze these data using various methods to identify and understand the issue of garbage in stadiums.
- The study also aimed to propose effective solutions for managing this problem.

Results:

3.1. Overview of Waste:
- Waste in the stadium is synthetic waste including plastic bags, cans, aluminum cans, glass bottles, cigarette paper boxes, phone batteries, CDs, packaging baked goods, excessive or discarded food, and drinks.
- Classifications of waste: the origins of waste, the state of waste–solid, liquid, or gas, the chemical properties of waste–inorganic or organic, the composition of waste–food, dead animals, plants, building materials, metal, glass or plastic, and toxic waste.
- Waste management requires a lot of effort and money

3.2.1 Waste - A global problem:
- Global environmental issues, including waste disposal, are of increasing concern.
- The World Bank issued a warning in 2012 about a growing garbage crisis with significant financial and environmental impacts on governments worldwide.
- In 2013, the Blacksmith Institute reported that over 200 million people in developing countries were at risk of health issues due to pollution.
- The United Nations projected that the global annual elimination of electronic products would reach 65.4 million tons in 2013.

- Concerning plastic waste, research from 24 ocean expeditions revealed approximately 27,000 tons of plastic waste floating on the ocean surface, including bottles, jars, bags, and toys.
- In 2010, a study found that coastal states had deposited around 8 million tons of plastic garbage in the oceans, surpassing surface-floating garbage.
- In 2013, Ocean Conservancy's International Coastal Cleanup volunteers collected over 11 million items, highlighting the most common types of waste.
- Discoveries made while searching for the missing plane MH370 underscored the issue of environmental pollution and the need for protective measures.
- The North Atlantic Ocean is a hotspot for plastic waste, primarily from the US, Canada, Mexico, and Europe.
- China ranked as the top contributor to ocean waste, with the United States at the 20th position, and several other Asian, African, and South American countries also contributing.
- Projections by the World Bank suggest a significant increase in urban waste, with an estimated 2.2 billion tonnes/year by 2025, compared to the current 1.3 billion tonnes/year, leading to a substantial increase in solid waste disposal costs.
- A 2018 World Bank Report predicted a 70% growth in global waste by 2050 due to urbanization and population size expansion.

3.2.2 Waste at Stadiums:

- Major sporting events like the Olympics, World Cup, and World Championships draw large crowds to stadiums.
- However, the aftermath often results in stadiums being littered with tons of garbage, primarily left behind by spectators.
- In the 2014 World Cup, an average of about 5 tons of garbage was scattered in and around the stadiums after each game.
- The host country, Brazil, had to employ around 850 workers to manage hygiene in the 12 World Cup stadiums.
- The average per-game attendance at major North American sports leagues in 2018 was 67,042 for NFL games.
- A study in California in 2006 revealed that, on average, each event attendee generated about 2.44 pounds of waste per day.
- Various stadiums in the US, like Beaver Stadium in Park University Campus, collected approximately 40 tons of waste after each game.
- The massive waste generation consumes a substantial budget for cleanup and management and prompts various solutions, including waste classification, recycling, and reuse to save money and protect the environment.

3.3. The Solutions and Recycling at Stadiums:

- Most waste is dumped into landfills
- Addressing the stadium waste problem requires a series of questions and solutions.
- Key questions include how to manage waste efficiently without harming the environment, how to repurpose discarded items, and how to transform trash into valuable resources.
- Environmentalists and waste management professionals worldwide have successfully implemented diverse solutions to tackle this issue.

3.3.1 Using Recycling Binds and Solar-Powered Self-Compacting Trash Bins:

- Recycling bins with three different colors (green, magenta, and grey) are used in stadiums to organize waste effectively.
- These bins simplify waste sorting and encourage recycling.
- Various stadiums, including Gillette (Massachusetts), Fenway Park (Boston), Qualcomm Field (California), and Folsom Field (Colorado), have deployed recycling solutions, such as recycling bags in parking lots, compactors, and new recycling bins.
- Self-compacting trash bins, like the BigBelly Solar Compactor, are employed to address the limitations of traditional bins.
- These bins are solar-powered and occupy the space of a standard garbage container but can compress garbage, increasing their capacity by 5 times.
- They reduce garbage collection trips and cut fuel use by 80%.
- These solutions result in significant cost savings on labor, fuel, and maintenance, while also providing environmental benefits by reducing greenhouse gas emissions.
- The self-compacting trash bins are safe, weather-resistant, and designed to deter insects and animals, making them suitable for public spaces, especially stadiums.

3.3.2 Construction Unburied Solid Waste Treatment Areas:

- Stadiums worldwide aim to achieve "non-waste" status, recycling 90% of their garbage instead of sending it to landfills.
- Many stadiums have integrated solid waste treatment plants within their premises to achieve this goal.
- These treatment plants employ advanced technology to process solid waste thoroughly, eliminating the need for landfills and minimizing environmental emissions.
- They also produce renewable energy products from solid waste.
- Washington Nationals Stadium in Washington, D.C., obtained LEED Certification for its efficient waste recycling center.
- Cardinals Stadium in Arizona recycles approximately 120 tons of waste annually.
- In Vietnam, Chi Lang Stadium in Da Nang inaugurated a solid waste treatment complex in January 2015 to manage its annual waste production effectively.
- The complex uses advanced technology to treat solid waste without landfills, minimize environmental pollution, and produce renewable energy products.

3.3.3 Waste Separation and Recycling (the Solution of Sorting and Mechanical Treatment):

- This approach involves processing organic waste through anaerobic firing to produce biochar, heating glass bottles and debris to remove pollutants, and creating unfired bricks for construction.
- Products resulting from this method must meet industry quality standards.
- Organizers for the 2018 World Cup in Russia facilitated efficient garbage collection by placing instruction labels on trash bins, aiding in sorting and recycling efforts.
- Arrow Ecology, an Israeli company, deployed the Arrow Bio System, recycling over 70% of waste in various countries, including the US, Australia, Greece, Mexico, and the UK.
- Safeco Field Stadium was notably successful, saving approximately 1 million USD over three years by recycling 80% of waste from sporting events.

3.3.4 Recycling of Nylon, Discarded Plastic Bottles into Industrial Fuel Oil and Useful Widgets:

- In stadium waste management, plastic waste is categorized along with organic debris and glass bottles.
- The nylon waste is subjected to cracking pyrolysis to produce PO, RO, and FO oil.
- Chemical biowaste is filtered out and can be transformed into biodiesel or used as fuel in various industrial applications.
- Vietnam implemented the technology of converting nylon waste to PO and RO oil in 2012, producing around 17 tons per day.

3.3.5 Turning Garbage into Clean Energy:

- Lagos, Nigeria, effectively adopts a technology to address urban environmental issues, including waste management at stadiums.
- The city is converting urban and stadium waste into an advantage by generating electricity through the production of methane gas.
- The process involves placing plant-based food and damaged fruit in a chamber, crushing them into powder, and fermenting them in a 20m3 tank to produce gas.
- The gas is then transferred to an upper chamber, and the remaining waste is repurposed as agricultural fertilizer.
- Finally, the gas is filtered and used to power generators for electricity production.

3.3.6 Using Recycled Paper and Water Cups from Cornstarch Material:

- Catering services for fans have been improved through collaboration between the multinational company Cargill and NatureWorks, LLC, the world's largest polylactic acid polymer manufacturer.
- Target Field in the US, home to the Minnesota Twins baseball team, signed a 3-year contract with a catering service manufacturer to provide cups, spoons, trays, eating utensils, and straws made of Ingeo materials, which can be mixed with food scraps to create organic waste.

3.3.7 Waste Treatment by Packet Compression Techniques and Hydromex:

- Waste treatment by packet compression techniques involves collecting all stadium waste, manually sorting it, categorizing recyclables, and using hydraulic compression to maximize packet volume.
- The resulting packets serve various purposes, such as constructing dikes, groins, or leveling lowlands with layers of sand and soil.
- The Hydromex technology, developed in the US, grinds trash, polymerizes it, and applies immense pressure to compress the materials into various shapes for construction and agricultural purposes.

3.3.8 Decomposing Grass Clippings, Then Brewing Till Fermenting to Make Compost:

- Decomposing grass clippings and fermenting them to make compost is a sustainable solution, as it reduces the need for fertilizers and water.
- SBC Park in California initiated a recycling program for brewing waste, actively retrieving recyclable materials and collecting over 1,760 tons of raw materials per match.
- Folsom Field in Colorado and an Ohio stadium demonstrated the potential for recycling or composting all items sold inside stadiums during matches.

3.3.9 Recycle Vegetable Oil and Grease into Organic Diesel:

- Recycling vegetable oil and grease into organic diesel helps reduce health risks and environmental pollution. The Kobe University in Japan and Lincoln Financial Stadium applied this method.

3.3.10 Dispose of Rubbish by Burning and Using Output Energy:

- Burning rubbish with energy recovery is an effective method used in developed countries, where the energy produced can be utilized for various purposes, such as heating, electricity, and industry.
- The idea of using waste heat from a crematorium to heat facilities, like a swimming pool, was implemented by the Redditch Borough Council in England, resulting in cost savings.
- Burning waste for electricity is common in many countries, with Singapore burning 100% of its rubbish.
- Ho Chi Minh City in Vietnam is investing in its first waste-to-energy plant, which aims to handle about 1,000 tons of garbage daily and is expected to pay off the investment in 14 years.

3.3.11 Waterless Urinal:

- Use waterless urinals so that the massive amounts of water wasted when flushing are no longer wasted and are saved instead

3.3.12 Establish Group of Volunteers to Collect Rubbish and Educate Community Concious:

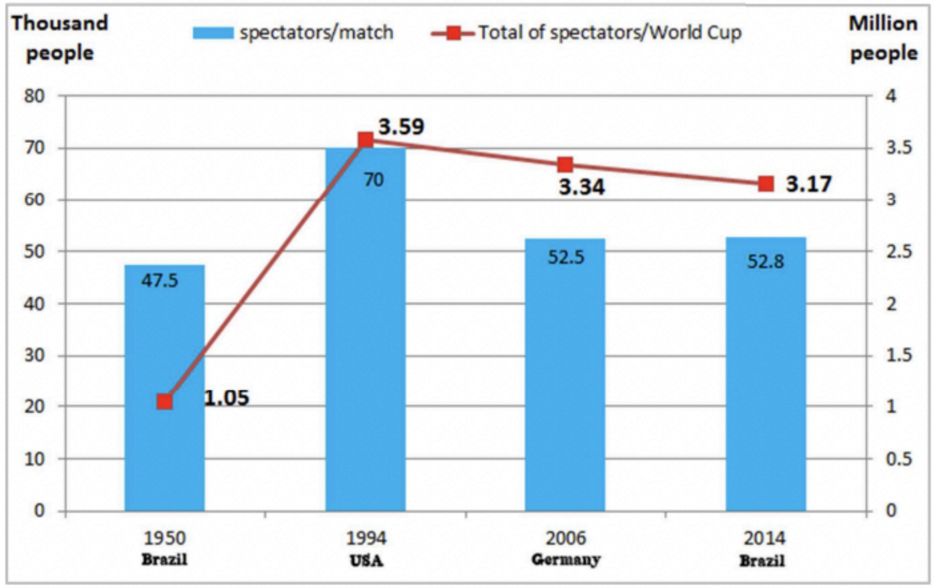
- Stadium staff form teams of hundreds of volunteer members to collect rubbish and educate the community on proper garbage disposal, including classification and the use of recyclable products.
- Japanese spectators are exemplary in environmental consciousness, consistently maintaining clean stands at festivals and sports events in their country and abroad.
- Japanese fans have left positive impressions on World Cup history by enthusiastically supporting the host and cleaning up the stands after matches.
- Brazil, China, and Vietnam spectators also participate in stadium cleaning efforts after matches.
- Numerous practical solutions for garbage disposal, applicable to the sports industry and stadium campuses, aim to achieve high conservation values and significantly reduce pollution.

Conclusion:

- Stadiums worldwide have implemented valuable inventions, including solar power and rainwater harvesting for irrigation, as well as various waste recycling and disposal solutions.
- These innovations offer practical benefits such as energy savings, cost reduction, and a decrease in greenhouse gas emissions while raising environmental protection awareness.
- There are numerous efficient waste management solutions for stadiums globally, tailored to specific conditions in different areas and countries. A combination of these solutions can potentially create new, environmentally friendly stadium models worldwide.

Source Title	Global Garbage Problem - Addressing Waste Management Woes in Stadiums
Source citation (APA Format)	Duc Thanh, N. (2019). Global Garbage Problem - Addressing Waste Management Woes in Stadiums. *International Journal of Sports Science and Physical*

	Education, *4*(1), 1. https://doi.org/10.11648/j.ijsspe.20190401.11
Original URL	https://www.researchgate.net/profile/Thanh-Nguyen-Duc/publication/335405310_Global_Garbage_Problem_-_Addressing_Waste_Management_Woes_in_Stadiums/links/5da6965d299bf1c1e4c380d3/Global-Garbage-Problem-Addressing-Waste-Management-Woes-in-Stadiums.pdf
Source type	Journal article
Keywords	Environment; Recycling; Saving; Solutions; Stadium; Waste
#Tags	#wastemanagement #stadiums #recycling #solutions #sustainiblepractices
Summary of key points + notes (include methodology)	This journal articles explores the global issue of waste management in stadiums and presents various solutions to address this challenges. First, it highlights the environmental impact of the waste generated by sporting events and the need for sustainable waste disposal methods. Some of the efficient waste treatment strategies it discusses are recycling, waste separation, and advanced technologies like packet compression and Hydromex. It also emphasizes tribe importance of community involvement and volunteer efforts in keeping stadiums clean and educating others about proper waste disposal. The application of these solutions not only saves energy and costs but also contributes to reducing GHG emissions. The paper ends by stressing the flexibility of these solutions, which can be adapted to various local conditions, offering the potential for creating environmentally friendly stadium models worldwide.
Research Question/Problem/ Need	How can waste management in stadiums be improved to reduce environmental impact and promote sustainability during large sporting events?

Important Figures	 ***Figure 5.*** *Number of spectators, the protagonist of waste, through World Cups.* - The following figure shows the proportion of spectators at each match of the World Cup vs the total number of spectators at the World Cup.
VOCAB: (w/definition)	anaerobic: relating to, involving, or requiring an absence of free oxygen. biochar: charcoal produced from plant matter and stored in the soil as a means of removing carbon dioxide from the atmosphere. dike: a long wall or embankment built to prevent flooding from the sea. crematorium: another term for crematory. pyrolysis: decomposition brought about by high temperatures. polycarbonate: a synthetic resin in which the polymer units are linked through carbonate groups, including many molding materials and films.
Cited references to follow up on	[1] Readymag.com (2018), LEED in Motion Venues. Retrieved from Readymag.com website (https://readymag.com/usgbc/venues/leed/). [2] WM.com (2013). Sustainable Stadiums & Arenas. Retrieved from WM.com website (https://www.wm.com/sustainabilityservices/documents/insights/Stadiums%20and%20Arenas%20 Insight.pdf). 8 Nguyen Duc Thanh: Global Garbage Problem - Addressing Waste Management Woes in Stadiums [3] Nguyen Xuan Nguyen, Tran Quang Huy (2004). The technology of solid waste

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Follow up Questions	- How can some of these solutions be implemented in reality? - Are there any case studies or real-world examples of stadiums that have successfully implemented the strategies discussed in the article, and what were the outcomes? - How do the waste management solutions discussed in the article compare in terms of their effectiveness and feasibility in different stadium environments? - What role can community engagement and volunteering play in improving waste management practices in stadiums?

Article #11 Notes: Reusing Stadiums for a Greener Future: The Circular Design Potential of Football Architecture

Date and Time: 11/19/2023 11:27 am

Notes:

Introduction to the Shift in Stadium Architecture (Chronological Order):

- Turn of the new Millennium marked an increase in efforts to build environmentally-friendly sports arenas worldwide.
- Influenced by large sporting events like the 2000 Sydney Olympics (‘Green Games’) and the 2006 FIFA World Cup in Germany.
- New stadiums were emphasized due to the prevailing belief that older buildings are less energy-efficient and the need for newness to attract sponsors, investors, and larger audiences.

Critical Examination of the Strategy of Replacing Old Stadiums:

- The paper questions the climate impact of new arenas and explores the reuse potential of existing stadiums.
- Focus on two existing stadiums: Tynecastle Park in Edinburgh (underwent renovation) and Stadio Flaminio in Rome (currently under renovation).
- Integration of perspectives from sports science, preservation, architecture, and circular design theory.
- Objective is to challenge the assumption of the obsolescence of older stadiums and to highlight green strategies for prolonging their life.

Introduction to the Concept of Degrowth and Circular Thinking in Architecture:

- Reference to the idea of ‘degrowth’ in architecture, as advocated by Ohno Hidetoshi and echoed in the 2019 Oslo Architecture Triennale.
- Recipients of the 2021 Pritzker Architecture Prize (Lacaton and Vassall) emphasize ‘Never demolish, never replace.’
- Circular economy principles gaining prominence as an antidote to overspending and waste accumulation in the building industry.

Urgency of Sustainable Practices in the Building Industry:

- Building industry statistics from the EU reveal that it accounts for about 50% of all extracted materials in Europe, with the construction sector responsible for over 35% of the EU's total waste generation.

Architectural Preservation Concepts and Application to Football Stadiums:

- Three contemporary architectural preservation concepts—Adaptive reuse, maintenance architecture, and circular heritage—are introduced.
- Application of these concepts to the study of two historical stadiums: Tynecastle Park in Edinburgh and Stadio Flaminio in Rome.

Methodological Considerations:

- The article relies on critical literature studies, theoretical perspectives from various disciplines, and field trips to Edinburgh and Rome.
- Data collected through fieldwork, interviews, and archival research.
- Limitations due to the COVID-19 pandemic, leading to reliance on previous studies.

Super-Size Me: Challenges of Large-Scale Stadium Architecture:

- Discussion on the historical transformation of European stadia, characterized by grandness of scale, ambition, and expansion.
- Challenges associated with the super-size approach, including environmental impact, energy consumption, and post-event maintenance issues.
- Societal changes in football culture, detraditionalization, and the impact of stadium relocations on social identity and community bonds.

Inner-City vs. Suburban Stadiums:

- Evolution of football stadium architecture from inner-city locations to suburban areas.
- Tension between the need for redevelopment and the preservation of social contracts with the local community.
- Critique of the lack of social engagement in the super-size approach, focusing on hyper-commodification and prioritization of tourist appeal.

Green Rhetoric in Football Architecture:

- Despite evident problems, contemporary football architecture emphasizes green rhetoric.
- Examples like Eco Park, marketed as the world's first timber stadium, showcase the influence of early 2000s sustainable architecture discourse and technology-driven optimism.

Challenges of Sustainable Mega-Events:

- Mega-events like the Sydney Olympics and the 2006 FIFA World Cup sparked interest in environmentally-friendly features, but the focus often fades after the tournament.
- Legacy should not be confused with sustainability; mega-events often cause more physical and economic change than conservation of natural, cultural, and social values.

Tynecastle Park Case Study:

Location and History:

- Tynecastle Park, home to Heart of Midlothian, is a historic British football ground located in Gorgie, west of Edinburgh. Established in 1881, surrounded by a school, distillery, church, and tenements, it underwent renovations and expansions, reaching a peak capacity of 53,396 in 1932.

Challenges and Transformation:

- In the early 1990s, faced with the Taylor report's recommendations after the Hillsborough disaster, proposals emerged to relocate to a new 25,000 all-seater stadium.
- Fans resisted, emphasizing the emotional connection to Tynecastle and its role in the community. Eventually, Tynecastle underwent redevelopment, preserving its historical significance while meeting modern requirements.

Fan Sentiment:

- Fans expressed a deep connection to Tynecastle, emphasizing its role in the club's history and the sociality of the Gorgie area.
- The proposed move was seen as a threat to the community and matchday experience, highlighting the significance of the stadium's location.

Redevelopment Challenges:

- Despite redevelopment efforts, there were subsequent attempts to leave Tynecastle for a larger venue.
- Balancing the need for modern facilities with preserving historical social stability and fan sentiment proved challenging.

Stadio Flaminio Case Study:

Origins and Design:

- Stadio Flaminio, situated in Rome's Parioli district, was built for the 1960 Rome Olympics, replacing the Stadio Nazionale.
- Designed by Pier Luigi Nervi, it showcased innovative engineering and spatial diversity, hosting football, rugby, concerts, and more.

Post-Olympic Use:

- After the Olympics, Stadio Flaminio continued as a versatile venue, hosting concerts, rugby, and football matches.
- Despite its success, it became abandoned after the dissolution of Atletico Roma FC in 2011.

Conservation Challenges:

- The stadium, now in an advanced state of decay, faced challenges in conservation due to its strong dependence on concrete.
- Concrete's environmental impact posed sustainability issues, and the conservation team aimed to develop a plan to rehabilitate the stadium.

Future Prospects:

- Despite challenges, preservation efforts secured funding and legal protection.
- The conservation team faced the dilemma of adhering to international sports governance guidelines while adapting the stadium for modern use.
- The prospect of turning it into the official home for Italian rugby emerged as a potential solution.

Source Title	Reusing Stadiums for a Greener Future: The Circular Design Potential of Football Architecture
Source citation (APA Format)	Wergeland, E. S., & Hognestad, H. K. (2021). Reusing Stadiums for a Greener Future: The Circular Design Potential of Football Architecture. *Frontiers in Sports and Active Living*, *3*. https://www.frontiersin.org/articles/10.3389/fspor.2021.692632
Original URL	https://www.frontiersin.org/articles/10.3389/fspor.2021.692632/full
Source type	Journal article
Keywords	sustainable architecture, circular heritage, historic stadiums, reuse & recycling of materials, football culture, maintenance

#Tags	#stadiums #solutions #sustainiblepractices #sustainabledesign
Summary of key points + notes (include methodology)	In the article, a chronological exploration of the shift in stadium architecture since the new Millennium is presented, driven by the push for environmentally-friendly sports arenas after major events like the 2000 Sydney Olympics and the 2006 FIFA World Cup. The emphasis on new stadiums, fueled by the belief in their energy efficiency and attractiveness to sponsors, is critically examined. The paper questions the climate impact of new arenas and explores the reuse potential of existing stadiums, focusing on Tynecastle Park in Edinburgh and Stadio Flaminio in Rome. The introduction of concepts such as 'degrowth' and circular thinking in architecture underscores the need for sustainable practices in the building industry. The methodology involves critical literature studies, field trips, and reliance on previous studies due to the COVID-19 pandemic. The challenges of large-scale stadium architecture, the evolution from inner-city to suburban stadiums, and the tensions between redevelopment and community preservation are discussed. Case studies of Tynecastle Park and Stadio Flaminio highlight the historical, social, and environmental aspects of football stadiums, offering insights into fan sentiment, redevelopment challenges, and conservation efforts. The article also touches on the green rhetoric in football architecture and the challenges of achieving sustainability in mega-events. (Source: ChatGPT)
Research Question/Problem/ Need	What would it take, within the field of football architecture and in the context of obsessive growth orientation, to embrace degrowth as a principle for future development?

Important Figures	Figure 1  FIGURE 1. Hearts fans enjoying the sun in the new main stand at Tynecastle Park, shortly after it was opened in October 2018 (Credit: Hans K. Hognestad). Figure 2  FIGURE 2. Closed and abandoned: Outside the gates of Stadio Flaminio in September 2017 (Credit: Even Smith Wergeland). - These two figures pictures the two stadiums that are case studied and discussed in the article
VOCAB: (w/definition)	Degrowth: the concept of reducing economic activity, with the aim of achieving a more sustainable and environmentally friendly economy. Boosterism: the enthusiastic promotion of a person, organization, or cause. Trickle-down economic benefits: the idea that policies benefiting the wealthy or businesses will ultimately benefit the broader population as wealth and benefits "trickle down" to the lower classes. Sector expansion: the growth or enlargement of a specific economic sector. Circular economy: an economic system based on the reuse and regeneration of materials or products, especially as a means of continuing production in a sustainable or environmentally friendly way. Detraditionalization: the erosion of tradition in religion (secularization, agnosticism, religious disaffiliation) and society in postmodernism. Hyper-commodification: an extreme emphasis on turning something into a commodity, often to the detriment of its original cultural or social values.

	Topophilic: having a strong sense of place or love for a particular location. Super hyper-commodification: an intensified and extreme emphasis on turning something into a commodity.
Cited references to follow up on	ECOM (2012). *2016 Rio Olympic and Paralympic Games*. Aecom.com. Available online at: https://aecom.com/projects/2016-rio-olympic-paralympic-games (accessed September 18, 2020). Aritua, B., Bower, D. A., and Turner, M. (2008). Managing the delivery of iconic football stadiums in England. *Manage. Procur. Law* 161, 55–60. doi: 10.1680/mpal.2008.161.2.55 CrossRef Full Text | Google Scholar Armstrong, G. (1998). *Football Hooligans: Knowing the Score*. Oxford: Berg. Google Scholar Baker-Brown, D. (2017). *The Reuse Atlas. A Designer's Guide Towards a Circular Economy*. London: RIBA publishing. Google Scholar Bale, J. (1991). “Playing at home: British football and a sense of place,” in *British Football and Social Change*, eds W. John and W. Stephen (Leicester: Leicester University Press), 130–144. Bale, J. (1993a). The spatial development of the modern stadium. *Int. Rev. Soc. Sport* 28, 121–133. doi: 10.1177/101269029302800204 CrossRef Full Text | Google Scholar

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Follow up Questions	- How have the principles of circular economy and sustainability been practically implemented in the renovation or construction of football stadiums, and what specific challenges have emerged in integrating these concepts into sports architecture? - In examining the case studies of Tynecastle Park and Stadio Flaminio, what were the key factors influencing the decision-making processes regarding the renovation, preservation, or potential relocation of these historical stadiums? How did fan sentiment, community engagement, and environmental considerations influence these decisions? - Given the increasing emphasis on environmentally-friendly sports arenas, how effective have major sporting events like the Sydney Olympics and the FIFA World Cup been in promoting sustainable practices in stadium architecture?

Article #12 Notes: From Spectacle to Sustainability: Navigating Waste Management Challenges in Mega-Sporting Events of the Modern Era

Date and Time: 11/19/2023 4:49 pm

Notes:

Introduction

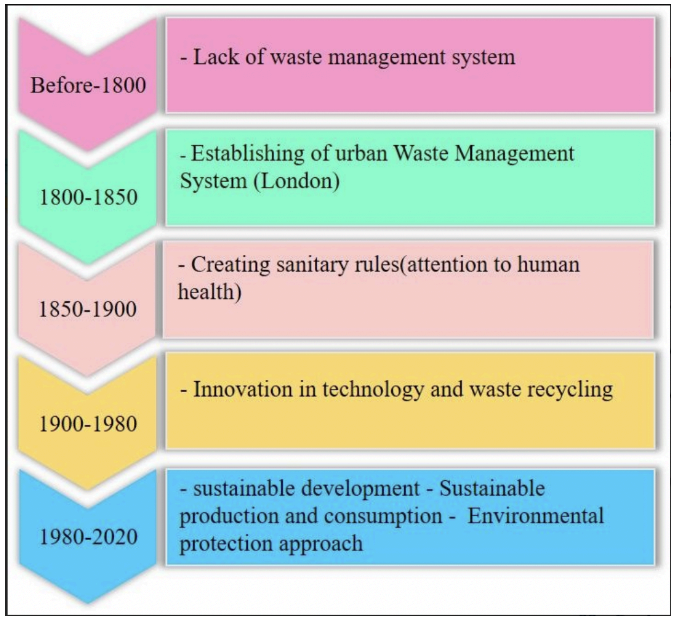
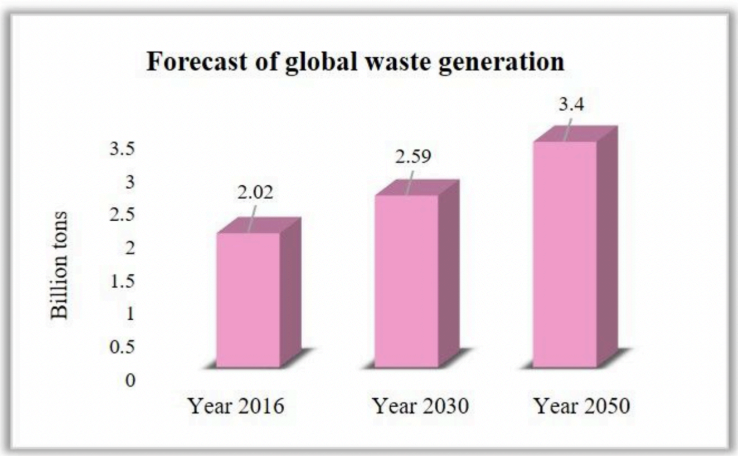
- Global issue: Waste production is significant worldwide, especially in countries with inadequate municipal solid waste management.
- Contributors to the problem: Rapid population growth, unregulated urban development, unsustainable consumption patterns, mass media advertising, and increased production of products and packaging.
- Disparities between developed and developing nations: Developed countries, while pledging to reduce municipal solid waste, produce and consume more waste per capita; however, they excel in recycling due to better management and higher productivity levels.
- Global trend in solid waste management: Fig. 1 illustrates the current state of global solid waste management.
- Unfavorable state of waste management: Lack of fundamental planning and consideration of sustainable development at micro and macro levels pose risks to human life, ecosystem health, and may lead to extinction, especially in marine ecosystems.
- World Bank statistics: Research by the World Bank indicates that waste output has already exceeded 2 billion tons annually, with a projected 68% increase to reach 3.4 billion tons annually by 2050 (see Fig. 2).
- Circular economy as a strategy: Developed nations increasingly consider the circular economy method as the primary strategy for achieving a sustainable waste and resource management system.
- Success of the circular economy: The approach has successfully reduced waste production and increased waste recovery in Organization for Economic Cooperation and Development member nations over the past decade.

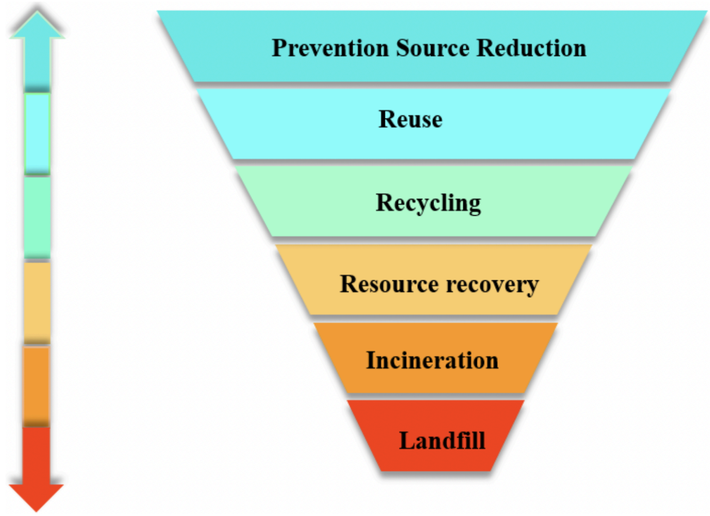
Conclusion

- Waste management is crucial for sustainable development, evaluated through social, economic, basic, and environmental indicators.
- Human activities generate diverse waste types, posing environmental and ecosystem risks if not managed effectively.
- Managing waste at sporting events involves overseeing production, collection, transportation, landfilling, and recycling, requiring a strategic plan.
- Improper waste disposal can contribute to environmental contamination and the spread of infectious diseases, emphasizing the urgency of waste management at sporting events.
- Minor pollution levels can significantly impact the atmosphere, water bodies, and soil, necessitating a comprehensive waste management strategy.

- An integrated and sustainable approach to waste management in sports events is crucial, considering the unique characteristics of stadium environments.
- Careful planning and organization of the financial system throughout waste management stages are vital for minimizing environmental impact and maintaining reasonable costs.
- Production waste management has seen ongoing improvement, with strategies based on the 4Rs: reduction, reuse, recycling, and recovery.
- Embracing an integrated approach to waste management allows for sustainable, cost-effective, and environmentally friendly production waste management.
- Future sporting events should prioritize circular economy principles and smart waste management, utilizing technology-based solutions like RFID, GSM, and GIS.
- Smart waste management technologies enable intelligent waste separation, efficient recycling, and systematic routing of non-recyclable waste to appropriate landfills.
- Information technology in waste management promotes sustainable development by reducing costs, enhancing productivity, and conserving resources.
- It represents a novel approach to electronic sports event management, offering innovative solutions for waste reduction and improved environmental outcomes.

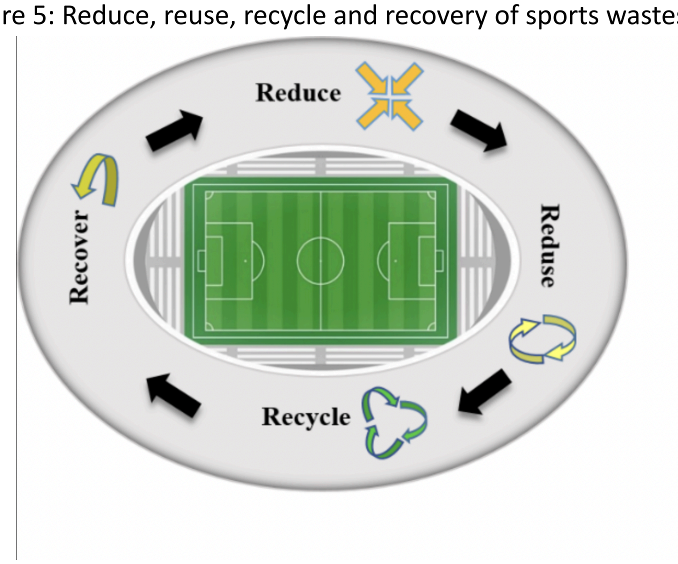
Source Title	From Spectacle to Sustainability: Navigating Waste Management Challenges in Mega-Sporting Events of the Modern Era
Source citation (APA Format)	Zafari, Z., & Golzary, A. (2023, September 26). From Spectacle to Sustainability: Navigating Waste Management Challenges in Mega-Sporting Events of the Modern Era. *Environmental Science and Pollution Research.* https://doi.org/10.21203/rs.3.rs-3278496/v1
Original URL	https://www.researchsquare.com/article/rs-3278496/v1
Source type	Journal article
Keywords	waste management, sports, recycling, environment, World Cup, olympics
#Tags	#stadiums #sustainability #recycling #reduceGHG #wastemanagementstrategies #wastemanagement #reducewaste
Summary of key points + notes (include methodology)	This article addresses the pressing issue of global waste production, with a focus on municipal solid waste management and the alarming increase in waste output predicted by the World Bank. It mentions the importance of this issue by stating that one of the significant issues improper waste management causes is detriment to human health. The circular economy method emerges as a promising strategy to address this challenge, particularly in developed nations where its implementation has shown success in waste reduction and recovery. The study then delves into the realm of sports events, emphasizing the substantial waste generated during such occasions and the environmental impact of inadequate

	waste management. The article also highlights the importance of waste composition analysis in stadiums, citing studies on various events globally(most big sporting events like the World Cup), and emphasizes the necessity of efficient waste management systems. Overall, the article emphasizes the critical need for sustainable waste management practices, especially in the context of sports events, and advocates for the adoption of circular economy principles to mitigate environmental risks associated with waste production. (helped by ChatGPT)
Research Question/Problem/ Need	How have waste management strategies for mega-sporting events evolved over the last two decades, and what are the key factors influencing their effectiveness?
Important Figures	 - Figure 1: The trend of waste management in the world  - Figure 2: Forecast of global waste generation

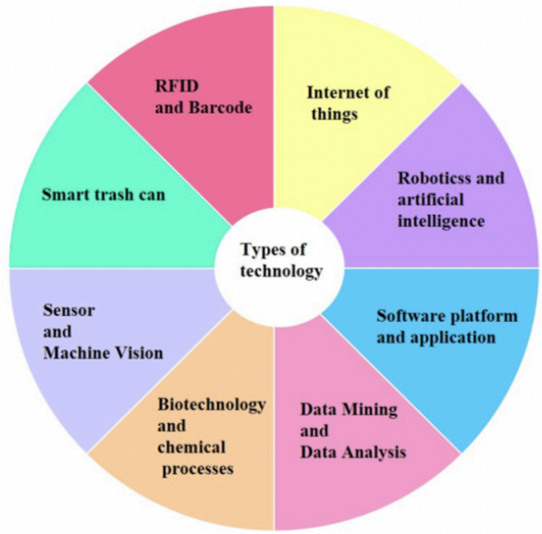


- Figure 4: The hierarchy of action in waste management

- Figure 5: Reduce, reuse, recycle and recovery of sports wastes



- Figure 6: Define the 4R principle in brief: Refuse, Reduce, Reuse, Recycle



- Figure 7: Proposed technologies in sports waste management

Table 2
Stadium Waste production and composition

Events	2005 World Championships in Athletic	2006 FIFA world cup	2006 Torino winter Olympics	2010 FIFA world cup (capetown stadium)	2015 Prince George Canada Winter Games	2017 Thai Premier League (3 stadiums)	2018 FIFA world cup	2018 Asian Games
Waste production	0.53 kg / per person	0.44 kg /per person	1.35 kg / ticket sold	1.8 kg / per person	×	0.097 kg / per person	0/03 – 0/02–3 kg / per person	0.0329 kg / per person
Paper, cardboard	11%	7%	10%	35%	17%	4%-7%	297.6 tonnes	×
Plastic	2%	2%	2%	20%	16%	16%	55.7 tonnes	31.56%
Glass	×	9%	×	6%	×	6%-8%	34.6 tonnes	×
Cans	×	×	×	10%	×	5%-12%	46.4 tonnes	×
Food	×	×	×	×	55%	×	×	×
Non recyclable	×	×	76%	35%	×	×	×	×
Refundable beverage	×	×	×	×	1%	×	×	×
Biowaste	35%	16%	9%	×	×	×	×	59.19%
Wood	×	×	×	×	×	×	1.6 tonnes	×
Hazardous waste	×	×	×		×	1%-2%	0.3 tonnes	×
Other	×	66%	×	×	×	1%-3%	×	×
Mixed	52%	×	×	×	8%	×	×	×
Electronic waste	×	×	×	×	×	×	0.3 tonnes	×

- Table 2: Data on waste production for each sporting event discussed in the article

Table 3
Summary of waste reduction actions in world cups

2006 FIFA World Cup	**- Use of packaging-free and multiple systems (e.g.in catering and for the supply of drinks)** **- Minimization of throwaway items** **- Installation of a standard waste system** **- Grilled sausage, schnitzel, etc. were sold in a bread roll without a cardboard plate** **- Paperless media (Paperless media (World Cup organizers suggested media representatives use an electronic "media channel" where all information can be accessed)** **- Use of returnable crockery for media representatives and volunteers** **- Dispensing with flyers) tracts were distributed in limited numbers only by sponsors(**
2010 FIFA World Cup	- Minimizing the packaging of food sold and using cardboard and paper products - Separation of dry and wet waste at source.)Labeling of waste bins encourages people to separate waste, thereby reducing the cost of sorting and recycling.(- Composting organic waste such as grass andleaves - Reduce the use of glass containers to reduce the risk of injury - Use reusable plastic boxes instead of cardboard boxes - Serving beer and soft drinks from draught and soda fountains - Use reusable commemorative cups
2019 FIFA World Cup	- Use of digital communication tools such as e-mail, video conference - Use of hand dryer instead of paper towels in toilet facilities - Use of double-sided black and white printing and economic mode for printers - Stop using tableware packaging and plastic bags made from non-recyclable materials - Placing empty glass / plastic bottles and aluminum cans in special recyclable waste collection containers for further recycling - Placing used documents and drafts in special containers for paper collecting (e.g.waste paper) for further recycling. - Stop using mixed waste baskets for each workplace
2021 FIFA Arab Cup	- Reduction of single-use plastic - Reduce Packaging Materials - Reduce food waste Food waste reduction measures included: - Food quality control (If the food is of good quality, food waste is reduced - Controlling the Menu served(different food menus were provide for different testes to reduce food waste(- Supply and demand control - Separation of food waste Food waste separation measures include the following: - Steel trays were used tofacilitate the food segregation - Creating awareness campaigns about waste segregation - Special tranning on food waste management for cateres and claners - Various bins to separate food and plastic

- Table 3: Summar of waste reduction strategies employed in the sporting events discussed in the article

VOCAB: (w/definition)

Constituents: a component part of something.

Topography: the arrangement of the natural and artificial physical features of an area.

Corrosive: tending to cause corrosion.

Alkyd paints: typically have thinners made from either alcohol or mineral spirits, often used for doors, cabinets, floors, trim, furniture and commercial wall coverings.

Concurrently: at the same time; simultaneously.

Paradigm: a typical example or pattern of something; a model.

Cited references to follow up on	1. Atchariyasopon, K., 2017. Sustainable solid waste management in sports events: A case study of football matches in thailand. Journal of Population and Social Studies [JPSS], 25(1): 69-81. 2. Azari, A., H. Tavakoli, B.D. Barkdoll and O.B. Haddad, 2020. Predictive model of algal biofuel production based on experimental data. Algal Research, 47: 101843. 3. Bahl, M., S. Dua, A. Patro and N. Mahajan, 2021. Don't transfer waste, transform waste: A sustainable approach towards zero waste events initiative during hockey world cup in bhubaneshwar, india. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing: pp: 012018. 4. Bianchini, A. and J. Rossi, 2021. Design, implementation and assessment of a more sustainable model to manage plastic waste at sport events. Journal of Cleaner Production, 281: 125345. 5. Chandrappa, R. and D.B. Das, 2012. Solid waste management: Principles and practice. Springer Science & Business Media. 6. Chappelet, J.-L. and M.M. Parent, 2017. Routledge handbook of sports event management. Routledge. 7. Chersulich Tomino, A., M. Perić and N. Wise, 2020. Assessing and considering the wider impacts of sport-tourism events: A research agenda review of sustainability and strategic planning elements. Sustainability, 12(11): 4473. 8. Corona, B., L. Shen, D. Reike, J.R. Carreón and E. Worrell, 2019. Towards sustainable development through the circular economy—a review and critical assessment on current circularity metrics. Resources, Conservation and Recycling, 151: 104498. 9. Costello, C., R.G. McGarvey and E. Birisci, 2017. Achieving sustainability beyond zero waste: A case study from a college football stadium. Sustainability, 9(7): 1236. 10. Cox, G., 2012. Sustaining a legacy–from sydney 2000's environmental guidelines to the commission for a sustainable london 2012. Australian Planner, 49(3): 203-214. 11. Death, C., 2011. 'Greening'the 2010 fifa world cup: Environmental sustainability and the mega-event in south africa. Journal of Environmental Policy & Planning, 13(2): 99-117. 12. Ermolaeva, P. and A. Lind, 2021. Mega-event simulacrum: Critical reflections on the sustainability legacies of the world cup 2018 for the russian host cities. Problems of Post-Communism, 68(6): 498-508. 13. Esmaeilian, B., B. Wang, K. Lewis, F. Duarte, C. Ratti and S. Behdad, 2018. The future of waste management in smart and sustainable cities: A review and concept paper. Waste management, 81: 177-195.
Follow up Questions	- How widely adopted is the circular economy approach in sports events globally? - How do waste management practices in sports events compare between developed and developing nations?

	- Since the technological innovations that have been used in controlling waste generated during big sporting events are mentioned in this article, how have they had an impact on the environment? In other words, how much environmental damage did they prevent?

Article #13 Notes: A Guide to Fine-Tuning CLIP Models with Custom Data

Date and Time: 12/2/2023 9:17 pm

Notes:

The training loop itself involves several steps:

1. We begin each epoch by initializing a progress bar using tqdm to keep track of our progress.
2. In each iteration, we load a batch of images and their corresponding captions.
3. The data is passed through our model, generating predictions.
4. These predictions are compared with the ground truth to calculate the loss.
5. This loss is then back-propagated through the network to update the model's parameters.

Source Title	A Guide to Fine-Tuning CLIP Models with Custom Data
Source citation (APA Format)	Vats, S. (2023, June 7). A Guide to Fine-Tuning CLIP Models with Custom Data. *AI Monk.io*. https://medium.com/aimonks/a-guide-to-fine-tuning-clip-models-with-custom-data-6c7c0d1416fb
Original URL	https://medium.com/aimonks/a-guide-to-fine-tuning-clip-models-with-custom-data-6c7c0d1416fb
Source type	Article
Keywords	artificial intelligence, machine learning, CLIP model, zero-shot classification, fine-tuning, transfer learning, CLIP model training
#Tags	#ArtificialIntelligence #MachineLearning #CLIPModel #ZeroShotClassification #FineTuning #TransferLearning #DeepLearning
Summary of key points + notes (include methodology)	This article discusses the significance of fine-tuning the CLIP model in the field of artificial intelligence and machine learning. It emphasizes the model's multimodal capability, enabling it to comprehend and interrelate text and images, particularly in the context of zero-shot classification. For the methodology, the process involves importing necessary libraries, preparing a custom dataset, and utilizing PyTorch and CLIP for model training. Fine-tuning is explored as a process of adapting the pre-trained model to specific tasks, leveraging transfer learning to apply knowledge gained from a broader dataset. The article provides a step-by-step guide, including importing libraries, preparing datasets, loading the CLIP model, creating a custom dataset class, and implementing the fine-tuning and

	training process. The aim is to showcase how fine-tuning the CLIP model with a custom dataset can enhance its performance for specialized tasks, offering practical insights and a code implementation for readers to follow. (helped by ChatGPT)
Research Question/Problem/ Need	How can we make the CLIP model better at understanding and recognizing specific types of images and text by fine-tuning it? What benefits does this bring to AI applications, especially in tasks like zero-shot classification?
Important Figures	`import json` `from PIL import Image` `import torch` `import torch.nn as nn` `from torch.utils.data import DataLoader` `import clip` `from transformers import CLIPProcessor, CLIPModel` - Necessary libraries for fine-tuning CLIP model `class image_title_dataset():` `    def __init__(self, list_image_path,list_txt):` `        # Initialize image paths and corresponding texts` `        self.image_path = list_image_path` `        # Tokenize text using CLIP's tokenizer` `        self.title  = clip.tokenize(list_txt)` `    def __len__(self):` `        return len(self.title)` `    def __getitem__(self, idx):` `        # Preprocess image using CLIP's preprocessing function` `        image = preprocess(Image.open(self.image_path[idx]))` `        title = self.title[idx]` `        return image, title` - Custom dataset and data loader
VOCAB: (w/definition)	unprecedented: never done or known before. multimodal: involving or using several modes or methods of expression or representation (e.g., both text and images in this context). contrastive learning: a technique in machine learning where the model is trained to differentiate between similar and dissimilar pairs of data. preprocessing: the preparation and manipulation of data before it is fed into a model. tokenize: the process of breaking down text into smaller units, or tokens.

	PyTorch: an open-source machine learning library used for tasks such as deep learning and natural language processing. optimizer: A mathematical optimization algorithm used to adjust the parameters of a model during training. back-propagated: The process of updating a model's parameters by adjusting them based on the computed loss during training
Cited references to follow up on	https://github.com/openai/CLIP https://www.kaggle.com/datasets/validmodel/indo-fashion-dataset https://github.com/openai/CLIP/issues/83
Follow up Questions	- Why is it helpful to use a pre-trained model like CLIP instead of starting from scratch when working with artificial intelligence? - What are the main reasons for using the fine-tuning process in machine learning, and how does it save time and resources? - What are the potential risks or pitfalls that practitioners might encounter when fine-tuning models, and how these challenges can be mitigated?

Article #14 Notes: CLIP Itself is a Strong Fine-tuner: Achieving 85.7% and 88.0% Top-1 Accuracy with ViT-B and ViT-L on ImageNet

Date and Time: 12/3/2023 2:25 pm

Notes:

- Recent studies acknowledge CLIP's success in zero-shot inference but highlight its unsatisfactory fine-tuning performance.
- The paper investigates and identifies the significant impact of hyper-parameter choices on CLIP's fine-tuning efficacy.
- Various key hyper-parameters are empirically evaluated to comprehend their influence on CLIP's performance in classification tasks.
- The findings reveal that CLIP's fine-tuning potential has been underestimated, attributing the discrepancy to hyper-parameter choices.
- Through hyper-parameter refinement, the study demonstrates that CLIP, when appropriately tuned, competes favorably or surpasses large-scale supervised pre-training and latest methods using CLIP as prediction targets in Masked Image Modeling.
- CLIP ViT-Base/16 and CLIP ViT-Large/14 showcase notable fine-tuning achievements with 85.7% and 88.0% Top-1 accuracy on the ImageNet-1K dataset.
- These results challenge the conventional belief that CLIP is unsuitable for fine-tuning, prompting a reassessment of recent proposed enhancements leveraging CLIP.

Source Title	CLIP Itself is a Strong Fine-tuner: Achieving 85.7% and 88.0% Top-1 Accuracy with ViT-B and ViT-L on ImageNet
Source citation (APA Format)	Dong, X., Bao, J., Zhang, T., Chen, D., Gu, S., Zhang, W., Yuan, L., Chen, D., Wen, F., & Yu, N. (2022). CLIP Itself is a Strong Fine-tuner: Achieving 85.7% and 88.0% Top-1 Accuracy with ViT-B and ViT-L on ImageNet (arXiv:2212.06138). *arXiv*. https://doi.org/10.48550/arXiv.2212.06138
Original URL	https://arxiv.org/abs/2212.06138
Source type	Journal article
Keywords	CLIP, fine-tuning, hyper-parameters, zero-shot inference, image classification, transfer learning, multimodal learning
#Tags	#CLIP #fine-tuning #hyper-parameters #zero-shotinference #imageclassification #transferlearning #multimodallearning

Summary of key points + notes (include methodology)	The article reevaluates CLIP's fine-tuning capabilities, challenging the belief that it is unsuitable for the task. It identifies hyper-parameter choices as crucial and conducts a detailed study, showing that refined parameters enable CLIP to outperform existing approaches in fine-tuning, even surpassing supervised pre-training. Methodologically, the study explores learning rates, EMA, LLRD, and training length. Ablations cover partial fine-tuning, architecture modifications, augmentations, and regularization. The findings position CLIP as a powerful model for ImageNet-1K fine-tuning, providing a baseline for future research. (helped by ChatGPT)
Research Question/Problem/ Need	How does adjusting the fine-tuning process and hyper-parameters influence the performance of CLIP on classification tasks? Does this challenge previous beliefs about CLIP's suitability for fine-tuning, and what does it mean for future developments in multimodal vision models?

Important Figures

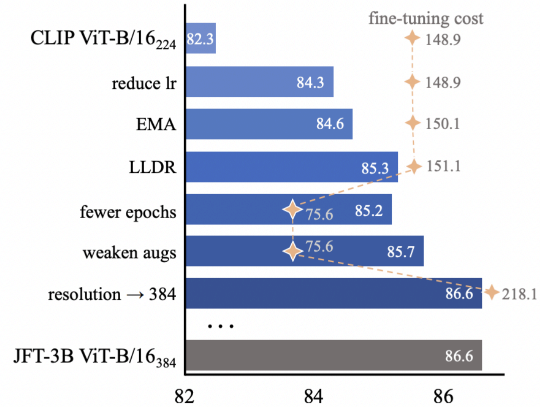


Figure 1. **Overview**. We show the components changed to improve the CLIP fine-tuning performance. With a proper fine-tuning strategy, the CLIP model gets a comparable fine-tuning performance with the model supervisedly pre-trained on JFT. The "fine-tuning cost" denotes the GPU hours calculated with a single V100.

-

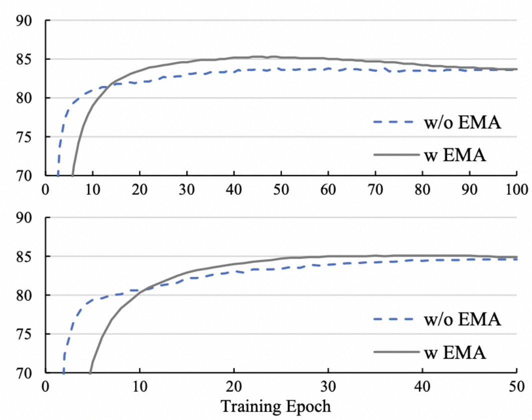


Figure 2. **Training Length**. Each figure shows the epoch-accuracy curve during the training. **Top**: 100 epoch fine-tuning setting, the model gets its best result with half of the training epochs and overfits the training set with the rest epochs. **Bottom**: 50 epoch fine-tuning setting, the model gets similar best accuracy and is under-fitting.

-

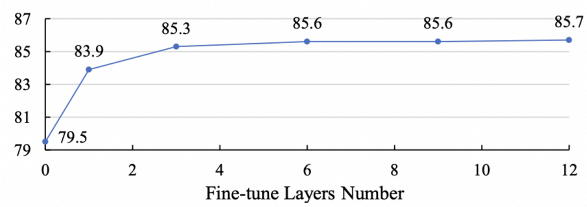


Figure 3. **Partial fine-tuning** results of CLIP-Base/16. The 0 layer tuning is linear probing and 12 is the full fine-tuning. The feature learned by CLIP is quite strong that freezing half of the layers gets 85.6% top-1 accuracy, close to the full fine-tuning result.

-

VOCAB: (w/definition)	empirically: refers to gaining knowledge through observation or experimentation rather than relying solely on theoretical considerations. paramount: used to emphasize the supreme importance or significance of something. baseline: refers to the initial, standard configuration or state used for comparison in experiments. reproducibility: the ability of an experiment or study to be accurately reproduced or replicated by others to validate the results. augmentations: these are modifications or enhancements made to data during training, often used to improve a model's generalization and performance. inductive bias: the inherent assumptions or biases that a learning algorithm incorporates, shaping the kind of knowledge it can acquire from the training data. probing: evaluating or investigating specific aspects or layers of a pre-trained model. overfitting: occurs when a model learns the training data too well, including its noise and random fluctuations, leading to poorer performance on new, unseen data. cosine decay: a learning rate schedule where the learning rate decreases in a cosine pattern over time.
Cited references to follow up on	[1] Alexei Baevski, Wei-Ning Hsu, Qiantong Xu, Arun Babu, Jiatao Gu, and Michael Auli. Data2vec: A general framework for self-supervised learning in speech, vision and language. arXiv preprint arXiv:2202.03555, 2022. [2] Hangbo Bao, Li Dong, and Furu Wei. Beit: Bert pre-training of image transformers. arXiv preprint arXiv:2106.08254, 2021. [3] Xiaokang Chen, Mingyu Ding, Xiaodi Wang, Ying Xin, Shentong Mo, Yunhao Wang, Shumin Han, Ping Luo, Gang Zeng, and Jingdong Wang. Context autoencoder for self-supervised representation learning. arXiv preprint arXiv:2202.03026, 2022. [4] Ekin D Cubuk, Barret Zoph, Jonathon Shlens, and Quoc V Le. Randaugment: Practical automated data augmentation with a reduced search space. In Proceedings of the IEEE/CVF conference on computer vision and pattern recognition workshops, pages 702–703, 2020. [5] Xiaoyi Dong, Jianmin Bao, Ting Zhang, Dongdong Chen, Weiming Zhang, Lu Yuan, Dong Chen, Fang Wen, and

	Nenghai Yu. Peco: Perceptual codebook for bert pre-training of vision transformers. arXiv preprint arXiv:2111.12710, 2021. [6] Xiaoyi Dong, Jianmin Bao, Ting Zhang, Dongdong Chen, Weiming Zhang, Lu Yuan, Dong Chen, Fang Wen, and Nenghai Yu. Bootstrapped masked autoencoders for vision bert pretraining. arXiv preprint arXiv:2207.07116, 2022. [7] Xiaoyi Dong, Jianmin Bao, Ting Zhang, Dongdong Chen, Weiming Zhang, Lu Yuan, Dong Chen, Fang Wen, and Nenghai Yu. Bootstrapped masked autoencoders for vision bert pretraining. arXiv preprint arXiv:2207.07116, 2022. [8] Xiaoyi Dong, Yinglin Zheng, Jianmin Bao, Ting Zhang, Dongdong Chen, Hao Yang, Ming Zeng, Weiming Zhang, Lu Yuan, Dong Chen, et al. Maskclip: Masked selfdistillation advances contrastive language-image pretraining. arXiv preprint arXiv:2208.12262, 2022. [9] Yuxin Fang, Wen Wang, Binhui Xie, Quan Sun, Ledell Wu, Xinggang Wang, Tiejun Huang, Xinlong Wang, and Yue Cao. Eva: Exploring the limits of masked visual representation learning at scale. arXiv preprint arXiv:2211.07636, 2022. [10] Kaiming He, Xinlei Chen, Saining Xie, Yanghao Li, Piotr Dollar, and Ross Girshick. Masked autoencoders are scalable ´ vision learners. arXiv preprint arXiv:2111.06377, 2021.
Follow up Questions	- How do the identified hyper-parameter choices impact the fine-tuning performance of CLIP, and are there specific combinations that consistently yield superior results? - Can the success of CLIP in fine-tuning be extended to other datasets or tasks, and are there potential limitations or challenges in applying this approach to diverse multimodal vision models beyond ImageNet-1K? - In the context of real-world applications, how does the proposed CLIP fine-tuning strategy compare with other state-of-the-art methods, and are there specific domains or tasks where CLIP demonstrates particular advantages or areas for improvement?

Article #15 Notes: Robotic Waste Sorting Technology: Toward a Vision-Based Categorization System for the Industrial Robotic Separation of Recyclable Waste

Date and Time: 12/4/23 9:26 pm

Notes:

Source Title	Robotic Waste Sorting Technology: Toward a Vision-Based Categorization System for the Industrial Robotic Separation of Recyclable Waste
Source citation (APA Format)	Koskinopoulou, M., Raptopoulos, F., Papadopoulos, G., Mavrakis, N., & Maniadakis, M. (2021). Robotic Waste Sorting Technology: Toward a Vision-Based Categorization System for the Industrial Robotic Separation of Recyclable Waste. *IEEE Robotics & Automation Magazine*, *28*(2), 50–60. https://doi.org/10.1109/MRA.2021.3066040
Original URL	https://ieeexplore.ieee.org/abstract/document/9395690?casa_token=3D1mBQHdLWUAAAAA:Tb5hDDyXc_aH4XyV-5p8YejDFAJIm8QJdfqChvw7XyH-IdAxPc1-O7Vi4ZxFnttdpxkZWjs
Source type	Journal article
Keywords	recyclable, anipulation, computer vision, robotics technology, waste management, seasonal characteristics, mask R-CNN
#Tags	#recyclablemanipulation #computervision #roboticstechnology #wastemanagement #wastesorting #sustainabletechnology #artificialintelligence
Summary of key points + notes (include methodology)	This paper outlines the development and implementation of an intelligent autonomous system for recyclable material recovery in industrial waste management. The system integrates a robotic manipulator with a vision-based material categorization module to autonomously identify, localize, and categorize recyclables in an industrial setting. The methodology involves a comprehensive research setup, including the use of a conveyor belt, waste feeder, stereo camera, ABB IRB360 delta robot, and a vacuum gripper. The study introduces a blower-based vacuum system for improved recyclable manipulation. The vision-based categorization employs Mask R-CNN, trained on a synthetic data set generated through innovative techniques. The article discusses the validation of both the robotic manipulation and vision-based categorization modules, highlighting the system's potential impact on future automated waste treatment

	plants. (helped by ChatGPT)
Research Question/Problem/ Need	How can advanced technology improve recycling in industrial waste management?

Important Figures

Parameter	Value
BACKBONE	ResNet-50
BATCH_SIZE	1
DETECTION_MIN_CONFIDENCE	0.85
FPN_CLASSIF_FC_LAYERS_SIZE	1,024
RPN_ANCHOR_RATIOS	[0.5, 1, 2]
RPN_ANCHOR_SCALES	(32, 64, 128, 256, 512)
RPN_ANCHOR_STRIDE	1
RPN_BBOX_STD_DEV	[0.1 0.1 0.2 0.2]
RPN_NMS_THRESHOLD	0.7
RPN_TRAIN_ANCHORS_PER_IMAGE	256

- The training parameter configuration

	Network	Mask R-CNN Bounding Box	Mask R-CNN Class	Mask R-CNN Mask	RPN Bounding Box	RPN Class
Training	Net 1	0.22	0.21	0.21	0.41	0.04
	Net 2	0.21	0.15	0.21	0.4	0.04
	Net 3	0.2	0.12	0.2	0.38	0.04
	Net 4	0.1	0.09	0.18	0.22	0.02
Validation	Net 1	0.18	0.18	0.21	0.88	0.04
	Net 2	0.17	0.14	0.22	0.73	0.04
	Net 3	0.17	0.12	0.18	0.81	0.04
	Net 4	0.1	0.09	0.11	0.21	0.02

- The training and validation losses (minimum values)

Augmentation	Range	Real Flow MAP	Real Flow MAR	Real Flow F1
Translation (*x*, *y*)	(−0.2, 0.2)	68.5	76.7	72.2
Translation (*x*, *y*)	(−0.5, 0.5)	65.4	72.9	68.8
Rotation	(−20, 20)	70.3	78.8	74.2
Rotation	(−40, 40)	71.8	80.1	75.6
Scale	(0.9, 1.1)	72.4	79.4	75.7
Scale	(0.7, 1.3)	75.3	84.2	79.5
Gaussian_Blur	Sigma = 2	56.2	57.6	56.9
Gaussian_Blur	Sigma = 3	48.4	42.2	45.1
Translation + Rotation + Scale + Blur	(−0.2, 0.2) + (−30, 30) (−0.8, 1.2) + 2	71.3	73.4	72.3
Translation + Rotation + Scale	Same as Net 4	**87.4**	**90.1**	**88.7**

- The resulting performance (%)

Approach		Aluminum	Paper/Cardboard	Bottle	Nylon	Average
Venturi	Pick success	68	85	81	98	83
	Transfer fail	0	1	3	0	1
Pump	Pick success	**82**	**96**	**84**	**99**	**90.2**
	Transfer fail	0	0	4	0	1

- The PnP performance evaluation (%)

VOCAB: (w/definition)

presupposes: assumes or requires as a precondition.

replica: a copy or reproduction of something.

rommel: a rotating cylindrical sieve or screen used for sorting or sizing particles.

effector: a device or part that produces a desired effect or response.

venturi generators: devices that use the Venturi effect, utilizing fluid dynamics to create a vacuum.

composite system: a system composed of several interconnected parts or elements.

affine transformations: transformations that include translation, rotation, scaling, and shearing of an image.

harmonic mean: a type of average, calculated by dividing the number of observations by the reciprocal of each number's value.

seminal: highly influential, original, and important.

MRF (Material Recovery Facility): a specialized plant that receives, separates, and prepares recyclable materials for marketing to end-user manufacturers.

Cited references to follow up on	[1] E. Papadakis, F. Raptopoulos, M. Koskinopoulou, and M. Maniadakis, “On the use of vacuum technology for applied robotic systems,” in Proc. ICMRE 2020—IEEE 6th Int. Conf. Mechatron. Robot. Eng., 2020, pp. 73–77. [2] F. Raptopoulos, M. Koskinopoulou, and M. Maniadakis, “Robotic pick-and-toss facilitates urban waste sorting *,” in Proc. IEEE 16th Int. Conf. Automat. Sci. Eng. (CASE), 2020, pp. 1149–1154. [3] R. Sarc, A. Curtis, L. Kandlbauer, K. Khodier, K. Lorber, and R. Pomberger, “Digitalisation and intelligent robotics in value chain of circular economy oriented waste management—A review,” Waste Manage., vol. 95, pp. 476–492, July 15, 2019. doi: 10.1016/j.wasman.2019.06.035. [4] E. Mokled, G. Chartouni, C. Kassis, and R. Rizk, “Parallel robot integration synchronization a waste sorting system,” in Mechanism, Machine, Robotics and Mechatronics Sciences (Mechanisms and Machine Science), R. Rizk and M. Awad, Eds. Cham: Springer-Verlag, May 2019, pp. 171–187. [5] Z. Zhang, H. Wang, H. Song, S. Zhang, and J. Zhang, “Industrial robot sorting system for municipal solid waste,” in Intelligent Robotics and Applications, H. Yu, J. Liu, L. Liu, Z. Ju, Y. Liu, and D. Zhou, Eds. Cham: Springer International Publishing, 2019, pp. 342–353. [6] Sadako. Accessed Oct. 2020. [Online]. Available: http://www.sadako.es/max-ai/ [7] “SAMURAI robotic sorting system.” SAMURAI, Canada. Accessed Sept. 2020. [Online]. Available: https://www.machinexrecycling.com/products/samurai-sorting-robot/ [8] AMP Robotics. Accessed Oct. 2020. [Online]. Available: https://www.amprobotics.com/ [9] Zen Robotics. Accessed Oct. 2020. [Online]. Available: https://zenrobotics.com/ [10] C. Zhihong, Z. Hebin, W. Yanbo, L. Binyan, and L. Yu, “A visionbased robotic grasping system using deep learning for garbage sorting,” in Proc. Chinese Control Conf. (CCC), 2017, pp. 11,223–11,226.
Follow up Questions	- How scalable is the proposed robotic system for recyclable sorting, and how well does the vision-based material categorization module generalize to different industrial environments and waste compositions? - In future iterations, how can the robotic system be further developed to collaborate with human workers in waste management facilities, optimizing efficiency and ensuring adaptability to changing waste characteristics? - What considerations have been made regarding the environmental impact of implementing such robotic systems in waste management?

Article #16 Notes: Toward zero waste: Composting and recycling for sustainable venue based events

Date and Time: 12/9/23 10:51 pm

Notes:

Introduction:

- Context setting for waste management and sustainability in large-scale events.
- Identifies research gap in understanding waste management efficiency.
- Objective: Assess and compare waste management scenarios at university baseball games.

Methods:

- Three key areas: raw data collection, modeling and scenario analysis, waste disposal behavior.
- Collaboration with ASU Athletics for controlled waste audits during baseball games.
- Two-bin collection system at Packard Stadium with color-coded bins and signs.

Results:

- Raw data collection: Details waste audit results from four games, 66% average collection rate.
- Scenario analysis using WARM: Examines carbon emissions and energy consumption for seven scenarios.
- Waste disposal behavior: Analyzes impact of signage and volunteer bin guards on public behavior.

Discussion:

- Emphasizes recycling benefits in CO2 emissions and energy impacts.
- Highlights challenges of contamination in multi-bin systems.
- Proposes simplification approach to reduce contamination.

Conclusion:

- Notes tradeoffs between waste materials and end-of-life treatments.
- Stresses importance of effective consumer education over time.
- Provides insights for venue operators and facility managers.
- Indicates research findings informed ASU's environmental initiatives.

Source Title	Toward zero waste: Composting and recycling for sustainable venue based events
Source citation (APA Format)	Hottle, T. A., Bilec, M. M., Brown, N. R., & Landis, A. E. (2015). Toward zero waste: Composting and recycling for sustainable venue based events. *Waste Management*, *38*, 86–94. https://doi.org/10.1016/j.wasman.2015.01.019
Original URL	https://www.sciencedirect.com/science/article/pii/S0956053X15000562?casa_token=CL5MfsJtdkUAAAAA:XXtofXyhNHYF_VpP-YfScj-R4dcu02Jj_4Qfyfc5MpOALKIXTowB0_PLLHjzlkppQrWzJvw
Source type	Journal article

Keywords	single stream, composting, sustainability, biopolymers, zero waste
#Tags	#WasteManagement #SustainabilityPractices #UniversityEvents #WasteReductionModel #PublicBehaviorinWaste Disposal
Summary of key points + notes (include methodology)	The study investigates sustainable waste management practices at large events, specifically focusing on university baseball games. The introduction highlights the research's aim to address a gap in understanding waste management efficiency and sustainability. The methodology involves collaboration with ASU Athletics, conducting waste audits during baseball games at Packard Stadium. The study uses a two-bin collection system with color-coded bins and signs for composting and recycling. Results indicate a 66% average collection rate during four games, and a scenario analysis, using the WARM tool, assesses carbon emissions and energy consumption for seven waste management scenarios. The discussion emphasizes the benefits of recycling in CO2 emissions and energy impacts while acknowledging challenges of contamination in multi-bin systems. It proposes a simplification approach to enhance waste stream management. The conclusion underscores tradeoffs in waste materials and end-of-life treatments, emphasizes the importance of effective consumer education, and provides insights for venue operators and facility managers. The study's methodology informs ASU's environmental initiatives and offers valuable lessons for waste management at large events.
Research Question/Problem/ Need	How effective are different waste management practices at university baseball games, and what are the quantified waste composition, generation rates, and environmental impacts, particularly in terms of CO_2 equivalent emissions?

Important Figures	

Seven Scenarios for Waste Management

	1	2	3	4	5	6	7
Material Type	Landfill Only	Landfill/ Recycle	Compost/ Recycle	Aluminum, PET, PLA Landfill	Aluminum/ PET Recycle, PLA Compost	PLA/ Organics Landfill	PLA/ Organics Compost
Aluminum Cans	2.7%	2.7%	2.7%	2.7%	2.7%		
HDPE	8.1%	8.1%	8.1%				
PET	21.6%	21.6%	21.6%	21.6%	21.6%		
PP	10.8%	10.8%	10.8%				
Corrugated Containers	2.7%	2.7%	2.7%				
Newspaper	2.7%	2.7%	2.7%				
Mixed Paper	5.4%	5.4%	5.4%				
Mixed Organics	46.0%	46.0%	46.0%	56.8%	56.8%	56.8%	56.8%
PLA				18.9%	18.9%	43.2%	43.2%

landfill | recycle | compost

- Waste management scenarios by percent mass. The first three scenarios represent the current waste mix, which has no PLA. The subsequent scenarios investigate methods of altering the materials in the waste stream for improved performance.

Waste Generation at Four Games

Collected Bin Material					
	4-May-13	17-May-13	18-May-13	19-May-13	All Games
Total (kg)	54.00	35.94	51.52	40.32	181.78
Recycle %	44%	55%	59%	60%	54%
Compost %	56%	45%	41%	40%	46%

Recycle					
	4-May-13	17-May-13	18-May-13	19-May-13	All Games
Total (kg)	23.78	19.66	30.46	24.10	98.00
Correct (kg)	20.16	14.06	26.14	18.70	79.06
Incorrect (kg)	3.62	5.60	4.32	5.40	18.94
Contamination	15%	28%	14%	22%	19%

Compost					
	4-May-13	17-May-13	18-May-13	19-May-13	All Games
Total (kg)	30.22	16.28	21.06	16.22	83.78
Correct (kg)	28.72	9.84	19.56	12.56	70.68
Incorrect (kg)	1.50	6.44	1.50	3.66	13.10
Contamination	5%	40%	7%	23%	16%

Extrapolated Total Bin Material and Attendance					
	4-May-13	17-May-13	18-May-13	19-May-13	Averages
Material (kg)	77.14	59.90	90.16	51.80	69.75
Attendance	3052	3198	3260	1500	2753
Per capita (g)	25.28	18.73	27.66	34.53	25.34

- Waste audit data for four games. Waste audit collection data from four

	ASU baseball games at Packard Stadium. Collected bin material only represents the bin materials that were sampled and weighed at each game, which accounts for 66% of total waste. Extrapolated total bin material was calculated by applying the average bag mass to the uncollected bags for each game and totaling that figure with collected bin material.
VOCAB: (w/definition)	efficacy: the ability of a strategy or method to produce the desired results or effects. sequester: to isolate or remove something from circulation; in this context, referring to carbon being sequestered in landfill conditions. tipping floor: the location where waste collection trucks dump their loads for further processing or disposal. manned bins: bins that are staffed or attended by individuals, such as volunteer bin guards. biopolymers: polymers derived from natural sources, often used in the context of compostable materials. life cycle assessment: an analysis of the environmental impact of a product or process throughout its life, from raw material extraction to disposal. procurement: the process of obtaining goods or services, often referring to the purchasing practices of an organization.
Cited references to follow up on	ASTM, 2003a ASTM ASTM D5338-98(2003) Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions ASTM International, West Conshohocken, PA (2003) Google Scholar ASTM, 2003b ASTM ASTM D6868-03 Standard Specification for Biodegradable Plastics Used as Coatings on Paper and Other Compostable Substrates ASTM International, West Conshohocken, PA (2003) Google Scholar ASTM, 2004 ASTM

	ASTM D6400-04 Standard Specification for Compostable Plastics ASTM International, West Conshohocken, PA (2004) Google Scholar
Follow up Questions	- How can waste management strategies at large events be further optimized to achieve higher recycling rates and lower contamination levels? - What are the economic implications of implementing different waste disposal methods, such as single-stream composting or two-stream recycling, and how do these compare in terms of environmental impact? - In what ways can the successful waste management practices observed at university sporting events be translated to other large-scale gatherings and venues, contributing to broader sustainability initiatives?

Article #17 Notes: Design, implementation and assessment of a more sustainable model to manage plastic waste at sport events

Date and Time: 12/9/23 1:14 am

Notes:

- Running events like marathons can be more sustainable by managing plastic waste better, rather than simply eliminating it. This includes efficient collection, sorting, and recycling.
- The new model proposed in this paper helps marathons achieve complete sustainability:
- Environmentally: It significantly reduces landfill waste by increasing collection and recycling rates.
    - Economically: It can be cost-effective when recycling technology is advanced and virgin plastic prices are high.
    - Socially: Engaging participants creates positive perceptions of the event's sustainability.
- Additional insights for improvement:
    - Standardizing plastics could make them easier to recycle.
    - Educating consumers about responsible waste disposal is crucial.
    - Supporting technological advancements in recycling can further increase efficiency.

Source Title	Design, implementation and assessment of a more sustainable model to manage plastic waste at sport events
Source citation (APA Format)	Bianchini, A., & Rossi, J. (2021). Design, implementation and assessment of a more sustainable model to manage plastic waste at sport events. *Journal of Cleaner Production*, *281*, 125345. https://doi.org/10.1016/j.jclepro.2020.125345
Original URL	https://www-sciencedirect-com.ezpv7-web-p-u01.wpi.edu/science/article/pii/S0959652620353907
Source type	Journal article
Keywords	circular economy, waste management, marathon, assessment tool, environmental impact
#Tags	#CircularEconomy #WasteManagement #Marathon #Sustainability #EnvironmentalImpact #EconomicImpact
Summary of key points + notes (include methodology)	This paper proposes a new model for managing plastic waste at a marathon. The model does not aim to eliminate plastics at sport events, but to better manage waste by increasing collection, and sorting and recycling efficiency, following the

circular economy paradigm. To demonstrate the sustainability of the model, a precise and quantitative methodology is applied to an innovative visualisation tool, developed by the University of Bologna, to assess circular initiatives and some key performance indicators (KPIs) to compare the sustainability of the new model to waste management in the previous editions of the same event. With this approach, it is demonstrated that a marathon can be completely sustainable: (i) from an environmental point of view, plastic collection efficiency increased by 120.5%; the recycling rate by 157.0% and the landfill rate decreased by 75.4%. (ii) from an economic point of view, it was demonstrated that, with the technological level of the involved recycling plant, the initiative is cost-effective when the virgin PET price is greater than V776/tonne. (iii) with regard to the social impact, it was proved that the direct engagement of participants (runners and walkers) and their positive perceptions about the initiative achieved the highest score for the two selected qualitative KPIs (3/3). Moreover, some insights have been derived to improve plastic manage- ment, covering different disciplines: technical standardisation of plastics, consumer training and legis- lative support for technological innovation in the industrial context.
(helped by ChatGPT)

Research Question/Problem/ Need

How can a circular economy approach be applied to effectively manage plastic waste at marathons and achieve sustainability across environmental, economic, and social dimensions?

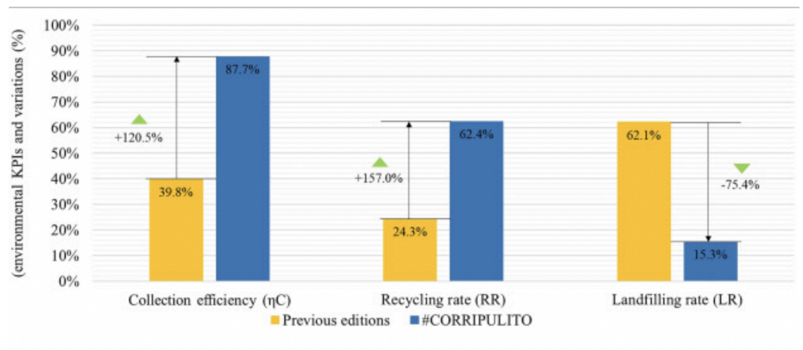
Important Figures

Polymer type	Distributed plastics (kg) $W_{distributed\ plastics_i}$	Number of rubbish bags $\#_{rubbish\ bags_i}$	Gross weight of collected plastics (kg) $W_{GROSS\ collected\ plastics_i}$	Net weight of collected plastics (kg)[a] $w_{rubbish\ bag}$
PET - bottles	54.9	44	38.4	37.0
PP – plates and cups	151.4	176	165.7	160.1
PS – cutlery	10.3	12	10.7	10.3
MIX - other plastics	0.4	47	30.3	28.8
Total	217.1	279	245.2	236.2

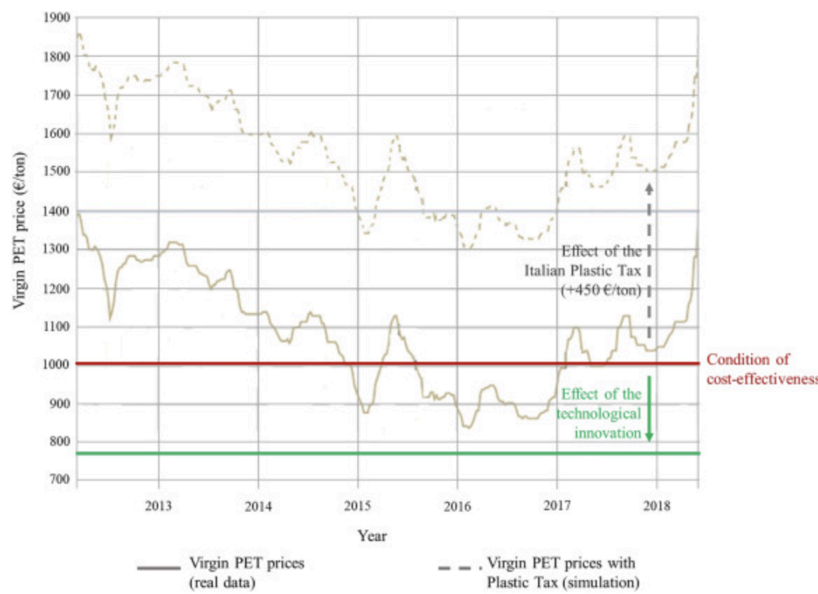
a

Unit weight of rubbish bags $w_{garbage\ bag} = 0.032\ kg$.

- Flows of distributed and collected plastics sorted by polymers.



- Values of the selected KPIs to assess environmental sustainability and their variations in: (i) previous editions and (ii) the #CORRIPULITO initiative.



- Trend in virgin PET price over time: real data and simulation with the addition of the Italian Plastic Tax.

VOCAB: (w/definition)	circular economy: an economic system aimed at eliminating waste and pollution by reusing, repairing, and recycling materials for as long as possible. key performance indicators (KPIs): measurable values used to track and assess the success of a project or initiative. landfill rate: the percentage of waste that is disposed of in landfills. recycling rate: the percentage of waste that is recycled and turned into new materials. virgin PET: plastic made from new, unrecycled materials.

	standardization: the process of establishing common rules or specifications for a product or process. technological innovation: the development and introduction of new technologies.
Cited references to follow up on	Abbas et al., 2018 M. Abbas, Y. Gao, S. Shah CSR and customer outcomes: the mediating role of customer engagement Sustainability, 10 (2018), p. 4243, 10.3390/su10114243 View article View in ScopusGoogle Scholar Agostinho et al., 2019 F. Agostinho, T. Richard Silva, C.M.V.B. Almeida, G. Liu, B.F. Giannetti Sustainability assessment procedure for operations and production processes (SUAPRO) Sci. Total Environ., 685 (2019), pp. 1006-1018, 10.1016/j.scitotenv.2019.06.261 View PDFView articleView in ScopusGoogle Scholar Amrutha and Geetha, 2020 V.N. Amrutha, S.N. Geetha A systematic review on green human resource management: implications for social sustainability J. Clean. Prod., 247 (2020), p. 119131, 10.1016/j.jclepro.2019.119131 View PDFView articleView in ScopusGoogle Scholar Arenas-Vivo et al., 2017 A. Arenas-Vivo, F.R. Beltràn, V. Alcàzar, M.U. de la Orden, J.M. Urreaga Fluorescence labeling of high density polyethylene for identification and separation of selected containers in plastics waste streams. Comparison of thermal and photochemical stability of different fluorescent tracers Mater. Today Commun, 12 (2017), pp. 125-132, 10.1016/j.mtcomm.2017.07.008 View PDFView articleView in ScopusGoogle Scholar
Follow up Questions	- What are the biggest challenges in implementing a circular economy approach for plastic waste management at marathons? - What are the long-term environmental benefits of reducing plastic waste

	at marathons, such as potential impacts on greenhouse gas emissions? - Beyond cost-effectiveness, could the #CORRIPULITO model also create economic opportunities, like new jobs in recycling or innovative product development?

Article #18 Notes: Solid waste prevention and management at green festivals: A case study of the Andanças Festival, Portugal

Date and Time: 12/12/23 5:17 pm

Notes:
Introduction:
- There are limited studies on waste prevention and management at green festivals.
- The focus of the study is to analyze waste prevention/reduction and management measures at Andanças festival, Portugal.

Methodology:
- Waste characterization campaigns and questionnaire survey conducted during the festival.
- Dual approach to gather insights into waste generation and participant perspectives.

Waste Generation at Andanças Festival:
- Residual waste was the largest category of waste generated.
- Following categories: food and kitchen waste, packaging waste.
- Amount of waste per person per day lower than other festivals (venue and canteen).

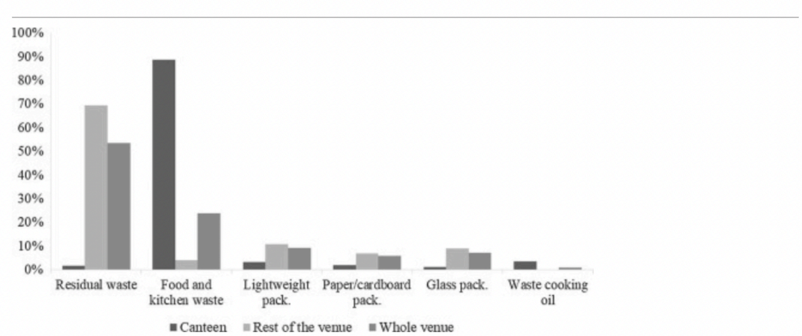
Canteen-Specific Waste Insights:
- Edible fraction of food and kitchen waste relatively low compared to total waste generated.
- Source separation rates high, aligning with food-waste source separation practices at other festivals.

Factors Influencing Waste Prevention Measures Participation:
- Type of participant, region of origin, frequency of visits, and family attendance.
- Indicates the need for tailored strategies to enhance waste prevention awareness.

Challenges and Recommendations:
- Low awareness of waste prevention measures among attendees.
- Need for guidelines and quantification methods for waste prevention.
- Advocacy for policies promoting the application of the zero-waste principle at festivals.

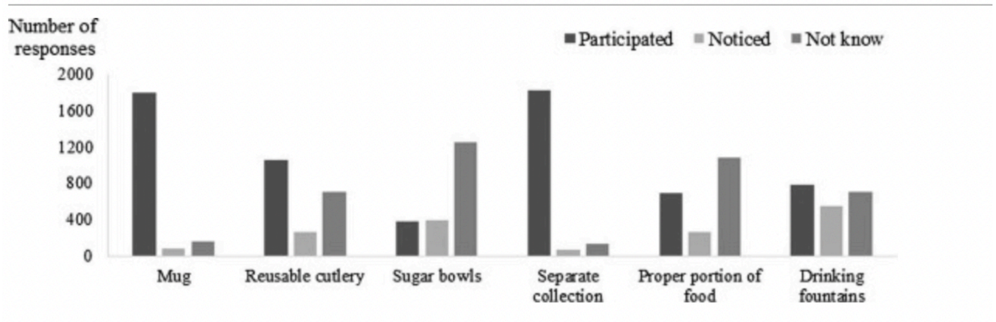
Conclusion:
- Emphasizes the significance of increasing attendee awareness, developing practical guidelines, and formulating policies to advance waste prevention efforts at festivals.
- Urges further research and concerted efforts to enhance sustainable waste management practices in festival settings.

Source Title	Solid waste prevention and management at green festivals: A case study of the Andanças Festival, Portugal
Source citation (APA Format)	Martinho, G., Gomes, A., Ramos, M., Santos, P., Gonçalves, G., Fonseca, M., & Pires, A. (2018). Solid waste prevention and management at green festivals: A

	case study of the Andanças Festival, Portugal. *Waste Management*, *71*, 10–18. https://doi.org/10.1016/j.wasman.2017.10.020
Original URL	https://www-sciencedirect-com.ezpv7-web-p-u01.wpi.edu/science/article/pii/S0956053X17307687
Source type	Journal article
Keywords	waste prevention, recycling, awareness, festivals
#Tags	#WasteManagement #GreenFestivals #WastePrevention #SourceSeparation
Summary of key points + notes (include methodology)	A Portuguese green festival called Andanças implements successful waste management practices, according to a recent study. Researchers investigated how waste is generated, sorted, and perceived by festival participants. They found that Andanças produces less waste per person than other festivals, with most waste being general trash followed by food scraps and packaging. Recycling rates are high, similar to other festivals that prioritize food waste separation. Notably, attendees, staff, artists, and vendors all actively participate in waste prevention efforts. The study suggests that Andanças effectively manages waste through a combination of strategies and strong stakeholder engagement. To further improve, the researchers recommend raising attendee awareness about waste prevention, developing methods to quantify waste reduction efforts, and implementing policies that encourage zero-waste practices at festivals.
Research Question/Problem/ Need	What are the waste management practices at the Andanças festival, a Portuguese green festival, and how do stakeholders perceive these practices?
Important Figures	 - Waste composition analysis from the study

Waste stream	Waste generation per person per day (g person⁻¹ day⁻¹)			Waste generation per area per day (g m⁻² day ⁻¹)		
	Whole festival	Canteen	Rest of the venue	Whole festival	Canteen	Rest of the venue
Residual waste	249.2	1.8	247.4	28.6	1.0	35.5
Food and kitchen waste	110.8	96.9	13.9	12.7	55.7	2.0
Lightweight packaging	42.3	3.8	38.5	4.9	2.2	5.5
Paper/cardboard packaging	26.6	2.1	24.5	3.1	1.2	3.5
Glass packaging	33.3	0.7	32.6	3.8	0.4	4.7
Waste cooking oil	3.7	3.7	0.00	0.4	2.2	0.0
Total	465.9	109.0	356.9	53.5	62.7	51.2

- Waste generation per waste stream



- Respondent awareness of and participation in different waste reduction measures at the Andanças festival.

VOCAB: (w/definition)

green festival: a festival that is committed to sustainability and environmental protection.

stakeholder: an individual or group that has an interest in or is affected by the activities of an organization.

residual waste: waste that cannot be recycled or composted.

packaging waste: waste from packaging materials.

prevailing: existing or widely accepted.

incentives: things that motivate someone to do something.

synergies: the combined effect of two or more things that is greater than the sum of their individual effects.

dissemination: the act of spreading information or knowledge.

Cited references to follow up on	Gustavsson et al., 2011 J. Gustavsson, C. Cederberg, U. Sonesson, R. van Otterdijk, A. Meybeck Global Food losses and Food Waste: Extent, Causes and Prevention Rural Infrastructure and Agro-Industries Division, Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy (2011) Google Scholar Han et al., 2015 J.H. Han, C.M. Nelson, C. Kim Pro-environmental behavior in sport event tourism: roles of event attendees and destinations Tour. Geographies, 17 (2015), pp. 719-737 View article CrossRefView in ScopusGoogle Scholar Hottle et al., 2015 T.A. Hottle, M.M. Bilec, N.R. Bown, A.E. Landis Toward zero waste: composting and recycling for sustainable venue based events Waste Manage., 38 (2015), pp. 86-94 View PDFView articleView in ScopusGoogle Scholar Kim et al., 2016 S. Kim, Y.-K. Lee, C.-L. Lee The moderating effect of place attachment on the relationship between festival quality and behavioral intentions Asia Pac. J. Tour. Res., 22 (2016), pp. 49-63 View in ScopusGoogle Scholar Kohler and Kreuter, 2005 U. Kohler, F. Kreuter Data Analysis Using Stata Stata Press, Texas (2005) Google Scholar Kulshrestha et al., 2004 U.C. Kulshrestha, T.N. Rao, S. Azhaguvel, M.J. Kulshrestha Emissions and accumulation of metals in the atmosphere due to crackers and sparkles during Diwali festival in India Atmos. Environ., 38 (2004), pp. 4421-4425 View PDFView articleView in ScopusGoogle Scholar Kuo et al., 2006

	C.-Y. Kuo, H.-S. Lee, J.-H. Laim Emission of polycyclic aromatic hydrocarbons and lead during Chinese mid-autumn festival Sci. Total Environ., 366 (2006), pp. 233-241
Follow up Questions	- How did the researchers differentiate between intentional and unintentional waste generation by festival attendees? - What specific aspects of the Andanças festival's waste management approach made it successful? Could these aspects be easily replicated at other festivals of different sizes or genres? - How could the waste management strategies in this study apply to sports venues?

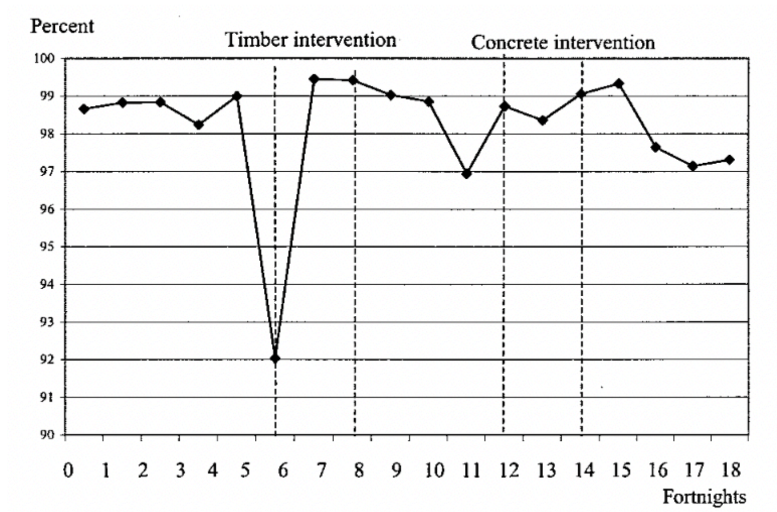
Article #19 Notes: Improving solid waste reduction and recycling performance using goal setting and feedback

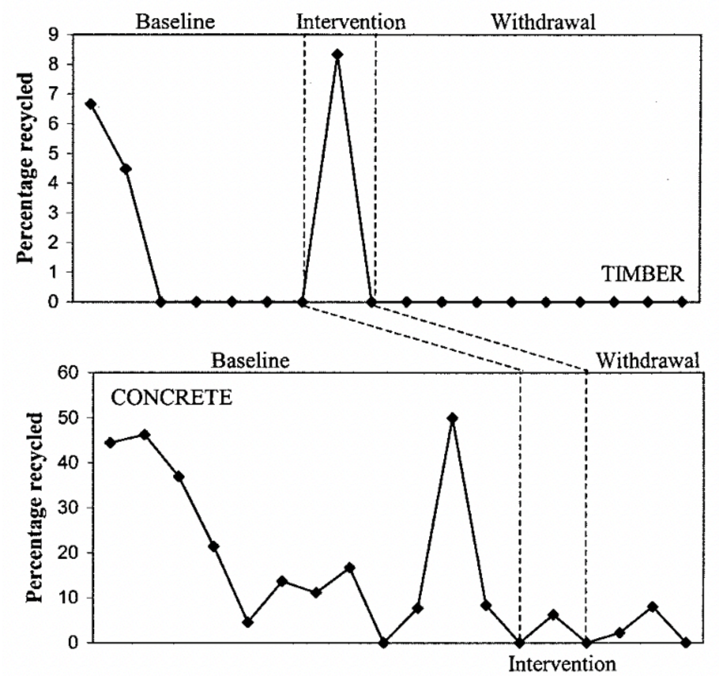
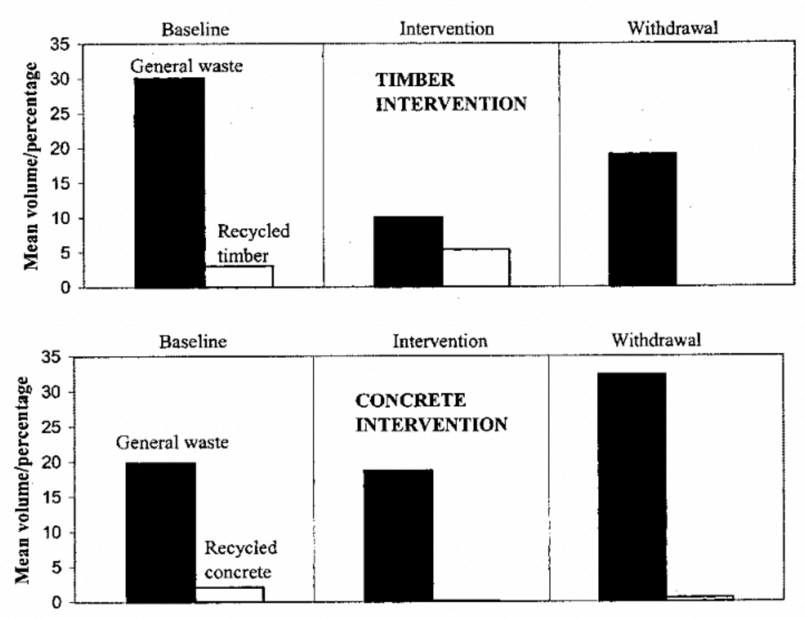
Date and Time: 12/13/23 6:18 pm

Notes:

- Waste Reduction: Setting clear goals and giving regular feedback helped significantly decrease the amount of waste sent to landfills, especially for materials like wood and concrete.
- Recycling: Results for recycling were mixed. While some types of waste were recycled more, others didn't see much improvement.
- Feedback Matters: Regular updates and encouragement kept people motivated and on track to reach their waste reduction goals. Think of it like having a friend cheer you on during a workout!
- The study used a special technique called "multiple baselines" to track the changes over time. Imagine having two thermometers side-by-side to see which one cools down faster.
- The focus was on two main types of waste: wood and concrete. Think of building a treehouse (wood) vs. pouring a sidewalk (concrete).
- Even though recycling didn't improve as much as waste reduction, the study shows that it's still an important part of managing construction waste. Every little bit helps the planet!
- This study is just one example of how research can help us make better choices for the environment. Keep an eye out for other ways to reduce your waste and make a difference!

Source Title	Improving solid waste reduction and recycling performance using goal setting and feedback
Source citation (APA Format)	Lingard, H., Gilbert, G., & Graham, P. (2001). Improving solid waste reduction and recycling performance using goal setting and feedback. *Construction Management and Economics*, *19*(8), 809–817. https://doi.org/10.1080/01446190110070952
Original URL	https://www.tandfonline.com/doi/abs/10.1080/01446190110070952?casa_token=bT6qZ0ziQwsAAAAA:FYT8ds3qb0bZRXNh5x-8DCJVQ21yJbK2kf40zW59OEscR_G-PkbkJNIveT7ZaIZowvD9pY6Wx_0
Source type	Journal article
Keywords	solid waste, reduction, re-USE, recycling, motivation, construction, australia
#Tags	#ConstructionWasteManagement #GoalSetting #Feedback #SolidWasteReduction #Recycling #SportsStadium
Summary of key points + notes	This study investigates the effectiveness of goal setting and feedback in improving

(include methodology)	solid waste reduction and recycling performance on a sports stadium construction site. A multiple-baseline experiment design across waste streams was used. The study had two objectives: 1, to evaluate the effect of goal setting and performance feedback in reducing solid construction waste; and 2, to evaluate the effect of goal setting and performance feedback in increasing recycling of solid construction waste. The study found that the intervention was effective in reducing the volume of waste disposed as landfill and increasing material usage efficiency. The average efficiency score for the whole experimental period was 98.1%. During the timber intervention, the average waste disposed as landfill fell from a high of 30 m3 per fort- night to 10.7 m3. Following the removal of the timber feedback, waste disposed at landfill increased again to an average of 19.9 m3 per fortnight. In the period prior to the concrete intervention, the average volume of waste disposed at landfill was 19.8 m3 per fortnight, and this average fell to 18.7 m3 during the concrete intervention. In the period following the removal of concrete feedback, the average waste disposed of at landfill rose dramatically to 32.3 m3 per fortnight. Recycling performance did not improve significantly with the introduction of the intervention. The volume of concrete that was recycled expressed as a percentage of total waste was signifi cantly lower during the concrete intervention period than it had been under baseline conditions. The average volume of concrete recycled expressed as a percentage of the concrete delivered to site also fell during the concrete intervention, although the difference was not significant. (ChatGPT)
Research Question/Problem/ Need	To what extent can goal setting and feedback be effective in improving solid waste reduction and recycling performance on a sports stadium construction site?
Important Figures	 - Material usage efficiency by fortnight

	 - Volume of waste recycled as a percentage of totalwaste leaving the site each fortnight  - Mean volume of general waste disposed at landfill and percentage of material recycled during each experi-mental condition
VOCAB: (w/definition)	fortnight: a period of two weeks. tangible: a thing that is perceptible by touch.

	imbedded: deeply integrated or woven into something. granularity: the level of detail in something concomitant: happening at the same time or as a result of something else. heuristic: a mental shortcut or rule of thumb used to make decisions quickly. contingency: a plan for what to do if something unexpected happens.
Cited references to follow up on	Corral-Verdugo, V. (1996) A structural model of reuse andrecycling in Mexico. Environment and Behavior, 28, 665–696. De Young, R. (1988–1989) Exploring the difference betweenrecyclers and non-recyclers: the role of information. Journalof Environmental Systems, 18, 341–51. Federle, M.O. (1993) Overview of building constructionwaste and the potential for materials recycling. BuildingResearch Journal, 2, 31–7. Hopper, J.R. and Nielsen, J.M. (1991) Recycling as altru-istic behavior: normative and behavioral strategies toexpand participation in a community recycling program.Environment and Behavior, 23, 195–220.
Follow up Questions	- Would this this approach would work for other construction projects, or just sports stadiums? - What are other ways, if any, to encourage waste reduction and recycling on construction sites? - What if this system was used in schools or even whole cities? Could it make a big difference?

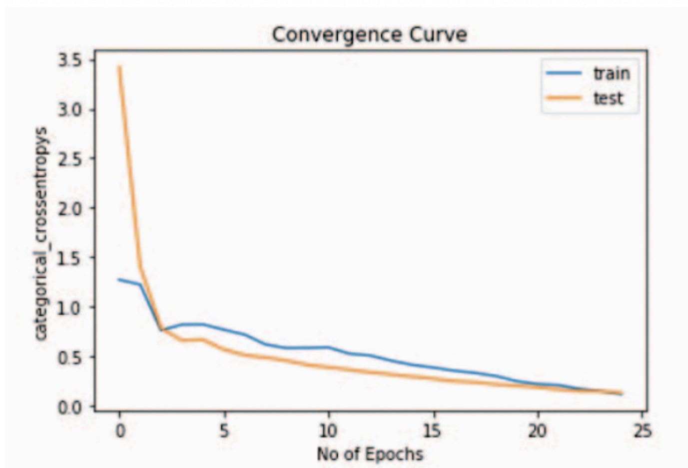
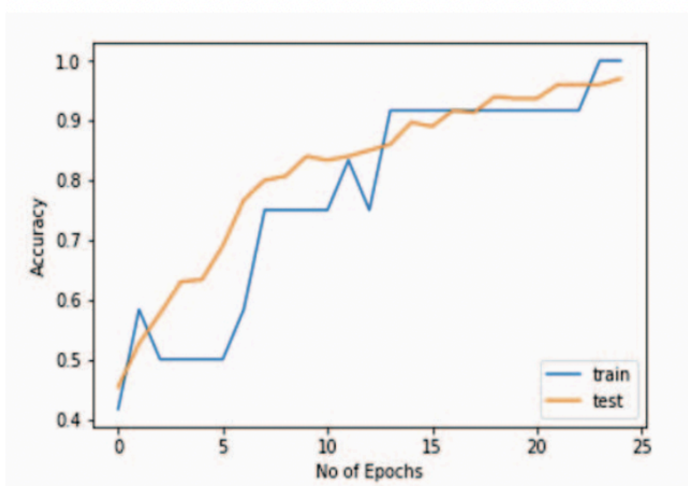
Article #20 Notes: Autonomous Trash Collector Based on Object Detection Using Deep Neural Network

Date and Time: 12/14/23 5:37 pm

Notes:

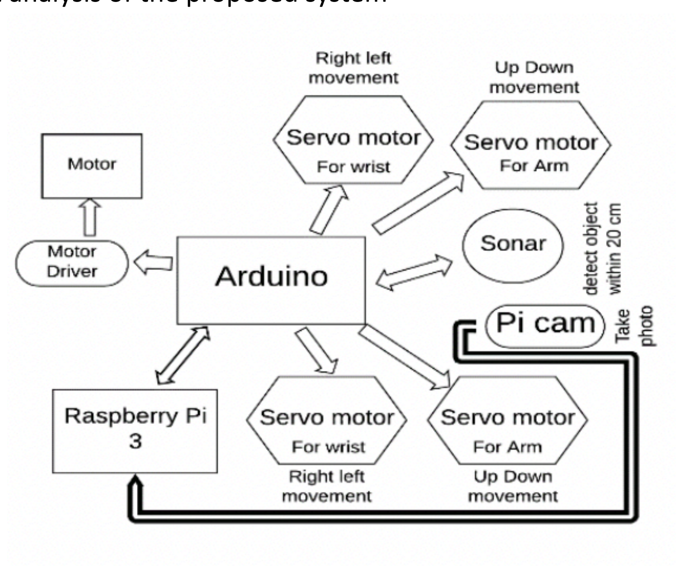
- Non-biodegradable product use and improper disposal causing increasing trash stacks
- Autonomous mobile trash collector with attached trash container for ground-level collection
- Trash detection through deep learning algorithm
- An ultrasonic sonar sensor on the robot detects objects along the path
- Pictures are sent to Raspberry Pi for trash or non-trash classification
- Low-cost robot capable of detecting a wide range of trash with high accuracy
- Positive environmental and economic effects anticipated
- Addresses the issue of growing trash stacks
- Low-cost prototype suggests economic feasibility
- Technology used inclues deep learning algorithm, ultrasonic sonar sensor, camera module, and Raspberry Pi
- Prototype offers a practical and cost-effective solution for efficient trash collection and classification, addressing the environmental challenge.

Source Title	Autonomous Trash Collector Based on Object Detection Using Deep Neural Network
Source citation (APA Format)	Hossain, S., Debnath, B., Anika, A., Junaed-Al-Hossain, Md., Biswas, S., & Shahnaz, C. (2019). Autonomous Trash Collector Based on Object Detection Using Deep Neural Network. *TENCON 2019 - 2019 IEEE Region 10 Conference (TENCON)*, 1406–1410. https://doi.org/10.1109/TENCON.2019.8929270
Original URL	https://ieeexplore.ieee.org/abstract/document/8929270?casa_token=l4LXuCy7JQ4AAAAA:k4f8L2iz-lWdvfg__aoHhWCaz2-GFQz83zwOPhWlpFg35xlFyn8XW0GN3RkO4VW-25cNato
Source type	Journal article
Keywords	DC motors, robot sensing systems, pins, cameras, servo motors, plastics, autonomous, trash detection, deep Learning, ultrasonic sensor, raspberry pi
#Tags	#AutonomousTrashCollector #ObjectDetection #DeepLearning #RaspberryPi #Arduino
Summary of key points + notes	The document proposes a prototype of an autonomous trash collector that can

(include methodology)	effectively collect trash from the ground using object detection based on deep neural networks. The robot is equipped with a Raspberry Pi, Arduino, ultrasonic sensor, servo motors, and DC motors. The Raspberry Pi is responsible for image processing and object detection using the Keras deep learning library. The ultrasonic sensor is used to detect objects in front of the robot and trigger the camera to take a picture. The Arduino controls the servo motors to pick up and dispose of the trash. The robot is able to detect and collect trash with an accuracy of 96%. The robot is also able to operate in various lighting conditions and with different types of trash. (chatGPT)
Research Question/Problem/ Need	How can an autonomous trash collector that can effectively collect trash be developed from the ground using object detection based on deep neural networks?
Important Figures	 (a)  - (a) Convergence Curve of categorical cross entropy & (b) accuracy curve between target and estimated type of the object.

Components	Quantity	Cost in USD
Raspberry Pi	1	41.48
Pi-cam	1	14.81
DC Motor	4	7.11
Motor driver	2	8.30
Sonar	1	2.96
Arduino	1	14.81
Power bank	1	14.22
Servo motor	4	18.96
Lipo battery	1	9.48
Others		14.22
Total		146.36

- Cost analysis of the proposed system



- Hardware components of the prototype robot

VOCAB: (w/definition)

ultrasonic sensor: a device that emits sound waves and measures the time it takes for the sound waves to reflect back from an object. It is used to detect objects in front of the robot.

servo motors: electric motors that can be controlled to rotate to a specific angle. They are used to pick up and dispose of the trash.

DC motors: electric motors that run on direct current (DC) power. They are used to drive the wheels of the robot.

keras: a high-level neural networks API that runs on top of TensorFlow. It is used to train the deep neural network for object detection.

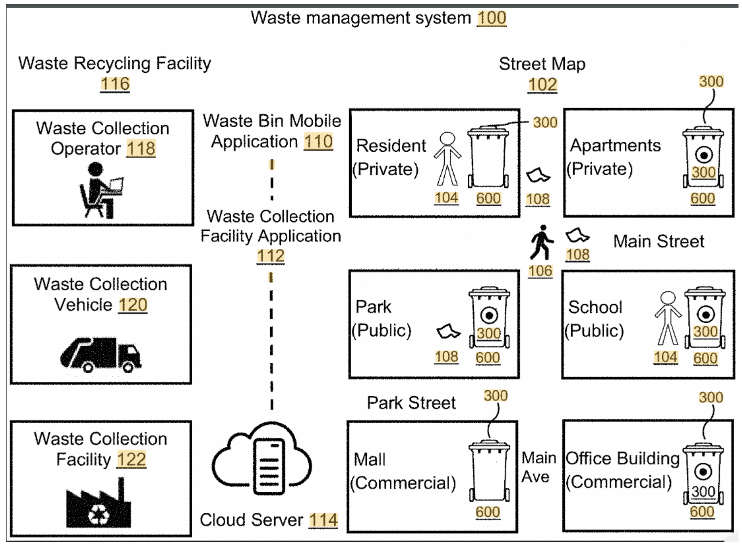
	decomposable: capable of being broken down into smaller parts. non-decomposable: not capable of being broken down into smaller parts. trash identification capability: the ability to identify different types of trash. smart garbage classification system: a system that uses sensors and cameras to sort trash into different categories. biodegradable: capable of being broken down by bacteria or other living organisms.
Cited references to follow up on	[1] Y. D. Emiral et al., The Association of Job Strain with Coronary Heart Disease and Metabolic Syndrome in Municipal Workers in Turkey, pp. 332338, 2006. [2] S. Rathi, S. Pande, and H. Lokhande, Smart Garbage Collection System, vol. 5, no. Iv, pp. 758764, 2017. [3] S. Khandare, S. Badak, Y. Sawant, and S. Solkar, Object Detection Based Garbage Collection Robot (E-Swachh), Int. Res. J. Eng. Technol., vol. 5, no. 3, pp. 38253828, 2018. [4] D. D. Apoorva S.*, Chaithanya, Rukuma S. Prabhu, Saiswaroop B. Shetty, Autonomous Garbage Collector Robot, Int. J. Internet Things, vol. 6, no. 2, pp. 4042, 2017. [5] O. Nurlansa, D. Anisa Istiqomah, and M. Astu Sanggha Pawitra, AGATOR (Automatic Garbage Collector) as Automatic Garbage Collector Robot Model, Int. J. Futur. Comput. Commun., vol. 3, no. 5, pp. 367371, 2014. [6] P. R. Wilson and T. G. Moher, Design of the opportunistic garbage collector, ACM SIGPLAN Not., vol. 24, no. 10, pp. 2335, 2005. [7] A. Salmador, J. Cid, and I. Novelle, Intelligent Garbage Classifier, Int. J. Interact. Multimed. Artif. Intell., vol. 1, no. 1, pp. 3136, 2008. [8] B. Divya Darshini, B. U. Adarsh, H. J. Shivayogappa, and K. N. Navya, Automated smart sericulture system based on 6LoWPAN and image processing technique, in 2016 International Conference on Computer Communication and Informatics, ICCCI 2016, 2016. [9] R. Rokade, A. Maurya, and V. Khade, Smart Garbage Separation Robot with Image Processing Technique, vol. 6, no. 12, pp. 15, 2018. [10] S. Kannan, S. Kumar, and R. R. Balakrishnan, Automatic Garbage Separation Robot Using Image Processing Technique, Int. J. Sci. Res. Publ., vol. 6, no. 4, pp. 326328, 2016. [11] S. Ramli, M. M. Mustafa, A. Hussain, and D. A. Wahab, Automatic Detection of ROIs for, no. December, pp. 04, 2007. [12] A. T. I. N. Mechatronics, AUTOMATIC PLASTIC BOTTLE CLASSIFICATION SYSTEM FOR RECYCLING Automatic Plastic Bottle Classification System for Recycling, 2005. [13] Y. L. B. B. J. S. D. D. Henderson, Backpropagation applied to handwritten zip code recognition, Neural Comput., vol. 1, no. 4, pp. 541551, 1989. [14] Y. Wang and X. Zhang, Autonomous garbage detection for intelligent urban management, MATEC Web Conf., vol. 232, p. 01056, 2018. [15] G. Mittal, K. B. Yagnik, M. Garg, and N. C. Krishnan, SpotGarbage, in

	Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing - UbiComp 16, 2016, pp. 940945. [16] M. S. Rad et al., A Computer Vision System to Localize and Classify Wastes on the Streets, 2014.
Follow up Questions	- Can the robot differentiate between recyclable and non-recyclable trash? If so, how? - How does the robot handle large or bulky objects? - What are the limitations of the current object detection system? - How could this technology be used to reduce littering or improve waste management in different settings?

Patent #1 Notes: Smart waste bin sensor device and methods for waste management system (US11702280B2)

Date and Time: 11/26/23 6:00 pm

Source Title	Smart waste bin sensor device and methods for waste management system (Google Patents)
Source citation (APA Format)	Kurani, H. B., & Kurani, H. B. (2023). *Smart waste bin sensor device and methods for waste management system* (Patent US11702280B2). https://patents.google.com/patent/US11702280B2/en
Original URL	https://patents.google.com/patent/US11702280B2/en
Source type	Patent
Keywords	smart waste bin sensor device, sensors, waste, litter, biohazardous waste, pathogen, biosafety, waste bin mobile application, user monitoring
#Tags	#recycling #wastemanagement #reduceGHG #reducewaste #sustainabledesign #engineeringtechnology
Summary of key points + notes (include methodology)	A waste management system comprises a waste bin storing waste, wherein the waste bin comprises a smart waste bin sensor device installed on the waste bin of a waste bin owner. The smart waste bin sensor device comprises a set of sensors that sends and receives signals through a wireless network to a cloud server. The set of sensors implements, operates, detects, measures, and monitors environmental conditions inside or outside the waste bin. A waste and litter sensor detects, measures, and monitors a waste type, a waste volume, a litter type, a litter level, a biohazardous waste type, and a biohazardous waste level. A pathogen biosensor detects, measures, and monitors a pathogen type and a biosafety level. The pathogen biosensor comprises a sterilizer to kill pathogens. A waste bin mobile application and a waste collection facility application functionality enable a user to monitor waste in the waste bin. (Abstract)
Research Question/Problem/ Need	How can a waste management system be effectively implemented to monitor and manage waste in a waste bin through the use of a smart waste bin sensor device, incorporating various sensors and functionalities such as waste and litter sensing, pathogen detection, and user monitoring through mobile applications?

Important Figures	 - This figure is a systems map of how the device/sensor that is patented plays a role in the waste management system.

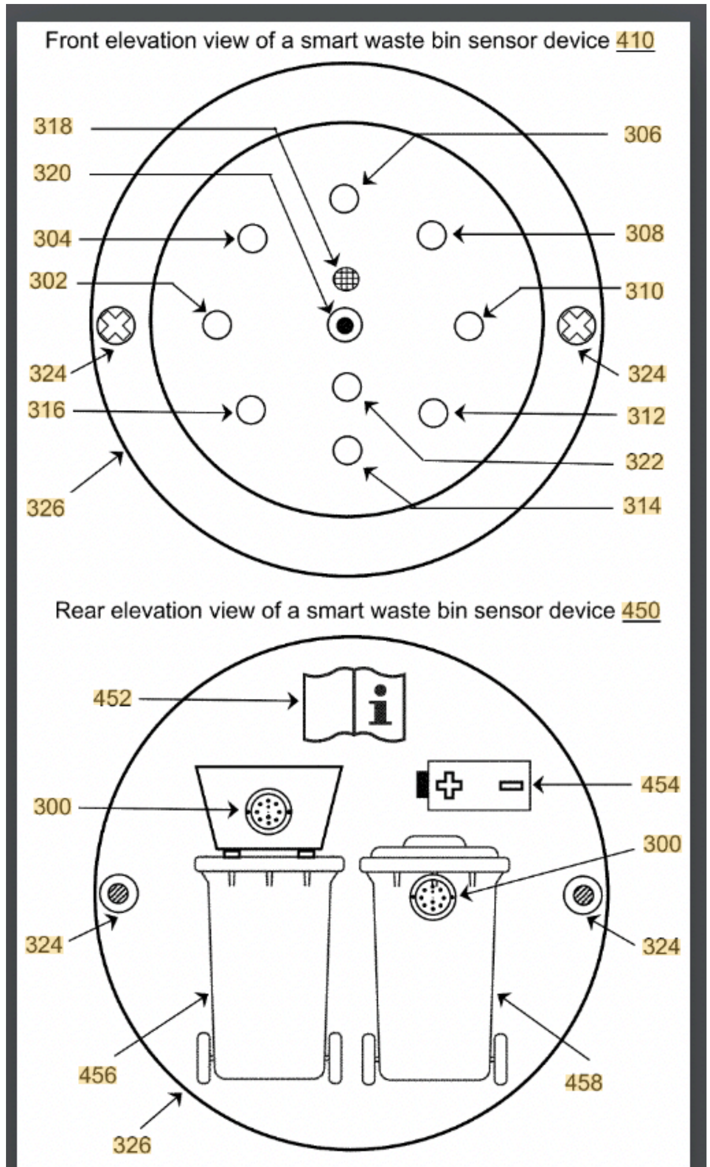
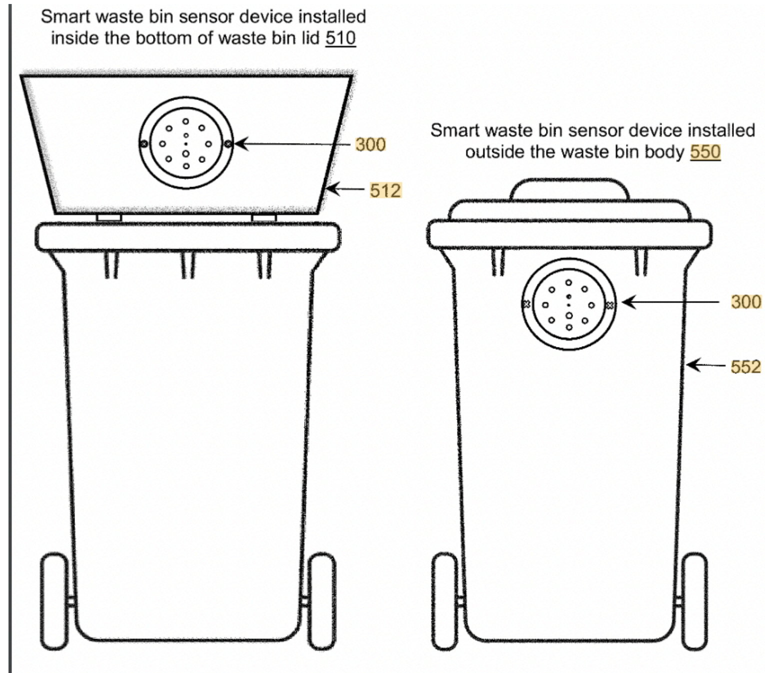


FIG. 4

- This figure shows a visual of the front view of the sensor that is patented. Each of the numbers represents many of the complex components of this sensor. The bottom part of the figure shows how the sensor would be used in action. The sensor is designed to be put on the inner part of a trash can lid or on the outside face of the trash can.

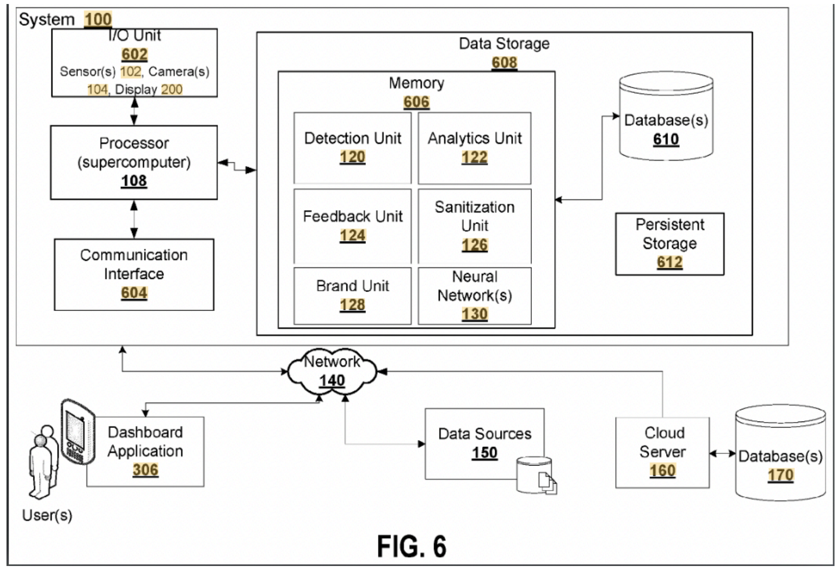
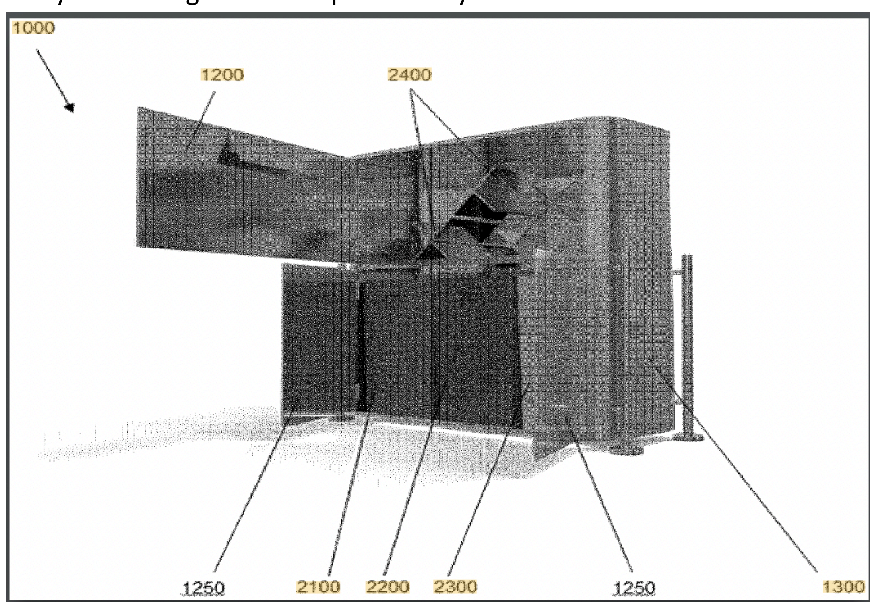
	 FIG. 5 - This figure shows how the sensor would be used in action. There are two possible ways that the sensor can be configured: it can be put on the inner part of a trash can lid or on the outside face of the trash can.
VOCAB: (w/definition)	Pathogen: a bacterium, virus, or other microorganism that can cause disease. Biohazardous: a risk to human health or the environment arising from biological work, especially with microorganisms. Bidding: the ordering or requesting of someone to do something. Geospatial: relating to or denoting data that is associated with a particular location. RFID: Radio Frequency Identification (RFID) technology uses radio waves to identify people or objects. Cumbersome: slow or complicated and therefore inefficient.
Cited references to follow up on	U.S. Patent App. No. 2016/0300297 U.S. Patent App. No. 2015/0324760 U.S. Patent App. No. 2015/0298903 U.S. Patent App. No. 2015/0323366
Follow up Questions	- How does the smart waste bin sensor device interact with the waste bin,

	and how is it installed? - How does the waste management system optimize waste removal vehicle routing based on the characterization of the waste? - Have there been any practical implementations or field tests of the waste management system, and if so, what were the results?

Patent #2 Notes: Systems and methods for waste item detection and recognition (US20200222949A1)

Date and Time: 11/26/23 6:05 pm

Source Title	Systems and methods for waste item detection and recognition (Google Patents)
Source citation (APA Format)	Murad, H., & Vyas, V. H. (2020). *Systems and methods for waste item detection and recognition* (Patent US20200222949A1). https://patents.google.com/patent/US20200222949A1/en
Original URL	https://patents.google.com/patent/US20200222949A1/en
Source type	Patent
Keywords	waste item, hardware, software, education system, feedback system, artificial intelligence, machine learning, user nudging, waste disposal
#Tags	#recycling #wastemanagement #reduceGHG #reducewaste #sustainabledesign #artificialintelligence #machinelearning #engineeringtechnology
Summary of key points + notes (include methodology)	Embodiments described herein relate to hardware and software for waste item detection and recognition, along with an education or feedback system. Embodiments described herein use artificial intelligence, which embodies machine learning and computer vision, to detect waste items and generate feedback to nudge the user to dispose the waste items into appropriate receptacles while generating smart operational insights of a designated premise. (Abstract)
Research Question/Problem/ Need	How can artificial intelligence, machine learning, and computer vision, be utilized to detect and recognize waste items, while providing an educational or feedback system to encourage users to dispose of waste appropriately, and generate operational insights for a designated premise?

Important Figures	 - System's diagram of the patented system  - The design of the patented system

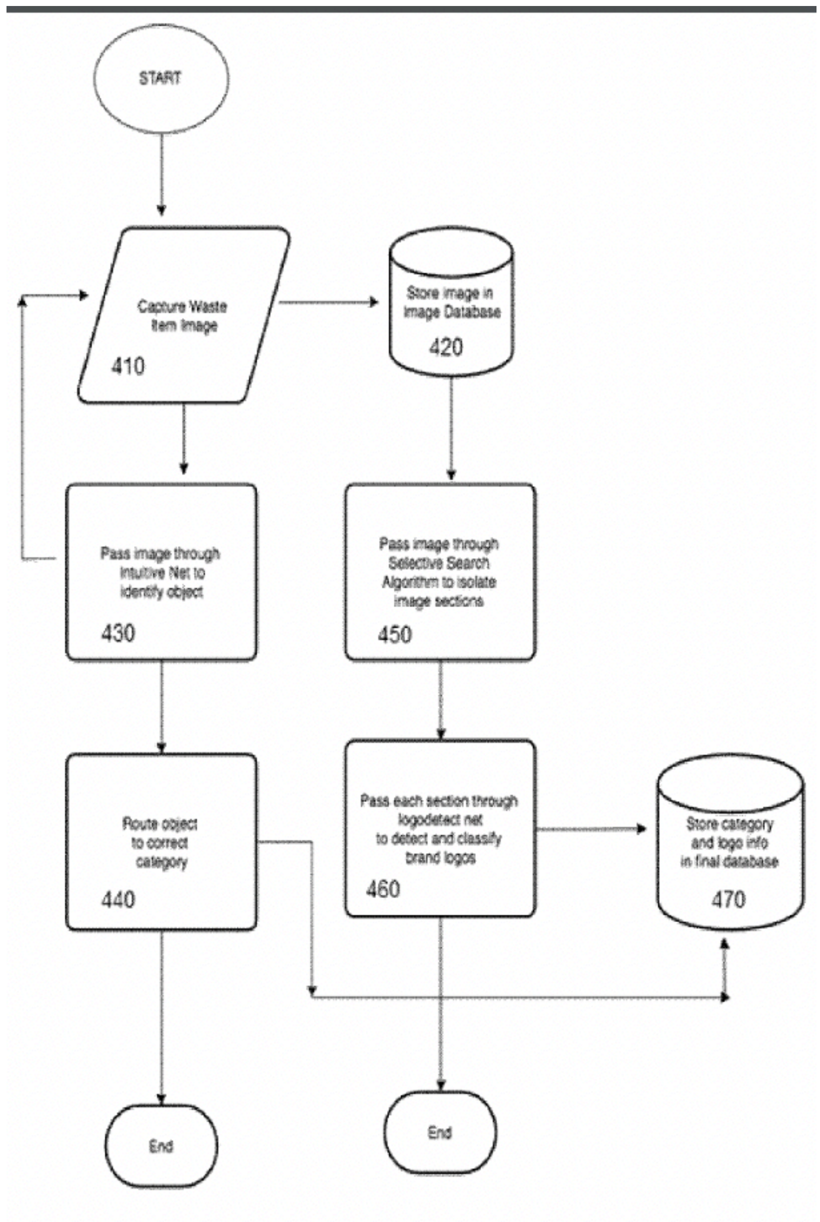


FIG. 13

- The process which the system goes through when given an object for waste detection

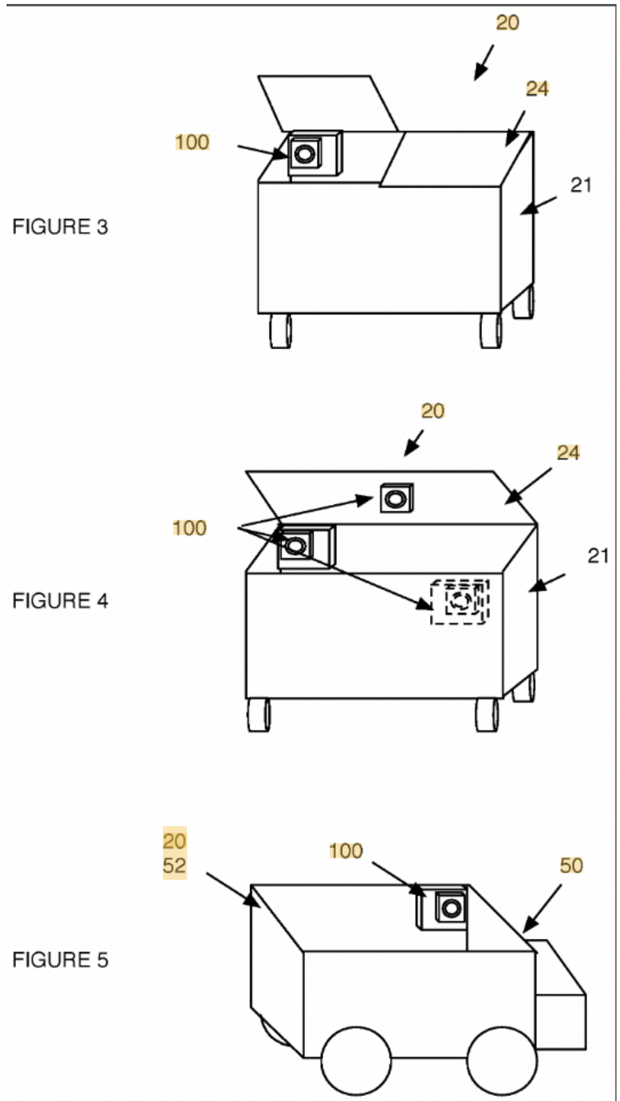
VOCAB: (w/definition)	herein: in this document or book. ominous: giving the impression that something bad or unpleasant is going to happen. extrapolating: extend the application of (a method or conclusion, especially one based on statistics) to an unknown situation by assuming that existing trends will continue or similar methods will be applicable.

	receptacles: something used to receive and contain smaller objects
Cited references to follow up on	US6625317B1 1995-09-12 2003-09-23 Art Gaffin Visual imaging system and method FR2752178B1 * 1996-08-06 1998-10-09 Vauche P Sa SORTING MACHINE FOR PLASTIC BOTTLES AND METHOD USED BY THE MACHINE GB0322043D0 * 2003-09-20 2003-10-22 Qinetiq Ltd Apparatus for,and method of,classifying objects in waste stream CN102118560A 2009-12-30 2011-07-06 深圳富泰宏精密工业有限公司 Photographic system and method
Follow up Questions	- Where can this system be used? - What limitations or drawbacks does the patent acknowledge in current waste audit methods, and how does it propose to overcome them? - What feedback mechanisms are implemented to guide users in disposing of waste items correctly?

Patent #3 Notes: System and method for waste management (US20230196307A1)

Date and Time: 11/26/23 6:16 pm

Source Title	System and method for waste management (Google Patents)
Source citation (APA Format)	Gates, J. S., & Chehebar, B. (2023). *System and method for waste management* (Patent US20230196307A1). https://patents.google.com/patent/US20230196307A1/en
Original URL	https://patents.google.com/patent/US20230196307A1/en
Source type	Patent
Keywords	system, content sensor, communication system, housing, measurement trigger detection mechanism, waste container, waste
#Tags	#recycling #wastemanagement #reduceGHG #reducewaste #sustainabledesign #engineeringtechnology
Summary of key points + notes (include methodology)	A method for waste management, including recording an image of content within a waste container; extracting a set of content parameters from the image; characterizing the content within the waste container based on the set of content parameters; and routing a waste removal vehicle based on the content characterization. (Abstract)
Research Question/Problem/ Need	How can waste management be enhanced by utilizing image analysis and content parameter extraction to characterize the contents of waste containers, ultimately optimizing waste removal vehicle routing based on this characterization?

Important Figures	 - These figures are schematic representations of a first, second, and third variation of waste containers including monitoring systems, respectively.

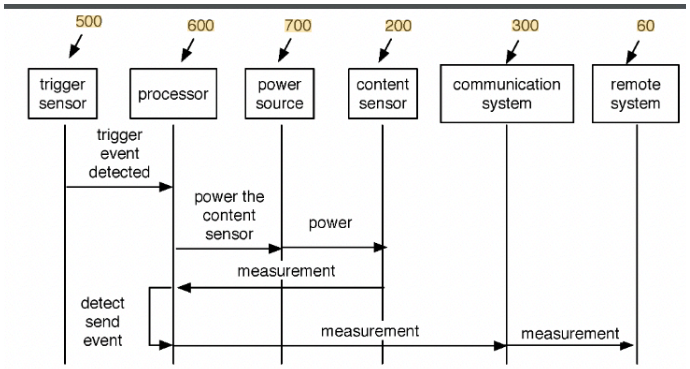


FIGURE 6

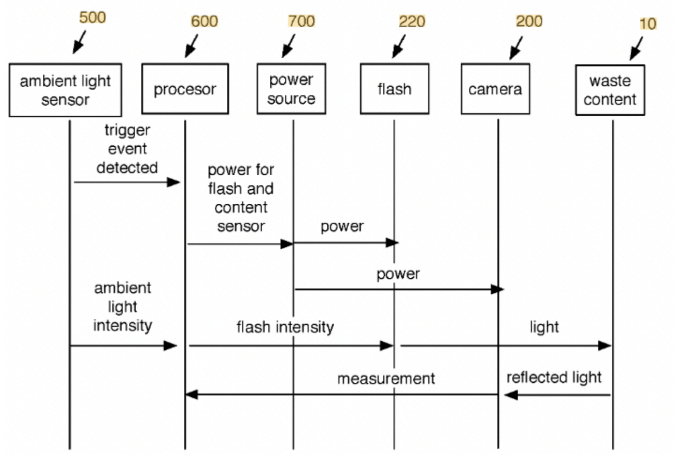
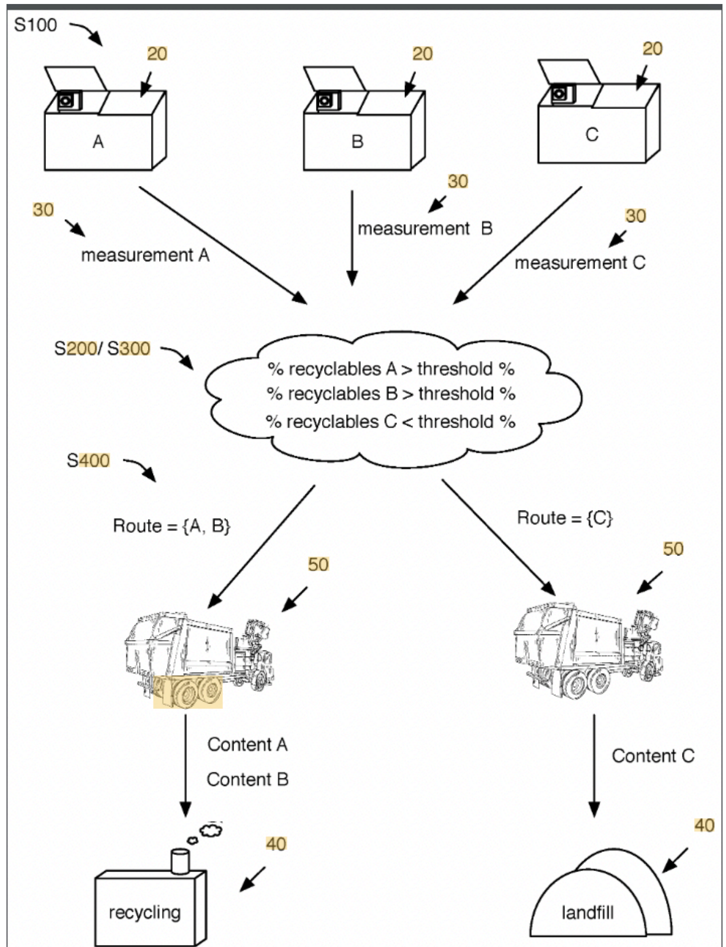


FIGURE 7

- These figures are schematic representations of a first and second variation of the method of recording a measurement of the waste contained within the waste container.

	 FIGURE 10 - This figure is a schematic representation of an example of a method of waste management, including recording measurements from waste containers A, B, and C and routing waste collection vehicles to the waste containers based on the respective content metrics.
VOCAB: (w/definition)	over the air (OTA) updates: a wireless method of updating software or firmware on electronic devices, allowing remote updates without physical connection. civic authorities: government entities at the local or municipal level responsible for managing public services and addressing community issues. waste audit: an assessment of the types and amounts of waste generated by a community or facility, often used to evaluate recycling and diversion efforts. LIDAR (Light Detection and Ranging) system: remote sensing technology that uses laser light to measure distances and create detailed, three-dimensional maps of the environment. RFID (Radio-Frequency Identification): a technology that uses radio waves to identify and track objects, often used for tagging and tracking items.

	hyperspectral camera: a camera capable of capturing images in multiple bands of the electromagnetic spectrum, providing detailed spectral information beyond what the human eye can perceive. monocular camera: a camera with a single lens, typically used to capture two-dimensional images. content purity index: a measure indicating the purity or composition of materials in a waste container, often expressed as a percentage. non-transitory computer readable storage medium: a form of storage, such as a hard drive or solid-state drive, that retains data without power and is readable by a computer. spectral camera: a camera designed to capture images at specific wavelengths or colors, providing detailed information about the composition of objects.
Cited references to follow up on	CA2558906A1 * 2005-10-07 2007-04-07 Sherwood Services Ag Remote monitoring of medical device US20070219862A1 * 2006-03-20 2007-09-20 Casella Waste Systems, Inc. System and method for identifying and processing recyclables US7313464B1 * 2006-09-05 2007-12-25 Adept Technology Inc. Bin-picking system for randomly positioned objects US20140214697A1 * 2011-06-03 2014-07-31 Paul Terence McSweeney Refuse collection system and method US20160355308A1 * 2010-07-28 2016-12-08 James Andrew Poss Electrically-powered programmable waste enclosure
Follow up Questions	- How is the monitoring system physically integrated with the waste container? - Are there specific requirements for the waste container material to ensure accurate monitoring? - How does the monitoring system account for variations in environmental conditions, such as temperature, weather, or lighting? - Are there any considerations for the environmental impact of the monitoring system itself?