Water Usage in Data Center Infrastructures: A Multidimensional Framework Ethical Analysis

Alessandra Martinez[1], Anthony Akins[2*], Christian Hood[2], Kiersten Johnson[2], and Kamar Mann[2]
[*] *Corresponding Author: anthonyaajr04@gmail.com*

[1] *Mechanical and Aerospace Engineering*
University of Virginia
Charlottesville, USA

[2] *School of Engineering, Architecture, and Aviation*
Hampton University
Hampton, USA

***Abstract*—With the rise of generative artificial intelligence (AI), demand for larger data centers has increased rapidly, at an estimated 15% annually. Data centers are essential to the digital economy, yet their water-intensive operations exacerbate global water scarcity and disproportionately impact vulnerable communities. These impacts appear across multiple dimensions, including economics, where increased local power demand raises residential bills from grid upgrades, and social impacts, where communities are displaced. Since 2020, both the scale and number of data centers have increased, placing greater pressure on resources required for availability and reliability. In the U.S., more than a billion liters of water are consumed daily, both directly for cooling and indirectly for other functions. Water consumption depends on factors such as location, climate conditions, cooling technology, and facility design. With rising water demand, ethical concerns have been raised regarding allocation, scarcity, stewardship, sustainable development, and transparency of local water sources. While the environmental footprint of data centers has global implications, ethical debates remain locally grounded, where communities often lack the coordination and leverage that technology firms have. Tensions have grown as communities attempt to balance conventional water use, such as residential and commercial consumption, with the massive water demands of data centers. This work complements technical efficiency metrics by integrating ethical implications of data center water use into strategy evaluation through a multi-dimensional, holistic framework integrating ethical principles such as utilitarianism, global ethics, rights ethics, and environmental ethics. The Water Ethics Framework [1] will be applied through a qualitative evaluation of the ethical implications and imperatives of solutions that aim to address underlying sustainability concerns of excessive water use, including location selection and alternative cooling technologies, using industry data and documented cases. These practices will be evaluated across environmental, economic, social, cultural, and governance values to examine trade-offs and effects. Ultimately, the findings aim to inform on current "water-blind" site selection as an unsustainable practice and suggest approaches that preserve future availability of natural resources as a matter of intergenerational justice.**

Keywords—* *Data Centers, Water Use, Sustainability

I. INTRODUCTION

Data centers are a critical component of today's digital infrastructure, and their size and construction have increased steadily [2], [3]. Globally, there are more than 6,000 data centers, growing annually 15% [4]. These facilities support Information and Communications Technology (ICT) infrastructure required to process large volumes of data for AI and services such as digital entertainment and cloud computing [2], [3], [5]. Their operation requires resource availability and reliability, placing greater pressure on water and energy systems while supporting a digital economy, projected to reach $288 billion by 2027 [3], [6]. However, this growth comes with significant water demands, raising ethical concerns.

A. Water Consumption and Measurement Challenges

Data center operations require large volumes of water for cooling and energy production [7]. Increased energy use raises indirect water consumption, creating a reinforcing water-energy cycle [8]. Water use occurs in three ways: (1) direct for cooling and other operations, (2) indirect through electricity generation, and (3) associated with required electricity for water supply and wastewater treatment [7]. Wastewater is generated through blowdown, where cooling water is discharged and replaced to prevent contaminant buildup [7].

Ignoring water impacts can shift environmental burdens from carbon to water, even when transitioning to nonrenewable energy sources, as these still impact land use [8]. Without a comprehensive evaluation, understanding of data center environmental effects remains incomplete [8]. Measuring water use is challenging due to limited transparency and inconsistent metrics. The Water Footprint (WF) quantifies freshwater consumption and pollution, while Water Usage Effectiveness (WUE), measures the ratio of water consumption to energy used by the IT equipment [6], [8], [9]. More efficient systems have lower WUE, with industry average 1.8L per 1kWh [9], but WUE does not consider the full cycle, unlike WF [8].

These metrics do not account for local water availability, limiting effectiveness across locations. The Water Scarcity Footprint (WSF) addresses this by quantifying pressure exerted by consumptive water use on available freshwater within river basins, indicating potential needs deprivation of communities

[7]. With water demand for thermoelectric power generation expected to increase by 40% [8], and AI water demands projected to reach 4.1-6.6 billion cubic meters, about half of UK's water consumption [2], understanding cooling technologies and their trade-offs is critical for the assessment of data center sustainability as competition intensifies.

B. *Cooling Technologies and Trade-offs*

Servers generate significant waste heat during operation that must be removed to prevent overheating and equipment break down, making cooling mechanisms necessary [8]. As a result, intensive cooling systems are widely used, including water-based, air-based, and hybrid systems [2], [10], each involving trade-offs between water and electricity use. Air-cooling systems rely on electricity, making them preferable when water is scarce and electricity is cheap [5], though this increases water use indirectly. Water-cooling systems are more energy and cost efficient but can strain water resources [5]. Closed-loop systems, transfer heat to recirculated water via a heat exchanger [5], while evaporative systems absorb heat using water that is evaporated and released. This option is cheaper, but water must be refilled regularly [5].

Water use is influenced by different factors, including IT equipment, the ventilation and air conditioning (HVAC) systems, energy sources, and climatic conditions [8]. While IT equipment does not directly consume water, it relies on electricity that contributes to indirect use [8]. HVAC systems regulate temperature and humidity at appropriate levels as temperature affects equipment efficiency, while humidity must be controlled to avoid dew collection, circuits' disruption, or static buildup and sparks [8]. These systems typically employ a vapor-compression cycle with chillers, refrigerant loops, and airflow systems [8]. Water-cooled systems are often preferred due to their efficiency and heat transfer capabilities, with chilled water commonly because of its superior thermal conductivity [8], [10], [11]. In dry climates, evaporative cooling significantly contributes to blue WF [8]. Accurately determining the WF of HVAC systems is challenging, as full information on water consumption is not always available. Systems that appear less water intensive due to lower direct water use may require more electricity, increasing indirect water use. These trade-offs accentuate the need to evaluate data centers operations beyond technical efficiency considering broader environmental and community impacts.

C. *Environmental, Social, and Governance Impacts*

Freshwater systems are unable to sustain ecological functions while meeting growing demands [8], a trend expected to worsen with data center expansion. For example, China's data center water use could double by 2030, exacerbating scarcity across Asia [10]. Terms like "the cloud" detach data from physical environments, obscuring environmental costs [12], leading the public to underestimate impacts, emphasizing the need for transparency. Data centers in western and south-western U.S regions rely on stressed watersheds, intensifying environmental and community risks [7], [11]. Such site selection pressures water limited communities, in The Dalles, Oregon, data centers used around 25% of local supplies, and in Altoona, Iowa, roughly 20% during drought conditions [5]. These regions are often selected for lower corrosion and electrical problems risks, and low cost electricity, but overreliance on water-stressed basins creates conflicts between corporations and communities [5], [11]. Climate change is expected to intensify droughts, exacerbating risks and conflicts, with companies often prioritized over individuals during disasters [7], [11].

Water insecurity disproportionately affects vulnerable communities, who are often excluded from resource allocation decisions [2]. This can undermine the right to water where industrial, agricultural, and residential demands compete [5], [6]. Governments often prioritize data centers for tax revenue, while utility companies benefit from increased demands. Conversely, despite limited long-term job creation, communities bear disproportionate effects including water use, air and noise pollution, social consequences like reduced amenities, curb appeal, and economic pressures related to electricity and water costs [5], [13]. Water scarcity is an increasing global concern, yet data center impacts are obscured as voluntary reporting varies across companies [5]. Lack of transparency limits public oversight and informed decision-making. The Dalles, Oregon case, illustrates this, where initial disclosure resistance later revealed that 25% of local water was used [5]. Some states have laws that encourage data center water conservation [5], but lack of mandatory compliance raises ethical concerns related to allocation, sustainability, and stewardship. To address these challenges, this study adopts a multidimensional framework integrating rights-based, environmental, and global ethics, with values such as governance and intergenerational justice and metrics like WUE, WF, and WSF to evaluate practices like site selection. This approach allows a more comprehensive evaluation of water use, addressing sustainability and equity.

II. ETHICAL DIMENSIONS OF DATA CENTER WATER USE

A. *Utilitarianism: Balancing Innovation and Harm*

Utilitarianism captures the tension among stakeholders, including local communities, governments, utility providers, technology companies, researchers, and future generations. Utilitarianism states that the right action produces the most good for the greatest number of people, while considering all affected equally [14]. This framework weighs the benefits of digital infrastructure and economic development against associated environmental and social harms.

Data centers support digital services, including communication and AI, benefitting large populations. They also generate tax revenue for governments and create short-term construction jobs, reinforcing their role in maximation of immediate benefits. At its extreme, this perspective can justify environmental harm to local communities for broader societal gains [2]. However, a comprehensive utilitarian analysis must consider long-term consequences, including the significant water demands for cooling, electricity generation, and daily operations. In water-scarce regions, this demand places additional strain on local supplies, creating competition between technology companies and communities for residential use, agriculture, and ecosystems needs. Over time, these pressures may lead to further environmental impacts such as local aquifer depletion, ecological degradation, and water pollution. These burdens are disproportionally experienced by local communities, who directly face environmental impacts while having limited leverage in decision making. Long-term water security implies the availability of sufficient water for human needs such as drinking water, domestic use, industrial activities, energy production, biodiversity and ecosystem maintenance, and food security [1]. Considering these cumulative environmental and social effects, impacts may outweigh immediate economic and technological benefits. Data center water use can undermine local sustainability, exacerbate water inequality, and threaten future generations' access to this limited resource at risk, exacerbating insecurity and increasing risks of water-related health issues. The greatest good may not be achieved if long-term, disproportionate harm is imposed on limited water resources. Therefore, sustainable water resource management is necessary to promote the greatest good.

B. *Rights-Based Ethics: Water Access as a Human Right*

Rights-based ethics is grounded in respect for human rights. The right to liberty implies that individuals should give informed consent regarding technological systems risks, while the right to life a livable environment [2]. This may be threatened by data centers through impacts like noise, air pollution, and water depletion [14]. Water and sanitation have been recognized as human rights in global governance [1], which implies prioritizing human needs over industrial uses, as reflected in policies such as the Water law of Taiwan (1983) and the Water Act of Zimbabwe (1998) [1]. Integrated water resource management is necessary to protect the rights of present and future generations, while balancing competing demands. This requires governance systems to ensure data centers do not compromise access to water. In water-stressed regions, the rights of local communities are at risk, especially if local aquifers are depleted, threatening the right to life. This requires transparent decision-making, careful trade-off analysis, and policies that prioritize human needs in allocating water resources. It also accentuates local communities to not be treated as means to an end, and their rights to be respected in pursuit of digital growth.

Communities have the right to participate in decisions affecting water access, making transparency essential. By 2021, about 20% of data centers were located in water-stressed regions, where withdrawals exceed natural supply [5]. In these areas, local residents may experience reduced water availability without meaningful input in the decision-making process. Unsustainable water use threatens long-term availability, limiting future generations' ability to meet basic needs and uphold their rights. Therefore, technology companies and governments have a responsibility to ensure their operations do not undermine the rights of current and future communities.

C. *Environmental Ethics: Stewardship and Responsibility*

Environmental ethics concerns moral beliefs, perspectives, and attitudes toward environmental issues [14]. Competition among data centers increases energy and water use, with environmental impacts addressed after construction rather than integrated into design, prioritizing economic and technological goals over sustainability. Addressing these challenges requires balancing economic efficiency with responsible management of shared resources [14]. The NSPE Code encourages engineers to adhere to sustainable development principles [15], which means meeting present needs without compromising future generations' ability to meet their own [14]. This emphasizes intergenerational justice, the responsibility to future generations of currently acting as responsible stewards of water [1]. Renewable energy and corporate sustainability commitments aim to reduce energy and water use, however industry growth relies on fossil fuels, high water use, and locating facilities near residencies to meet demands quickly, undermining progress to water sustainability goals [5].

Governments must regulate data center water use and require disclosure of metrics for informed decision-making. They have a duty to protect public interests, while communities share responsibility for preserving resources for future generations [14]. In Santiago, residents protested a data center construction after identifying plans of using 169 liters of water per second in an indigenous area experiencing drought conditions [2]. Supported by authorities, this case highlights water burdens and power imbalance between corporations and vulnerable communities. Participation of stakeholders like companies, communities, and governments is essential for effective water planning and policy decision-making [1].

Stewardship is central to intergenerational justice, as reflected in the UN Sustainable Development Goals, which include ensuring water availability and integrated management [1]. It was emphasized in UNESCO's water ethics report, where it refers to protecting and responsibly using water to support intergenerational and intragenerational equity and sustainability [16]. This implies integrated water management, regulated use, and disclosure. Human actions must align with the continued existence of human life and not jeopardize life future possibility [10]. Governance should ensure decisions are appropriately made, incorporating public participation, transparency, and supporting integrity in water use [1].

D. *Global Ethics and Justice*

Global ethics, as described by Hans Küng, refers to shared attitudes, standards, and values that form a basic ethical consensus [14]. It adopts a broad perspective that considers the interests and rights of all people, with human rights serving as a foundation for globally informed, decision-making [17]. Environmental ethics, a key branch, addresses issues not confined by borders, like water scarcity, which require multidisciplinary solutions [17]. These challenges intensify existing social and economic inequalities, as vulnerable populations lack the resources to adapt to environmental disruptions such as climate change driven floods or droughts. This dynamic is observed in data center water consumption, where resource-limited communities may struggle to maintain water access or productive land, worsening economic inequality [17]. As water availability declines, competition among domestic users, and technology companies may intensify, leading to social tensions and conflicts over resource allocation. Vulnerable communities face the greatest risks to their health, livelihoods, and long-term access to essential resources [17]. Water justice reinterprets water rights' moral concerns and focuses on allocation among competing demands, including who receives it and its quality [1]. Local communities are disadvantaged because they lack the leverage corporations have. Governments therefore play a critical role in ensuring citizens' rights and that water allocation is fair and sustainable, while balancing data center development and environmental stability.

III. WATER ETHICS EVALUATION FRAMEWORK

The water ethics framework [1] identifies five value categories to organize values, set priorities, and guide action.

Environmental values focus on protection, welfare, and health of ecosystems connected to water, including aquifers, rivers, wildlife, and wetlands.

Economic values emphasize efficient water use, avoiding waste, and finding minimize cost solutions, while using water for its most productive purposes and recognizing its economic benefits, like ecosystem services and tourism.

Social values address equity, social justice and benefits, including water access, sanitation, and river and wetland health.

Cultural values relate to spiritual and cultural relationships with water, including its role in personal identity, emotional connections, and the significance of rivers in community identity, traditions, and aesthetic benefits.

Governance values concern how water policy decisions and investments are made, including who takes part in decisions.

IV. ETHICAL ANALYSIS OF CURRENT PRACTICES

This section applies the Water Ethics Framework to assess data center technologies and planning, considering ethical perspectives, trade-offs, and sustainability impact distribution.

A. Reduce Indirect Water Footprint – Energy Source

Cases such as the Santiago data center protest in a drought-affected area [2] and facilities concentrated in water-stressed regions of western and southwestern U.S [11], show that site selection often prioritizes land cost, energy prices, and tax incentives over water availability and sustainability, shifting environmental burdens onto local communities and future generations. Indirect approaches to address this include improving energy efficiency through hyperscale centers and renewable energy such as wind and solar, which reduce energy use, indirect WF, and gas emissions [7], [8]. This produces broader societal benefits by lowering water withdrawals, carbon emissions, and pollution, contributing to climate change mitigation. This aligns with utilitarianism by maximizing overall well-being while supporting rights-based concerns through protecting access to clean water and a livable environment. Global ethics, highlights that these strategies support broader sustainability goals while meeting growing digital demands, addressing interconnected challenges like water scarcity. This can be evaluated with WUE, where reduced reliance on nonrenewable energy lowers indirect water use, values below 1.8L per 1kWh [9], indicating more efficiency.

From environmental and economic values, reducing reliance on water-intensive electricity protects freshwater ecosystems, lowers pressure on aquifers while improving operational efficiency and costs. From social and cultural values, reduced water demand alleviates pressure on shared resources, mitigates resource competition, promotes equitable distribution by easing pressure on local supplies, and supports natural environments' preservation for recreational, spiritual, and cultural value. From a governance perspective, strong policies and stewardship are needed to guide transition to renewable energy and practices that reduce water use. Stewardship, further emphasizes responsible management of shared water resources, ensuring their availability for present and future generations. Overall, while reducing indirect WF is beneficial, its ethical effectiveness depends on strong governance and responsible implementation.

B. Reduce Direct Water Footprint – Cooling Technologies

Liquid cooling technologies offer an alternative to in-rack air cooling by leveraging higher thermal conductivity and heat capacity of liquids, enabling efficient thermal management [9]. These systems use dielectric fluids to transfer heat and are classified into direct-to-chip and immersion cooling, including single-phase and two-phase modes [9]. In two-phase systems, dielectric fluid boils upon contact with hot components, condenses on a heat exchanger, and returns to liquid, removing heat efficiently with lower pumping power [9]. Performance can be evaluated using WUE, with values below 1.8L per 1kWh indicating higher efficiency [9], complemented by WSF to capture regional water impact.

Despite these advantages, liquid cooling leaks threaten IT equipment and the environment due to high global warming potential (HGWP) refrigerants [9]. From a utilitarian perspective, these systems improve efficiency, reduce water use, and contribute to broader environmental benefits. However, dielectric leaks and HGWP refrigerants offset gains and contribute to climate change. A rights-based perspective emphasizes community access to shared water resources, highlighting risks of environmental degradation or public health harm. From a global ethics perspective, these systems reduce energy demand and emissions, but HGWP refrigerants require responsible fluid management, undermining these benefits.

Considering environmental and economic values, these systems reduce reliance on water-intensive systems, lower direct water use, and improve operational efficiency, but these benefits depend on coolant type, leak prevention, and proper disposal. HGWP refrigerants require higher investment, specialized infrastructure, and waste management maintenance. From social and cultural values, reduced water demands lower competition between companies and locals, preserving natural water systems with recreational and aesthetic value within communities, but risks must be managed. From a governance perspective, ethical implementation requires clear environmental regulations, including standards for refrigerants, leak prevention, environmental compliance, and monitoring systems for safe exits in case of spills. Evaporative cooling systems transfer heat from a chilled water loop to a condenser and then to a cooling tower, where evaporation dissipates heat [18]. While these systems achieve competitive WUE values, they consume substantial water, making WSF essential for evaluating impacts. In water-stressed regions, higher WSF than WF, would suggest disproportionate reliance on scarce-watersheds [7].

Air-side economization is a low-cost strategy that uses outside air to cool IT equipment when ambient conditions are suitable, lowering direct water use [18]. Effectiveness depends on local climate and is most suitable in cooler regions. WUE metrics should be complemented with WSF, as direct water use reduction can result in high indirect use due to energy consumption. From a utilitarian perspective, it benefits communities by reducing water use, but increased HVAC reliance to maintain air quality and temperature may offset these benefits in unsuitable climates. It could reduce overall benefits if system's performance is compromised. A rights-based perspective supports preserving water, ensuring the right to a livable environment. However, air quality needs to be monitored as air pollution can be redistributed exposing communities to environmental risks. From a global perspective, it contributes to sustainability goals, but local climate limits effectiveness.

From environmental and economic values, reduced reliance on evaporative cooling protects rivers, aquifers, and other nearby freshwater ecosystems while reducing operational costs. However, indirect water use may increase if additional electricity is required, and continuous system monitoring requires investment. From social and cultural values, decreasing water demand reduces competition between companies and communities, supporting equitable access to shared resources for recreational, cultural, and identity-related activities through preservation of natural water systems. From governance values, effective and ethical implementation requires climate-appropriate design and regulatory guidance to manage water and energy use. It also requires transparent reports to ensure performance and accountability with alternative strategies considered when local conditions limit feasibility.

C. Water Recycling and Treatment Technologies

Reverse osmosis (RO) forces water through a membrane, removing dissolved solids and molecules that are rejected into a discharge stream [18]. RO can offset freshwater demand by enabling purified water reuse as cooling tower makeup, reducing water use [18]. However, it increases energy demand, indirect water use depending on the energy source, and adds operational and maintenance costs. While RO can improve WUE by lowering freshwater withdrawals, WSF should be evaluated to check local impacts, especially in water-scarce regions.

From a utilitarian perspective, RO has mixed outcomes, it reduces freshwater withdrawal but may increase energy and indirect water use, and carbon emissions, depending on the electricity source. A rights-based perspective emphasizes the right to water and sanitation by reducing freshwater use and preserving community access, but the right to a livable environment may be compromised if wastewater is mismanaged. Responsible reject stream disposal and strong governance oversight are essential to avoid environmental harm. Global ethics highlights water scarcity as an increasing concern, and RO contributes to sustainable water management. Though, its energy demand may increase carbon emissions and indirect water use, emphasizing the need for complementary strategies.

From environmental and economic values, RO reduces freshwater withdrawals, protecting aquifers while lowering water costs, but energy use, maintenance, and wastewater treatment costs, may offset these benefits. From social and cultural values, it reduces competition for water, supporting equitable access, and preserving freshwater for communities that rely on rivers and lakes for cultural and recreational purposes. However, improper reject stream management may pose risks to environmental quality affecting recreational and economic activities. From a governance perspective, strict regulatory wastewater disposal oversight and environmental protection is required. Benefits depend on balancing energy use, waste management, and transparency with strong stewardship.

C. Site Location and Infrastructure Planning

Strategic site selection is critical to reduce data centers' environmental footprints [7]. Locations with suitable climates lower cooling requirements and water use but minimizing water alone may result in higher carbon emissions due to electricity related indirect water use. Psychrometric conditions like temperature and humidity determine whether free cooling is feasible [8]. WSF is important, as data centers with similar WUE can differ in water impacts. WSF prevents water-blind site selection. Facility number and type matter, clustering can strain energy and water infrastructure due to cumulative demand, whereas broader geographic distribution can improve water and carbon footprints [7].

From a utilitarian perspective, it reduces water and energy use, benefitting companies and communities. Cooler climates can lower water withdrawals, electricity use, emissions, environmental damage, and operational costs. While clustering may create economic benefits, it can strain local resources through environmental degradation, and recreational land use. A rights-based perspective emphasizes avoiding water-scarce or drought prone regions to protect access to water and a livable environment. From a global ethics perspective, data centers provide global digital services, but environmental impacts remain local. Ethical location requires fair environmental burden distribution, protecting vulnerable communities from disproportionate effects tied to economic benefits.

From environmental and economic values, favorable climate sites improve energy efficiency, reduce water use, protect rivers and surrounding ecosystems, and lower operational costs, but long-term sustainability depends on grid reliability and low carbon energy. Poor decisions may shift burdens rather than reduce them. From social and cultural values, avoiding water-scarce regions and clustering reduces competition and distributes impact, as clustering may exacerbate inequalities and disrupt ecosystems. It is essential to consider Indigenous territories and act respectfully to preserve ecosystems with recreational, cultural, and spiritual significance. Some Indigenous communities in Latin America oppose anthropocentric views and promote laws that treat water as a political and ecological entity [1]. From a governance perspective, coordination among corporations, governments, and environmental agencies is required to integrate environmental assessments, infrastructure planning, and public participation into decision-making. Ethical effectiveness depends on balancing operational efficiency with equitable resource distribution and minimizing local community impacts.

D. Transparency and Reporting Requirements

Companies often treat energy and water use data as proprietary [19], limiting public access. Lack of standardized reporting restricts transparency, hindering innovation and environmental protection. Inconsistent metrics create gaps between reported and actual water use, complicating regulation, compliance, and comparisons. Standardized reporting, complemented by WUE, WF, and WSF with consistent methodologies is necessary for accurate comparisons.

From a utilitarian perspective, transparency maximizes societal benefits by supporting informed decision-making, accountability, and resource efficiency. Access to accurate data allows to develop strategies that reduce environmental footprints and encourage industry-wide improvements with global benefits outweighing competitive concerns. A rights-based perspective emphasizes that limited transparency undermines communities' abilities to assess environmental impacts and participate in decisions affecting health and well-being, limiting their right to environmental information. Providing data allows stakeholders to advocate for responsible management and protection of local ecosystems. From a global ethics perspective, standardized reporting enables tracking environmental footprints and developing coordinated strategies to manage impacts like water scarcity, while protecting right to a livable environment and access to water and sanitation.

From environmental and economic values, it improves stakeholders' understanding of local impacts, resource efficiency, operational costs, and minimizes environmental impacts by identifying opportunities to protect rivers and aquifers. From social and cultural values, it promotes fairness and accountability, supports equitable water management, and helps prevent disproportionate environmental burdens. Transparency ensures that decisions about water respect cultural relationships and protect ecosystems that are part of the community identity. From governance values, it is fundamental to effective governance and stewardship for sustainable and equitable water allocation. Standardized reporting enables governments to establish regulations, monitor compliance, and enforce sustainability standards to protect water. Addressing data center water use requires collaborative governance, ensuring diverse stakeholder concerns are considered.

V. RECOMMENDATIONS AND CONCLUSIONS

Transparency in data center water use is essential for informed site selection and resource management. Even if not legally required, ethical principles demand disclosure, as lack of transparency limits stakeholder accountability. Current practices prioritize short-term digital demands over long-term sustainability, contributing to water overuse. Addressing these challenges requires moving from water-blind use to collaborative governance that integrates transparency, stewardship, and responsible management to protect future generations. Based on this, three recommendations are proposed: (1) Standardized reporting. Regulatory bodies should adopt reports with consistent resource metrics to enable comparison, accountability, and informed decisions. (2) Integrated Planning. Stakeholders should consider water availability, community impacts, and direct and indirect water use in site selection to avoid shifting environmental burdens. Technologies and strategies must address risks like wastewater discharge. (3) Collaborative governance. Stakeholders, including policymakers, corporations, utility providers, and local communities should participate in shared decision-making to promote equitable resource allocation.

REFERENCES

[1] J. J. Bogardi, Handbook of Water Resources Management. Cham: Springer International Publishing AG, 2021.

[2] S. Lehuedé, "An elemental ethics for artificial intelligence: water as resistance within AI's value chain," AI Soc., vol. 40, no. 3, pp. 1761–1774, Mar. 2025, doi: 10.1007/s00146-024-01922-2.

[3] V. D. Reddy, B. Setz, G. S. V. R. K. Rao, G. R. Gangadharan, and M. Aiello, "Metrics for Sustainable Data Centers," IEEE Trans. Sustain. Comput., vol. 2, no. 3, pp. 290–303, Jul. 2017, doi: 10.1109/TSUSC.2017.2701883.

[4] B. Kelly, "Ethical AI and the Environment," IJournal Stud. J. Fac. Inf., vol. 7, no. 2, May 2022, doi: 10.33137/ijournal.v7i2.38608.

[5] M. K. Scanlan, P. McCauley, and C. Sutherland, "Powering Progress or Peril? The Hidden Environmental Costs of Data Centers and AI," SSRN Electron. J., 2025, doi: 10.2139/ssrn.5560480.

[6] A. Agarwal, "The Environmental Impact of Distributed Data Centers: Challenges and Sustainable Solutions," J. Comput. Sci. Technol. Stud., vol. 7, no. 5, pp. 999–1006, 2025, doi: https://doi.org/10.32996/jcsts.2025.7.5.115.

[7] M. A. B. Siddik, A. Shehabi, and L. Marston, "The environmental footprint of data centers in the United States," Environ. Res. Lett., vol. 16, no. 6, p. 064017, Jun. 2021, doi: 10.1088/1748-9326/abfba1.

[8] B. Ristic, K. Madani, and Z. Makuch, "The Water Footprint of Data Centers," Sustainability, vol. 7, no. 8, pp. 11260–11284, Aug. 2015, doi: 10.3390/su70811260.

[9] V. Vaccaro, L. C. Tagliabue, and M. Aldinucci, "Sustainable Data Centers: Advancing Energy Efficiency and Resource Optimization," in 2025 33rd Euromicro International Conference on Parallel, Distributed, and Network-Based Processing (PDP), Turin, Italy: IEEE, Mar. 2025, pp. 486–493. doi: 10.1109/PDP66500.2025.00075.

[10] Instytut Problemów Współczesnej Cywilizacji im. Marka Dietricha, Ethical Aspects of AI, 1st ed. Warsaw, Poland: Warszawa : Oficyna Wydawnicza Politechniki Warszawskiej, 2025. [Online]. Available: https://www.ipwc.pw.edu.pl

[11] T. Phan, J. Goldenfein, D. Kuch, and M. Mann, Eds., "Economies of Virtue – The Circulation of 'Ethics' in AI," 2022, Institute of Network Cultures. doi: 10.25969/MEDIAREP/19267.

[12] F. Lucivero, "Big Data, Big Waste? A Reflection on the Environmental Sustainability of Big Data Initiatives," Sci. Eng. Ethics, vol. 26, no. 2, pp. 1009–1030, Apr. 2020, doi: 10.1007/s11948-019-00171-7.

[13] W. M. Ngata, N. Bashir, M. Westerlaken, L. Liote, Y. Chandio, and E. Olivetti, "The Cloud Next Door: Investigating the Environmental and Socioeconomic Strain of Datacenters on Local Communities," in Proceedings of the ACM SIGCAS/SIGCHI Conference on Computing and Sustainable Societies, Toronto ON Canada: ACM, Jul. 2025, pp. 769–774. doi: 10.1145/3715335.3736324.

[14] Q. Zhu, M. W. Martin, and R. Schinzinger, Ethics in engineering, Fifth edition, International student edition. New York: McGraw Hill, 2022.

[15] J. Liu and Unesco, Eds., Water ethics and water resource management. in Ethics and climate change in Asia and the Pacific (ECCAP) Project, working group 14 report. Bangkok: UNESCO Bangkok, 2011.

[16] National Society of Professional Engineers, "NSPE Code of Ethics for Engineers | National Society of Professional Engineers." Accessed: Mar. 07, 2026. [Online]. Available: https://www.nspe.org/career-growth/nspe-code-ethics-engineers

[17] H. Widdows, Global Ethics: An Introduction, 0 ed. Routledge, 2014. doi: 10.4324/9781315711379.

[18] U.S. Department of Energy, "Cooling Water Efficiency Opportunities for Federal Data Centers." [Online]. Available: https://www.energy.gov/femp/cooling-water-efficiency-opportunities-federal-data-centers

[19] C. Hankendi, A. K. Coskun, and B. K. Sovacool, "Why transparency matters for sustainable data centers and carbon-neutral artificial intelligence (AI)," iScience, vol. 28, no. 11, p. 113705, Nov. 2025, doi: 10.1016/j.isci.2025.113705