ijamrsd.com
ISSN: 2583-6404
Journal of Advanced Multidisciplinary Research Studies and Development
Peer Reviewed Referred Journal | Bi-monthly | Open Access

BRIDGING THE GREEN CLOUD READINESS GAP: ORGANIZATIONAL BARRIERS, ENABLING CONDITIONS, AND A COST-ALIGNED FRAMEWORK FOR SUSTAINABLE AUTO-SCALING

Shloka Hitesh Kamdar
BCA Student, Education Facility Center Yash Infotech, Tilak Maharashtra Vidyapeeth.

Abstract:
Data centers are projected to consume 945 TWh of electricity globally by 2030 [3], and auto-scaling sits at the center of that problem. Cloud teams have the tools to manage dynamic resource allocation, carbon-aware scheduling, and intelligent scaling policies. Yet most infrastructure remains chronically over-provisioned. The barriers stopping adoption are not technical. This paper investigates what those barriers actually are. Through a mixed-methods study combining literature review with survey data from 40 cloud practitioners, it applies the Technology-Organization-Environment (TOE) framework to map what prevents sustainable auto-scaling in real DevOps environments. The numbers are striking: 85.0% of respondents were aware of the environmental impact of their infrastructure choices, yet when asked how much that awareness influenced actual decisions, the mean score was only 2.41 out of 5. Awareness, it turns out, is not the same as action. The barriers driving this gap are organizational far more than technical; absent management mandate, no visibility into carbon metrics, and the persistent reality that sustainability loses whenever it competes with cost. The 3M Framework proposed here - Measure, Monitor, Minimize, is built around that reality. Every intervention reduces carbon and cost together, so environmental goals stop requiring separate justification.
Keywords: Green Cloud Computing, Auto-Scaling, DevSusOps, Organizational Readiness, Sustainability, Carbon Efficiency, TOE Framework.

► *Corresponding Author: Shloka Hitesh Kamdar*

Introduction

Data centers consumed 415 TWh of electricity in 2024 and are projected to hit 945 TWh by 2030 [3]. Auto-scaling was designed to solve this dynamically matching compute resources to actual demand to eliminate idle over-provisioning. In practice, most teams run static 70-80% CPU thresholds that never scale down.

What makes this gap surprising: practitioners know better. Green cloud practices are well-documented. The tools exist. Yet adoption doesn't follow. This paper investigates why. Through a survey of 40 cloud practitioners, this study documents the awareness-action gap: 85% of respondents understand their environmental impact, yet report only 2.41/5 mean consideration when making actual decisions.The barriers are organizational, not technical.

To systematically examine this issue, the study is guided by three research questions. The first (R1) explores the prevailing auto-scaling practices among cloud practitioners, focusing on how infrastructure is currently configured and managed in real-world environments. The second question (R2) investigates the organizational, technological, and environmental barriers that

prevent the adoption of sustainable practices. The third question (R3) examines the enabling conditions that support the integration of green cloud practices into existing DevOps workflows. These questions are analyzed using the Technology-Organization-Environment (TOE) framework, which provides a structured lens to evaluate adoption challenges. Based on this analysis, a cost-aligned 3M Framework is proposed, designed to function within existing organizational constraints rather than requiring structural change.

Literature Review

The technical literature on sustainable cloud computing has matured considerably. Right-sizing instances to match actual workload requirements, adopting serverless architectures that scale to zero when inactive, and carbon-aware workload scheduling based on grid intensity data are all well-documented [2].

AWS Compute Optimizer and GCP Recommender provide automated right-sizing recommendations; Electricity Maps supplies hourly carbon intensity forecasts; open-source tools like Cloud Carbon Footprint calculate emissions directly from billing data. Despite this technological readiness, research indicates that proposed frameworks perform well in controlled environments but remain rarely validated against real production systems [6]. The implementation gap is organizational rather than technical.

Rogers' Diffusion of Innovations framework identifies five adoption stages: knowledge, persuasion, decision, implementation, and confirmation [4]. In green cloud contexts, practitioners appear to stall between knowledge and persuasion. Surveys consistently report that 80–90% of cloud teams acknowledge environmental impact, yet configuration practices remain largely unchanged. The TOE framework, originally developed by [5], provides structure for understanding this gap. Technological context examines tool complexity and compatibility; organizational context considers budgets, management priorities, and internal incentives; environmental context assesses regulatory pressure and industry norms. Applied to green cloud adoption, the pattern is consistent: technological barriers are relatively low, while organizational barriers like absence of dedicated budgets, performance-first priorities, and misaligned team incentives consistently block adoption.

DevSusOps represents an emerging reframing within DevOps culture, treating carbon emissions as a first-class operational metric alongside cost and performance [1]. Rather than positioning sustainability as an external requirement, it becomes integrated into daily observability and decision-making. This reframing proves theoretically compelling but remains uncommon in practice. The research gap addressed here is empirical: while literature documents both the technical practices and the theoretical barriers to adoption, there remains limited investigation of what specific organizational conditions enable adoption despite these barriers. The contribution of this research is grounding the barrier taxonomy in practitioner data and proposing a framework explicitly designed to operate within existing organizational constraints

Research Methodology

This study combines a systematic literature review with a practitioner survey conducted in March 2026. The literature review prioritizes empirical and practitioner-oriented sources over purely theoretical models, given the existing abundance of conceptual work in green cloud computing.

The survey employs a structured questionnaire to capture both quantitative and qualitative data. Quantitative metrics include scaling configurations, threshold settings, and sustainability

consideration scores, while qualitative responses provide insights into perceived barriers, instances of resource inefficiency, and decision-making trade-offs.

Quantitative data is analyzed using descriptive statistics, while qualitative responses undergo inductive thematic coding. Categories emerge directly from respondent input and are subsequently mapped to the TOE framework dimensions.

Table 1: Participant Profile (n = 40)

Dimension	Category	n	%
Role	DevOps Engineer	21	52.5%
	Cloud Engineer	11	27.5%
	Developer	6	15.0%
	Other	2	5.0%
Experience	5+ Years	18	45.0%
	1-5 Years	8	20.0%
	Less than 1 year	14	35.0%
Primary Platform	AWS	34	85.0%
	GCP	18	45.0%
	Azure	14	35.0%

Note: Platform figures exceed 100% as respondents could select multiple platforms.

The experience split, nearly half with five or more years, over a third with less than one – was not by design but proved useful. Experienced practitioners describe sustainability trade-offs they have navigated over careers; newer practitioners reveal what defaults look like when someone enters the field today. Both perspectives matter.

Quantitative responses were analyzed using descriptive statistics. Qualitative responses underwent inductive thematic coding. Categories emerged from respondent language rather than predetermined frameworks, then mapped onto TOE dimensions.

Findings and Discussion

The Awareness-Action Paradox

Thirty-four of forty respondents (85.0%) reported environmental awareness, approximately fifteen fully aware, and nineteen somewhat aware. Then the same respondents were asked how much that awareness actually influences auto-scaling decisions. The mean score was 2.41 out of 5. Twenty-three respondents, more than half, rated their consideration at 1 or 2, minimal to none. That is not a small discrepancy. Most people in this sample understand the environmental impact of what they are doing and then mostly do not factor it in when making decisions. The qualitative responses make the reasoning explicit: one respondent stated that environmental impact "does not play any role," another noted that "businesses care much less about saving trees," and a third framed it bluntly as a capitalism problem where "the ROI is too small." Seven respondents (17.5%) were different, describing performance, cost, and carbon as connected metrics rather than competing ones.

Barrier Taxonomy: A TOE Analysis

When respondents described what prevents adoption, the answers mapped clearly onto TOE dimensions

Table 2: Barrier Taxonomy (TOE-Mapped)

TOE Dimension	Barrier	Frequency
Organizational	No time or dedicated resources	17 (42.5%)
Organizational	Management does not prioritize sustainability	13 (32.5%)
Organizational	Perceived cost increase	12 (30.0%)
Technological	Lack of visibility into carbon metrics	13 (32.5%)
Technological	No integration with carbon intensity data	7 (17.5%)
Environment	No load testing before auto-scaling changes	5 (12.5%)
Environment	Practitioners do not know how	5 (12.5%)

No time or dedicated resources (42.5%): The data shows teams are not skipping sustainability because they don't care; they're skipping it because it's never an explicit Service Level Objective (SLO). When a performance incident requires immediate action, any tangential work like optimizing cloud usage instantly gets deprioritized. Sustainability is treated as 'nice-to-have' technical debt that only gets attention after an incident is resolved, which means it rarely gets attention at all.

Management does not prioritize sustainability (32.5%): Senior leadership decisions follow financial metrics, but carbon is not a line item in the profit-and-loss statement. If FinOps reporting only tracks dollar spend, then waste is only reduced when it hits the budget threshold. This organizational blind spot ensures that even well-meaning teams won't receive a formal mandate to dedicate cycles to environmental optimization.

Perceived cost increase (30.0%): The default practitioner mindset is that sustainable practices are add-on costs, like paying a premium for renewable-powered regions rather than intrinsic cost-saving measures. This mindset gap is critical because any environmental choice that requires spending money now to save energy or carbon later gets instantly vetoed by budget constraints. Practitioners fundamentally see performance and cost as first-order concerns, and sustainability as a distant, potentially expensive third.

Lack of visibility into carbon metrics (32.5%): This isn't a problem because tooling doesn't exist, but because integrating carbon APIs requires a dedicated project. Teams simply don't have native carbon data visible in the daily dashboards they use for debugging and operational decisions. It's a friction problem, not a capability problem: when a metric is invisible, as respondents put it, 'Carbon data isn't in our dashboards' - it never enters the decision matrix.

Proposed Framework: The 3M Model for Sustainable Auto-Scaling

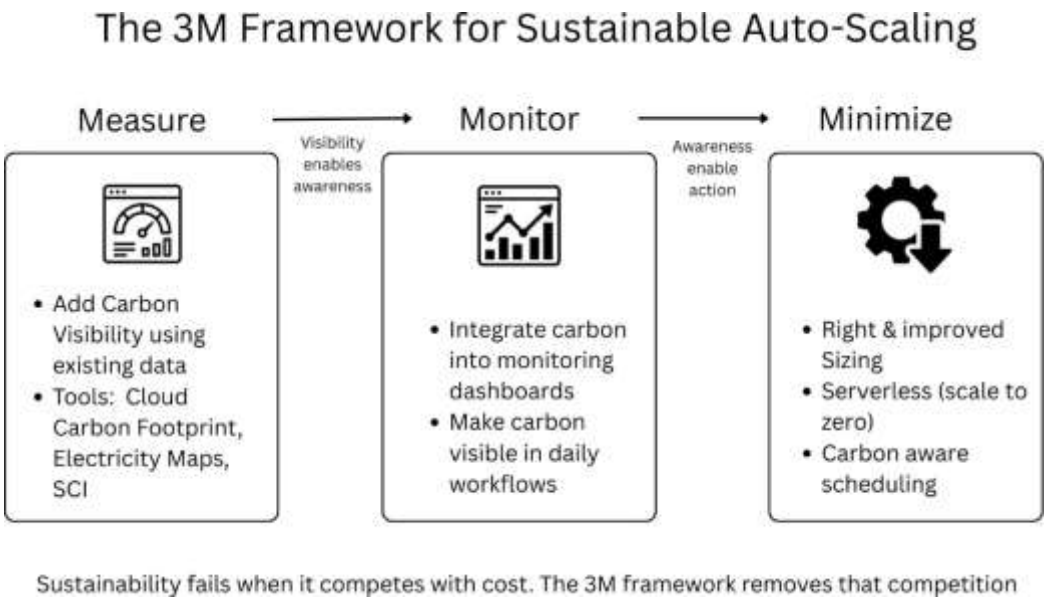

Figure 1 - The 3M Framework

The 3M Framework (Measure, Monitor, Minimize) is proposed as a structured, cost-aligned operational model to close the awareness-action gap in sustainable cloud adoption. This framework mandates a sequential flow, beginning with establishing carbon visibility (Measure), integrating these new metrics into existing operational dashboards (Monitor), and culminating in actionable waste reduction (Minimize). Its core design ensures that every step reduces both environmental impact and operational expenditure simultaneously. By removing the need for sustainability to compete with cost or performance, the 3M framework integrates carbon efficiency directly into the DevSusOps workflow, as visually detailed in Figure above

Conclusion

The gap between green cloud awareness and action is organizational, not technical. Through analysis of 40 practitioners mapped onto the TOE framework, this study finds that sustainable auto-scaling adoption is blocked primarily by organizational misalignment - absent management mandate, competing cost priorities, and metric invisibility. The awareness-action gap is not marginal: 85.0% awareness paired with 2.41/5 operational consideration. Technical knowledge and tools are necessary but insufficient conditions.

The 3M Framework provides a cost-aligned response designed to operate within existing organizational constraints rather than requiring structural transformation. By framing sustainability as cost optimization with environmental benefits as measurable side effects, it aligns with incentives that already exist. For the cloud industry to achieve widespread sustainable practice, the green path must become the easy path. The framework is designed to do exactly that. This distinction, while intuitive, is not reflected in existing literature. Most green-cloud research proposes technical solutions to what is fundamentally an organizational problem, a mismatch that explains why sophisticated carbon-aware scheduling algorithms remain largely unused in practice Three critical unknowns remain after this investigation.

First, the Behavior vs. Intention Gap: This study documents high awareness (85.0%) without subsequent action (2.41/5 mean consideration). The findings show that practitioners know what

they should do, but not what they will do. Longitudinal tracking of teams implementing the 3M Framework would test whether cost-aligned framing actually shifts daily operational behavior, or if deeper organizational barriers remain even with better tools and incentives. This study hypothesizes that teams with explicit carbon SLOs will adopt optimization faster, but that remains untested

Second, the Cost-Carbon Divergence: The 3M Framework is predicated on the assumption that cost reduction and carbon reduction move together. They don't always align. Studying cases where carbon-aware choices cost more, for instance, choosing a renewable-powered cloud region with a premium price point, would reveal where the cost-alignment hypothesis breaks down. This research would define the boundary conditions of the framework and clarify when practitioners are willing to choose sustainability purely for environmental reasons.

Third, Geographic and Market Context:The organizational barriers identified in this study echo across the AWS, GCP, and Azure users sampled, largely based in India. What remains unknown is whether these barriers hold in highly regulated markets (like the EU) or in regions where the carbon intensity of the local grid varies dramatically day-to-day. Further research focusing on emerging markets, which are still building their cloud infrastructure from inception, could identify the conditions that enable them to embed sustainability in architectural and procurement decisions from day one, avoiding the lock-in that constrains developed markets.

References

1. A. Cockcroft, "DevSusOps: Adding Sustainability to Development and Operations," QCon San Francisco, n.d.
2. Green Software Foundation, Software Carbon Intensity Specification (SCI), 2023.
3. International Energy Agency (IEA), Data Centres and Data Transmission Networks Report. IEA, 2024.
4. E. M. Rogers, Diffusion of Innovations, 5th ed. New York, NY: Free Press, 2003.
5. L. G. Tornatzky and M. Fleischer, The Processes of Technological Innovation. Lexington, MA: Lexington Books, 1990.
6. M. Yenugula, S. Sahoo, and S. Goswami, “Cloud computing for sustainable development: An analysis of environmental, economic and social impacts,” Journal of Cloud Computing, vol. 12, no. 1, pp. 1–19, 2023.