

Exploring Uncertainty in Responsible Management Scales: An Obstacle to Sustainable Decentralized Wastewater Management in Rural Alabama's Black Belt

*Shima Nikkhou*¹; and *Amal Bakchan*², Ph.D.

¹ Graduate Research Assistant, Department of Construction Science; Texas A&M University, 3137 TAMU, College Station, TX 77843, United States. ORCID: <https://orcid.org/0000-003-2391-7113>; Email: shima.nikkhou@tamu.edu

² Assistant Professor, Department of Construction Science; Texas A&M University, 3137 TAMU, College Station, TX 77843, United States (corresponding author). ORCID: <https://orcid.org/0000-0002-1709-5937>; Email: bakchan@tamu.edu

ABSTRACT

In many limited-resource communities across the United States, inadequate wastewater infrastructure poses significant public health challenges, especially in regions prone to septic system failures. Decentralized wastewater systems have emerged as cost-effective alternatives; however, their long-term sustainability depends on effective operation and maintenance (O&M)—often overseen by a responsible management entity (RME). The effectiveness of an RME depends on defining an appropriate scale—typically categorized as community, county, regional, or state—based on geographic scope and service organization. Despite its importance, there is limited understanding of how these scale categories are defined and applied in practice, thereby constraining the provision of sustainable O&M. Because scale also shapes how responsibilities, coordination mechanisms, and operational accountability are organized across jurisdictions and actors, uncertainty in scale interpretation further creates challenges for the governance and long-term delivery of decentralized wastewater infrastructure programs. Here, we evaluate the extent to which potential RMEs share a common understanding of these categories by analyzing survey data from 115 entities across 27 states, with a focus on the rural Alabama's Black Belt region. We develop a linear support vector machine (SVM) model to examine patterns in how potential RME interpret the four scale categories. Findings reveal a notable lack of clarity and consistency in how scale categories are understood and operationalized. This empirical assessment underscores the need for clearer and more standardized definitions of scale categories, providing a critical foundation for strengthening RME implementation and advancing the sustainability of decentralized wastewater systems in limited-resource rural communities.

INTRODUCTION

Many residents in the rural, 17-county Black Belt region of Alabama continue to face limited access to safely managed wastewater infrastructure, due in part to severely limiting (non-perc) soil

conditions that lead to hydraulic failure of conventional onsite septic systems (Buchanan 2010; Elliott et al. 2017; White et al. 2020; White and Jones 2006; Winkler and Flowers 2017). Field surveys of hundreds of rural residences in three counties (Bibb, Wilcox, and Hale)—performed in 2005 and 2017—have documented that as high as 50% of rural residents have untreated sewage at the ground surface (White and Jones 2006). Additional studies in Lowndes and Wilcox counties have shown an elevated prevalence of intestinal parasites (worms) among both adults and children linked to inadequate sanitation (Badham 1993; McKenna et al. 2017). Such unacceptable sanitation conditions have motivated research to examine alternative wastewater treatment strategies, technologies, and management models that can address wastewater issues in the rural Black Belt communities (Allaire et al. 2026, Bakchan et al. 2023; Bakchan and White 2022, 2024; White et al. 2020).

Current research efforts (CARWW 2023; White et al. 2020) are investigating cost-effective onsite treatment systems applicable to this region, as well as clusters (e.g., 90+ homes) suitable for connection to a decentralized wastewater treatment system—referred to as *clustered* systems. This combination of onsite and clustered systems provides a promising solution to the wastewater challenges in the Black Belt, while accounting for the widespread poverty and small customer base (rate payers) constraints (Bakchan and White 2022; US-EPA 2012). However, decentralized wastewater systems require continuous, organized, and accountable management to ensure proper operation and maintenance (O&M) and long-term reliability. Effective management of decentralized wastewater systems is therefore critical to their long-term sustainability (US-EPA 2005). This form of oversight—referred to as responsible management—is implemented by a responsible management Entity (RME) (US-EPA 2018, 2005, 2003). An RME is defined as a legal organization with the technical, managerial, and financial capacity to operate and maintain viable decentralized wastewater systems within the RME’s jurisdiction (US-EPA 2005).

Research Problem. It is important to note that the responsible management of small, decentralized wastewater infrastructures is a complex model, as it is a context-specific process highly dependent on cooperation across various community stakeholders (US-EPA 2005). There is a dearth of academic literature on the responsible management of decentralized wastewater infrastructure. Much of the existing work was published more than a decade ago in agency reports (Etnier et al. 2007; Pinkham et al. 2004; US-EPA 2003, 2005, 1997), except for recent studies by Bakchan and White (2024a & 2024b) and Bakchan et al. (2023). Furthermore, the growing attention and funding from both federal and state governments for addressing wastewater management needs in rural communities (US-Congress 2021a, 2021b) have led to a substantial increase in the number of decentralized wastewater systems, further highlighting the national need for effective responsible management. Establishing a viable RME requires early planning efforts to determine the appropriate scale of responsible management that aligns with the communities’ social and institutional dynamics and meets their specific needs (US-EPA 2005). Bakchan et al. (2023) define scale of responsible management as the geographic coverage defining the number of decentralized wastewater systems’ connections that the RME manages for proper O&M, classifying it into four broad categories—community, county, regional (spanning multiple counties), and state. However,

broader governance and water management literature suggests that scale extends beyond geographic coverage and also encompasses the jurisdictional, institutional, and organizational arrangements that shape how responsibilities and coordination are structured across multiple levels of management and governance (Cash et al. 2006; Norman et al. 2012). While the work of Bakchan et al. (2023) enhances our understanding of the scale of responsible management concept, it lacks clear, explicit definitions of what the four scale of responsible management categories entail. As a result, there is uncertainty regarding whether potential RMEs share a coherent understanding of this concept and its various categories. This lack of clarity may lead to inconsistent interpretations of these categories, thereby undermining RMEs' ability to adopt effective strategies for achieving a sustainable scale of responsible management. Because the scale of responsible management also determines how responsibilities, coordination mechanisms, and organizational relationships are distributed across jurisdictions and actors, uncertainty in scale interpretation may further complicate the organization and governance of decentralized wastewater management projects. As such, determining the appropriate scale of responsible management represents not only an administrative decision, but a project governance and lifecycle accountability design challenge that influences institutional coordination, stakeholder alignment, long-term O&M responsibilities, and the sustainable delivery of decentralized wastewater infrastructure projects.

Research Objectives. This study seeks to evaluate the extent to which potential RMEs for managing decentralized wastewater systems in the Black Belt share a common understanding of the four scale categories. To support this objective, a support vector machine (SVM) classifier is applied to empirically assess how RMEs interpret the scale of responsible management at the county, community, regional, and state levels. By identifying gaps in RMEs' understanding of these categories, this study would lay the groundwork for future efforts to further explore the scale of responsible management of decentralized wastewater systems and foster a common understanding among RMEs. In doing so, it provides the first empirical examination of how the scale of responsible management is actually perceived in practice, revealing whether these categories function as clearly defined concepts or as overlapping, context-dependent interpretations.

MATERIAL AND METHODS

Study Design. In this study, we adopt an exploratory diagnostic analysis approach to examine whether potential RMEs share a consistent understanding of the scale of responsible management categories. Prior machine learning studies have used classification performance diagnostically to assess whether survey responses and expert judgments exhibit distinguishable patterns, with weak performance often interpreted as evidence of limited separability or overlap across categories (Ramirez et al. 2019; Faiman et al. 2023). Following this approach, we develop a machine learning model to classify the categories of the scale of responsible management in the Black Belt. The purpose of model is diagnostic rather than predictive. The study does not directly measure conceptual understanding; instead, the analysis evaluates whether respondents who select the same

scale category exhibit similar response profiles and whether those profiles can be distinguished from those associated with other categories. We use model performance to identify patterns within the data, which may serve as indirect evidence of how RMEs interpret the scale of responsible management categories and the extent of convergence and divergence across respondents. Accordingly, interpretation focuses on diagnosing classification patterns and model behavior.

Data Collection. To explore potential gaps in RMEs' common understanding of the scale of responsible management, we distributed a survey questionnaire to various public and private management entities that could serve as potential RMEs in the Black Belt. These entities included water utilities, sewer utilities, and community development corporations. The survey questions were reviewed through expert feedback to improve clarity and relevance. Prior professional presentations and conference discussions concerning scale of responsible management categories and wastewater management challenges in Alabama's Black Belt also contributed to informing and clarifying the survey concepts for potential respondents. The survey captured information about participants' demographics, their experience within their organizations, entity type and structure, and the type of service provided (e.g., water, sewer). To assess potential RMEs' understanding of the scale of responsible management categories, we asked respondents to identify what they considered to be a feasible scale of responsible management within the Black Belt across the four major categories. Here, feasible scale refers to the scale at which decentralized wastewater systems can be effectively organized and managed, reflecting community characteristic, RMEs' technical and institutional capabilities, and regulatory constraints. We assessed these dimensions through survey questions examining factors such as familiarity with centralized versus decentralized wastewater management approaches, familiarity with non-conventional technologies, uncertainty regarding DWS operational costs, liability concerns associated with unfamiliar systems, and the ability to operate outside existing service areas. Additional factors included willingness to manage systems across multiple jurisdictions, willingness to accept effluent from another community, organizational structure limitations, local operator retention challenges, limited technical expertise, access to public funding for privately managed systems, financial incentives for assuming DWS responsibilities, and affordability of wastewater services for residents. Responses were evaluated using a Likert-scale format. Data collection occurred between March 2022 and January 2023, yielding a final sample of 115 responses from 115 distinct entities across 27 states. These respondents represent potential RMEs whose operational experience and management capacities are relevant to addressing decentralized wastewater management challenges in Alabama's Black Belt. Although responses were collected from entities across 27 states, participants were surveyed specifically in relation to the context and management challenges of Alabama's Black Belt, allowing the study to examine how respondents interpret scale of responsible management within that regional context.

Analysis Method. We evaluated several supervised machine-learning classifiers, including Random Forest, multinomial logistic regression, and SVM with both linear and radial basis function (RBF) kernels, to examine patterns in how potential RMEs interpret the scale of responsible management in the Black Belt. Among the tested models, the linear SVM

demonstrated the strongest overall and class-balanced performance and was therefore selected to analyze the survey responses and examine patterns in how potential RMEs interpret the scale of responsible management in the Black Belt. The dependent variable in the SVM model is the selected scale category—community, county, regional, or state—while the independent variables consist of structural and operational factors that may shape scale selection, including financial capacity, operator availability, regulatory constraints, and the ability to operate across multiple jurisdictions. SVM is a supervised machine-learning algorithm that identifies decision boundaries separating observations into distinct categories based on their predictor profiles (derived from survey responses) (Chang 2011). This method is well suited for identifying separable patterns in relatively small datasets with multiple explanatory variables and diverse data types. In this study, each respondent’s selection of a scale category defines a classification problem in which predictor profiles derived from survey responses are used to evaluate whether distinct patterns emerge across categories. The model is used diagnostically to assess respondents selecting the same scale category exhibit similar predictor profiles and whether these profiles are distinguishable across categories. Clear separation of predictor profiles would indicate a shared and consistent understanding of scale categories, whereas substantial overlap would suggest dispersed interpretations and a lack of shared understanding among potential RMEs.

Model performance was evaluated using overall classification accuracy, macro-averaged recall, and macro-averaged F1 score. Additionally, we assessed the developed SVM model’s performance using two primary tools: the confusion matrix and the receiver operating characteristic (ROC) curve. The confusion matrix provides insights into how well the SVM model classifies instances across all classes—i.e., the four scale of responsible management categories in this study—by comparing predicted class labels (outputs from the SVM model) with the actual class labels (true values) from the dataset (Powers et al. 2011). It summarizes the correct and incorrect predictions for each class, enabling identification of systematic misclassification patterns and highlighting where conceptual overlap between categories occurs. The ROC curve is a graphical representation that evaluates the SVM model's ability to distinguish between classes (i.e., categories of scale) by examining its discriminative capacity under varying classification conditions (Fawcett 2006), thereby providing a complementary perspective on whether each scale category is inherently distinguishable based on response patterns. ROC curves were generated using a one-vs-rest approach, where each category was compared against all remaining categories. The ROC curves were computed using SVM decision scores for each class.

RESULTS AND DISCUSSION

The linear SVM model achieved an overall cross-validated accuracy of 0.43, indicating that the model correctly classified the scale of responsible management categories in approximately 43% of the observations. Additional performance metrics were similarly modest, with macro recall = 0.37 and macro F1 score = 0.35 ± 0.056 , further reflecting limited separability across the four scale categories. Although the model performance exceeded random guessing (the baseline accuracy, which is 0.25 for four categories), and class weighting was applied to address imbalance among

the scale categories, these results indicate that predictor profiles do not produce clearly distinguishable patterns across the four scales categories. More specifically, respondents selecting different scale categories often reported similar predictor profiles, suggesting substantial overlap in how potential RMEs interpret the boundaries between these scale categories. This overlap indicates that the distinctions between scale categories are not consistently defined in practice, pointing to divergence in how scale of responsible management is understood. To gain a deeper understanding of this overlap, we further interpret the results using the confusion matrix and ROC curve.

The confusion matrix results are presented in Figure 1. Each number in the 4×4 matrix represents how many times the model classified a response into a specific category. The rows of the matrix correspond to the actual scale categories selected by respondents—community, county, regional, or state—while the columns represent the categories predicted by the SVM model. The diagonal cells represent correct predictions: instances where the predicted category matches the actual category. For example, the model predicted county 17 times, and in each of those cases, the respondent had also selected county. The off-diagonal cells indicate misclassifications: cases where the model incorrectly predicted the scale. For instance, the model predicted county 14 times when the actual response was regional, showing that the model confused these two categories. This pattern helps to highlight areas where the conceptual boundaries between scales may be unclear or inconsistently interpreted by respondents.

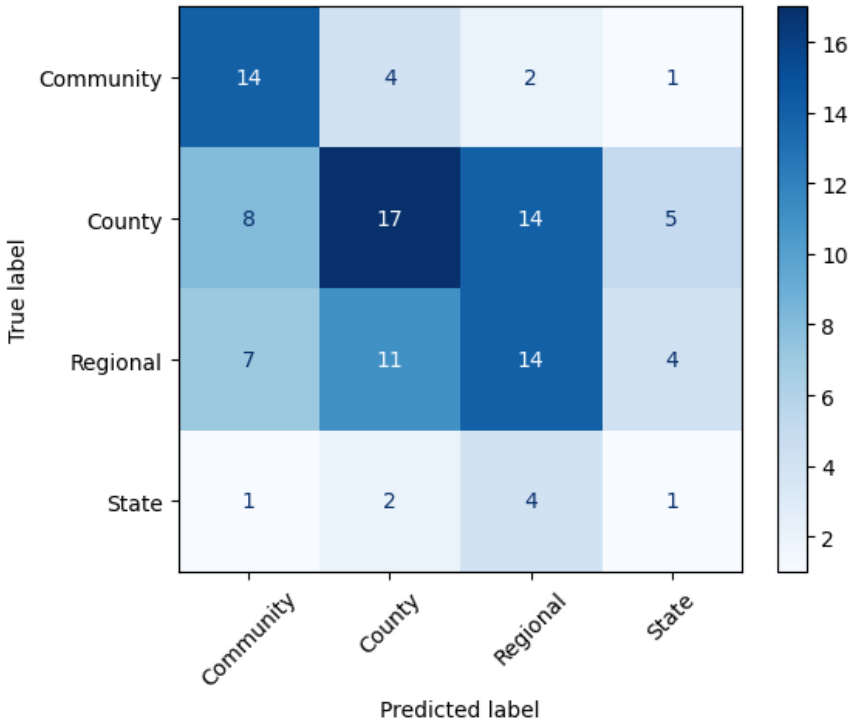


Figure 1. Confusion matrix for assessing the SVM model

The confusion matrix analysis reveals frequent misclassifications across the three scale categories—county, regional, and state—indicating limited separability among these categories. In contrast, the community category showed the strongest classification performance. Of the 21 community scale responses, 14 were correctly classified (66.7%), and the remaining responses were misclassified primarily as county (19.0%), followed by regional (9.5%) and state (4.8%). This pattern suggests that community-scale perceptions were relatively more distinct, although some overlap remained with adjacent scales categories. The county category showed only moderate classification performance. Of the 44 county scale responses, 17 were correctly classified (38.6%); the remaining responses were misclassified most often as regional (31.8%), followed by community (18.2%) and state (11.4%). These results indicate that county scale responses shared substantial similarities with regional scale perceptions, reflecting weak conceptual separation between these two categories. It can also be inferred that respondents may have a relatively more common or familiar understanding of the county category and may default to this category under uncertainty, which could contribute to its higher frequency of selection. The regional category exhibited a very similar pattern. Of the 36 regional scale responses, 14 were correctly classified (38.9%). However, a considerable share was misclassified as county (30.6%), while others were classified as community (19.4%) or state (11.1%). These results reinforce the strong bidirectional confusion between county and regional scales and suggest that respondents may not consistently distinguish the governance and operational features associated with these two categories. The state category exhibits the weakest performance, with only one out of eight responses correctly classified (12.5%). Most state responses were misclassified as regional (50.0%), followed by county (25.0%) and community (12.5%). This pattern indicates that the SVM model was unable to identify a stable and distinct response profile for the state category. The results further suggest that respondents who selected state scale management expressed perceptions that overlapped substantially with lower scale categories, particularly regional, indicating a significant lack of differentiation between the state scale and the other categories.

These findings point to a gap in how the defining features and boundaries of the four scale categories are understood, which may hinder the effective operation of RMEs. The confusion matrix identified where misclassifications occur, revealing the direction of overlap between categories. To complement this perspective, we also examined the ROC curve (see Figure 2), which provides a broader assessment of how well each scale category can be distinguished from the others under varying classification conditions. Notably, the ROC curve plots the true positive rate (sensitivity) against the false positive rate (specificity) under varying classification thresholds (see Figure 2). The area under the curve (AUC) provides a measure of how well a classification model can distinguish one class (e.g., community category) from the others. An AUC of 1.0 indicates perfect discrimination, meaning the model can completely distinguish a given class from the others without error, whereas an AUC of 0.5 indicates performance no better than random guessing. In practice, values above 0.7 are generally considered acceptable, indicating that the model can reasonably differentiate between classes (Fawcett 2006).

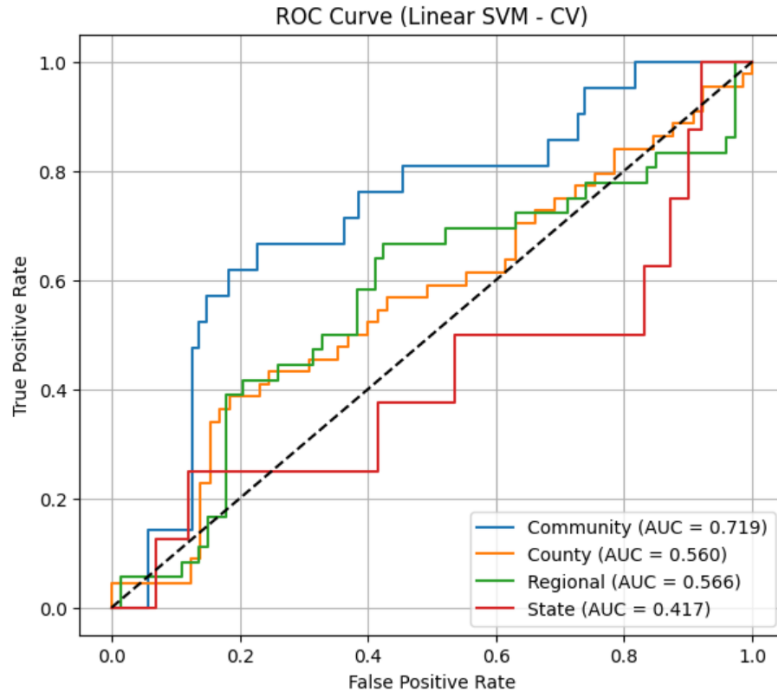


Figure 2. ROC curve plot for assessing the SVM model

The ROC curve analysis results align with the confusion matrix findings. The community scale showed the highest discriminative ability, with an AUC of 0.719, indicating moderate separability and relatively more consistent interpretation among respondents. In contrast, the county and regional scales exhibit much lower AUC values (0.560 and 0.566, respectively), indicating weak discrimination and substantial overlap between these two categories. This pattern reinforces the observed bidirectional confusion between county and regional scales, suggesting that respondents do not consistently distinguish their defining characteristics. The state scale demonstrates the weakest performance, with an AUC of 0.417, falling below random classification. These results indicate that the model was unable to identify a stable pattern for this category, reflecting particularly low coherence in how respondents interpret the state scale. Overall, the ROC results reinforce that respondents' interpretations of scale of responsible management categories are not equally coherent across categories, with community relatively more distinct and county, regional, and especially state exhibiting substantial conceptual overlap.

Findings point to a differentiated pattern of interpretation, not a uniform lack of understanding across the categories of the scale of responsible management. The observed overlaps reflect systematic differences in how respondents conceptualize scale. The relatively stronger performance of the community scale indicates that it is grounded in more tangible, experience-based features, making it easier for respondents to converge in their reasoning. In contrast, the persistent overlap between county and regional scales suggests that these categories are not being distinguished based on a single shared definition but are instead interpreted through different underlying logics—such as operational capacity versus resource coordination—leading to consistent but competing interpretations. The state scale presents a different dynamic, where the

absence of a clear and stable pattern implies that respondents lack a well-formed conceptual basis for this category. This stratified pattern—clarity at the local level, overlap at intermediate levels, and ambiguity at higher scales—suggests that scale of responsible management is not perceived as a strictly hierarchical construct, but rather as a context-dependent concept shaped by how respondents prioritize different institutional, technical, and resource-related factors.

These findings have important implications for the development of scale of responsible management frameworks. Improving these frameworks requires more than simply refining definitions, as the underlying issue is not uniform across categories. While clearer articulation of scale attributes may enhance consistency for some categories, the observed patterns indicate that intermediate scales—particularly county and regional—appear to be interpreted through different but individually coherent reasoning patterns, not a single shared definition. In this sense, scale does not function purely as a set of discrete categories, but reflects a continuum influenced by how respondents prioritize operational capacity, resource coordination, and contextual constraints. At the same time, the weak and unstable pattern observed for the state scale points to a more fundamental gap, where a coherent conceptual basis has yet to emerge. Recognizing this differentiated structure is critical for developing more robust and applicable responsible management frameworks. Future approaches should move beyond enforcing rigid boundaries and instead account for the multiple logics through which scales are interpreted and provide clearer guidance on when and why each scale is appropriate under specific conditions. This finding aligns with prior work in decentralized wastewater governance, which emphasizes that management effectiveness depends on institutional fit and context-specific arrangements rather than standardized structures (US-EPA 2005). Accordingly, policy frameworks should incorporate adaptive, criteria-based guidance that reflects local capacity, resource availability, and jurisdictional constraints. The observed overlap between intermediate scales (county and regional) further highlights the need for more comprehensive institutional coordination mechanisms, consistent with literature on regionalization and interjurisdictional collaboration in decentralized wastewater management (AWWA 2012). Such mechanisms can help reconcile competing operational and resource-based logics across scales. These insights point toward policy reforms that emphasize coordination across governance levels and the development of flexible frameworks that guide scale selection under varying contextual conditions. Such an approach can better support RMEs in aligning management strategies with local realities, ultimately improving the effectiveness and sustainability of decentralized wastewater infrastructure.

IMPLICATIONS

This study contributes to the literature on decentralized wastewater governance and project organization by providing the first empirical assessment of how potential RMEs interpret scale of responsible management categories within a shared problem context. The findings reveal substantial overlap in how these categories are understood, despite respondents evaluating the same regional setting in Alabama’s Black Belt. The study emphasizes the need for clear and precise definitions of scale categories—community, county, regional, and state—while

recognizing that their application must remain responsive to varying contextual conditions. This work contributes to the broader discourse on the theoretical underpinnings of the scale concept and lays the foundation for future research aimed at defining and applying these scale categories more effectively.

From a practical perspective, the findings emphasize the importance of refining these categories to enhance the operational capacity and long-term performance of RMEs. Clearer distinctions between the scale categories can enable RMEs to better align management structures with system needs, improving the design, implementation, and O&M of decentralized wastewater systems, particularly in limited-resource rural communities. For regulators, findings highlight the need to complement existing classification frameworks with guidance that links the four scale categories to specific conditions, enabling more consistent permitting and program design. For technical assistance providers and policymakers, findings underscore the value of developing decision-support tools that translate scale concepts into operational criteria, helping practitioners understand the advantages and tradeoffs associated with different scale categories and apply them in a more context-sensitive manner.

CONCLUSION

This study examined how potential RMEs interpret the scale of responsible management in decentralized wastewater systems, with the aim of identifying whether the main scale categories—community, county, regional, state—are consistently understood and applied in practice. By analyzing how practitioners conceptualize these categories, the study sought to clarify the underlying structure of scale in decentralized wastewater management. The findings show that while some categories, such as community, are interpreted relatively consistently, others—particularly county and regional—exhibit overlapping yet internally coherent reasoning patterns. The state scale, in contrast, lacks a stable conceptual foundation. These findings indicate that differences in scale interpretation are not random but reflect distinct underlying logics used by practitioners, such as operational capacity and resource coordination. This study contributes to the literature by demonstrating that scale should not be treated as a one-size-fits-all classification scheme, but rather as a context-dependent continuum shaped by different management logics. Future research should focus on translating these differentiated interpretations into practical criteria that guide scale selection under varying conditions. In particular, developing tools and guidelines that link management logics to appropriate scale categories can improve consistency and support more effective decentralized wastewater management across diverse contexts.

ACKNOWLEDGEMENT

This material is based upon work supported by the U.S. Department of Agriculture (USDA) under Grant No. TAC-RWTS 82329.

REFERENCES

- Allaire, M., Nikkhou, S., Lu, P.-J., and Bakchan, A. 2026. “The Sewer Divide: Challenges and New Approaches for Closing Gaps in U.S. Wastewater Access.” *PLOS Water*, 5(3), e0000525.
- AWWA Strategic Management Practices Committee of the Technical & Educational Council. (2012). TEC Project Report: National inventory of regional collaboration among water and wastewater utilities. *Journal-American Water Works Association*, 104(7), 67-78.
- Badham, A. 1993. “Wilcox County Alabama: Needs Assessment. University of Alabama at Birmingham.” The University of South Alabama.
- Bakchan, A., Chai, R. S., McCaskill, H., and White, K. D. 2023. “Scale of Responsible Management of Decentralized Clustered Wastewater Systems in Rural Alabama’s Black Belt: A Mixed-Method Analysis.” in *Water Environment Federation’s Technical Exhibition and Conference (WEFTEC)*. Water Environment Federation.
- Bakchan, A. and White, K. 2022. “Socio-Technical Barriers To Successful Responsible Management Entities of Decentralized Clustered Wastewater Systems in The Rural Alabama’s Black Belt.” in *Water Environment Federation’s Technical Exhibition and Conference (WEFTEC)*. Water Environment Federation.
- Bakchan, A. and White, K. D. 2024 a. “Identifying Socio-Technical Challenges to Decentralized Wastewater Infrastructure Management in the Rural Alabama Black Belt.” in *Construction Research Congress 2024*. Des Moines, Iowa.
- Bakchan, A., & White, K. D. 2024 b. Sustainable Development in Rural Underserved Communities through Improved Responsible Management of Decentralized Wastewater Infrastructure: A Focus on the Alabama Black Belt. *Environmental Science & Technology*, 58(42), 18671-18685.
- Buchanan, J. 2010. *Decentralized Systems: Performance and Cost of Decentralized Unit Processes*.
- CARWW. 2023. “Consortium for Alabama Rural Water and Wastewater Management.” Retrieved (<https://ruralwastewater.southalabama.edu/>).
- Cash, D. W., Adger, W. N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., & Young, O. 2006. “Scale and Cross-Scale Dynamics: Governance and Information in a Multilevel World.” *Ecology and Society*, 11(2), 8.
- Chang, C.-C.; Lin, C.-J. 2011. LIBSVM: A Library for Support Vector Machines. *ACM Transactions on Intelligent Systems and Technology*, 2(3), 27.
- Elliott, M., White, K., Jones, R., Das, P., Price, M., et al. 2017. “Surface Discharge of Raw Wastewater among Unsewered Homes in Central Alabama.” *EPA Decentralized Wastewater Webinar*.
- Etnier, C., Pinkham, R., Crites, R., Johnstone, S. D., Clark, M., et al. 2007. *Overcoming Barriers to Evaluation and Use of Decentralized Wastewater Technologies and Management*. Water Environment Research Foundation.
- Faiman, I., Sparks, R., Winston, J. S., Brunnhuber, F., Ciulini, N., Young, A. H., & Shotbolt, P. (2023). *Limited clinical validity of univariate resting-state EEG markers for classifying seizure disorders*. *Brain Communications*, 5(6), fcad330.
- Fawcett, T. 2006. An introduction to ROC analysis. *Pattern Recognition Letters*, 27(8), 861-874. <https://doi.org/10.1016/j.patrec.2005.10.010>
- McKenna, M. L., McAtee, S., Bryan, P. E., Jeun, R., Ward, T., et al. 2017. “Human Intestinal Parasite Burden and Poor Sanitation in Rural Alabama.” *Am. J. Trop. Med. Hyg.*, 97(5),1623–28.
- Norman, E. S., Bakker, K., & Cook, C. 2012. “Introduction to the Themed Section: Water Governance and the Politics of Scale.” *Water Alternatives*, 5(1), 52–61.
- Pinkham, R., Jurley, E., Watkins, K., Lovins, A. B., Magliaro, J., et al. 2004. *Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques*.

- Powers, D. M. W. 2011. Evaluation: from precision, recall and F-measure to ROC, informedness, markedness & correlation. *Journal of Machine Learning Technologies*, 2(1), 37-63
- Ramirez, C. M., Abrajano, M. A., & Alvarez, R. M. (2019). *Using machine learning to uncover hidden heterogeneities in survey data*. Scientific Reports, 9, 16061.
- US-Congress. 2021a. “H.R.1319 - 117th Congress (2021-2022): American Rescue Plan Act of 2021.” Retrieved March 15, 2023 (<https://www.congress.gov/bill/117th-congress/house-bill/1319>).
- US-Congress. 2021b. “H.R.3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act.” Retrieved March 15, 2023 (<https://www.congress.gov/bill/117th-congress/house-bill/3684>).
- US-EPA. 2012. *Case Studies of Individual and Clustered (Decentralized) Wastewater Management Programs: State and Community Management Approaches*.
- US-EPA. 2005. *Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems: An Introduction to Management Tools and Information for Implementing EPA’s Management Guidelines (EPA No. 832-B-05-001)*.
- US-EPA. 1997. *Response to Congress on Use of Decentralized Wastewater Treatment Systems (EPA 832-R-97-001b)*.
- US-EPA. 2018. *Using a Responsible Management Entity (RME) to Manage Tribal Onsite (Septic) Wastewater Treatment Systems (EPA No. 830K17003)*.
- US-EPA. 2003. *Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (EPA 832-B-03-001)*.
- White, K. D., Elliott, M., and Maliniemi, B. 2020. “Wastewater Challenges in the Rural Alabama Black Belt: Technology and Management Solutions for Underserved Communities.” in *Proceedings of the Water Environment Federation*. Water Environment Federation.
- White, K. and Jones, R. 2006. *A Survey of Onsite Wastewater Systems in Bibb County, Alabama*. Montgomery, AL.
- Winkler, I. T. and Flowers, C. C. 2017. “America’s Dirty Secret”: *The Human Right to Sanitation in Alabama’s Black Belt*. Vol. 49.1.