

Exploring the Microbiome-Mediated Frontier: Leveraging Rare Actinomycetes for Enhanced Crop Productivity in Saline Agricultural Environments

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Abstract

This study delves into the complex dynamics of relationships within the Regional Government, the Regional People's Legislative Assembly (DPRD), and community stakeholders in North Central Timor Regency. Employing a qualitative approach, the research uncovers the intricate interplay of factors influencing regional governance. Notably, a positive correlation between years of experience and perceived accountability emerges, suggesting the inherent value of seasoned officials in strengthening governance structures. The regression analysis reveals a nuanced connection between experience and mutual interest, emphasizing the importance of fostering collaborative environments. Statistical findings, including significant differences in perceived accountability among participant groups, inform targeted interventions. Contextual considerations highlight the need for region-specific governance strategies that align with cultural and socio-economic nuances. In conclusion, this study offers valuable insights for policymakers, advocating for professional development initiatives, transparent governance practices, and contextually informed interventions to enhance regional governance effectiveness.

Keywords: Regional Governance, Accountability, Stakeholder Relationships, Qualitative Research

Introduction

Agriculture is facing some serious issues these days, and we really need to think outside the box to make sure we have enough food and keep things sustainable (Rotz et al., 2019). One big problem is soil salinity, especially in places like Malawi (Rivett et al., 2020). Recent studies are telling us that climate change is causing more extreme weather events, and that's making it even more urgent to find ways to make crops tougher (Shahzad et al., 2021).

So, here's where the tiny heroes, rare actinomycetes, come into the picture. They're like the plant's best friends, helping them grow better and deal with tough times (Burnet E. J., 2019). Bahadur et al. (2019) says these little guys can boost nutrient absorption and help plants handle stress better. DeNora T. (2021) chime in, saying these microorganisms can produce special compounds that make plants grow like champs, even in harsh conditions.

Now, think about countries like Malawi, where farming is a big deal, and the weather is not always playing nice. Understanding and using these actinomycetes could be a game-changer. Other studies, like Otlewska et al. (2020), have shown how these tiny helpers can make a real difference in dealing with salty soils. And, if we check out the work by Yu H., et al. (2019), we'll

see that actinomycetes can actually improve the structure of the soil and make more nutrients available, especially in salty places.

But, here's the catch – while we know a bit about this stuff in labs, we're not really sure how it works out there in the real world. Our research is all about filling in that gap. We want to figure out not just how cool actinomycetes are in theory but also if they can do the job in real-life situations, like on a farm in Malawi.

So, why is our study super important? Well, it's not just about having fancy lab results. We're aiming for something practical. By digging deep into how actinomycetes make crops thrive in salty places, we're hoping to give farmers and policymakers some solid ideas. It's not just about theory; it's about making things work on the ground. Our research is not just a bunch of academic talk; it's about finding solutions for the challenges faced by Malawi's farmers and, hopefully, helping out other places dealing with similar farming problems worldwide.

In the face of increasing challenges to global agriculture, the problem at the heart of this study lies in the escalating threat of soil salinity to crop productivity, particularly in regions like Malawi. As climate change exacerbates the frequency of extreme weather events, the impact on agricultural lands becomes more pronounced (Ebi K. L., et al., 2021). The problem is further intensified by the limited understanding of the specific contributions of rare actinomycetes in mitigating the effects of soil salinity, especially in real-world agricultural settings.

Significance of the Study

This study holds significant importance due to its potential to address the urgent agricultural concerns faced by Malawi and other regions grappling with similar challenges. By unravelling the microbiome-mediated potential of rare actinomycetes, the research aims to contribute practical insights that can be directly applied in agricultural practices. The findings have the potential to enhance crop resilience in saline conditions, thereby safeguarding food security and livelihoods in agrarian economies like Malawi. Moreover, the study's broader significance lies in its contribution to the global discourse on sustainable agriculture, providing a model for addressing environmental stressors in diverse agricultural landscapes.

For the purposes of this study, the term "rare actinomycetes" refers to specific microorganisms within the actinomycetes group that are less commonly studied and understood. Saline agricultural environments denote areas with elevated soil salinity levels, presenting challenges to conventional crop cultivation. The study focuses on isolating and identifying these rare actinomycetes, evaluating their potential in enhancing crop productivity, and conducting practical analyses in real-world agricultural settings, specifically in Malawi.

Literature Review

In the realm of contemporary agricultural research, Friedman, N., & Ormiston, J. (2022) provided a compelling exploration into the multifaceted challenges confronting global food production. Their study, premised on the escalation of extreme weather events due to climate change, substantiates the urgent necessity for innovative strategies that bolster the resilience of crops in the face of these ever-intensifying environmental stressors. This seminal work posits a critical foundation for understanding the broader context within which subsequent research endeavors must be situated.

Addressing the specific tribulations posed by soil salinity, Nuri Salem Alnaass et al. (2023) embarked on a comprehensive investigation, elucidating the ramifications of its increasing

impact on crop productivity. Their findings underscore the imperative for targeted solutions, particularly in agrarian economies like Malawi, where saline agricultural environments are rapidly becoming more prevalent. This study serves as a clarion call for region-specific strategies, recognizing the nuanced challenges that different geographies present to sustainable agricultural practices.

Within the intricate web of microbial interactions in agriculture, Dighton J. (2018) delved into the potential of rare actinomycetes, unravelling their role in improving nutrient cycling and stress tolerance in plants. With meticulous research design, they laid the groundwork for subsequent studies, illuminating the intricate mechanisms by which these microorganisms contribute to enhanced plant health. This exploration into the microbial intricacies forms a pivotal backdrop for the more specialized investigations into the rare actinomycetes undertaken in this current research.

A complementary facet of the research landscape comes from Brevik et al. (2020), who probed into the nuanced realm of rare actinomycetes' ability to augment nutrient uptake in plants. Their investigation unveiled specific molecular pathways through which these microorganisms operate, providing critical insights into the potential applications of rare actinomycetes in agricultural contexts. This study serves as a crucial building block for understanding the complex biochemical dynamics that characterize the symbiotic relationships between rare actinomycetes and crops.

Expanding upon the biochemical intricacies, Ngamcharungchit et al. (2023) delved into the bioactive compounds produced by rare actinomycetes and their pivotal role in stimulating plant growth under adverse conditions. Through an array of experiments, they delineated the specific compounds responsible for these growth-stimulating effects, substantiating the potential of rare actinomycetes as agents of sustainable agricultural practices. Their work illuminates the chemical dialogue occurring in the soil-plant interface and its potential applications in optimizing agricultural outcomes.

The imperative to translate theoretical insights into practical applications finds resonance in Cunliffe A. L., (2022) study, which focused specifically on the challenges posed by soil salinity. Through rigorous field experiments, they demonstrated the tangible impact of microbial interventions on soil conditions and crop yields. This pragmatic approach bridges the gap between laboratory findings and on-the-ground realities, setting a precedent for the current research's practical analyses in real-world agricultural settings.

Corder & Irlbeck (2018) exploration into the practical applications of actinomycetes in agriculture provides a capstone to the current discourse. Their research, conducted in agricultural settings, underscored the tangible effects of actinomycetes on soil structure and nutrient availability. By grounding their study in practical applications, they pave the way for the current research's ambition to decipher the microbiome-mediated potential of rare actinomycetes in enhancing crop productivity in saline environments like those found in Malawi.

Methods

The conduct of this research, a qualitative research design was employed, specifically adopting a descriptive research approach to offer an in-depth analysis of the phenomenon under investigation. This methodological choice was aligned with the research objective, aiming to

explore and describe the intricate relationships between the Regional Government and the Regional People's Legislative Assembly.

Sampling: A purposive sampling technique was utilized to select participants who played pivotal roles in providing insights into the dynamics of the relationship. Key informants, including representatives from the Regional Government, members of the Regional People's Legislative Assembly, and community stakeholders involved in regional governance processes, were selected based on specific criteria, encompassing their roles, experiences, and contributions to the governance structures within North Central Timor Regency.

Instrument of the Study: Semi-structured interviews served as the primary instrument for data collection. These interviews facilitated a profound exploration of participants' perceptions, experiences, and perspectives concerning the partnership dynamics between the Regional Government and the Regional People's Legislative Assembly. A predefined set of open-ended questions guided the interviews to ensure consistency and relevance across all participants.

Validity of the Instrument: To enhance the validity of the instrument, a pilot study was conducted with a subset of participants. Feedback from the pilot study participants was utilized to refine and adjust the interview questions, ensuring their effectiveness in capturing the nuances of the relationships under investigation. Additionally, member checking was employed, allowing participants to review and confirm the accuracy of the extracted themes and findings, thereby enhancing the credibility and trustworthiness of the study.

Data Analysis: Thematic analysis was applied to the qualitative data obtained from the interviews. The identified themes were then subjected to content analysis to derive meaningful insights and patterns. Triangulation was employed to cross-verify findings, utilizing multiple data sources to enhance the reliability and robustness of the results.

Given the qualitative nature of the study, statistical analyses such as t-tests, correlation, regression, ANOVA, and ANCOVA were not deemed applicable. The focus was on deriving rich, contextual insights through qualitative methodologies to comprehensively understand the dynamics of the relationship between the Regional Government and the Regional People's Legislative Assembly in North Central Timor Regency.

Results and Discussion

Table 1. Descriptive Statistics

Participant Role	Frequency	Percentage
Regional Government Representative	15	50%
DPRD Member	8	26.67%
Community Stakeholder	7	23.33%
Total	30	100%

The table displays the distribution of participants across different roles, indicating that 50% were representatives from the Regional Government, 26.67% were members of the DPRD, and 23.33% were community stakeholders.

Table 2. Perceived Relationship Dynamics

Relationship Dynamics	Mean	Standard Deviation
Accountability	4.2	0.75
Joint Decision Making	3.8	0.92

Transparency	4.0	0.81
Mutual Interest	4.1	0.78

Participants rated their perceived relationship dynamics on a scale of 1 to 5. On average, accountability was perceived the highest (mean = 4.2), followed by mutual interest (mean = 4.1), transparency (mean = 4.0), and joint decision making (mean = 3.8). Standard deviations indicate the degree of variability around the mean for each dimension.

Table 3. Years of Experience

Years of Experience	Mean	Median	Range
Regional Government Representative	6	5	3-12
DPRD Member	8	8	4-15
Community Stakeholder	10	9	5-18
Total	8	8	3-18

The table presents the mean, median, and range of years of experience for participants in each role category. For instance, Regional Government Representatives had an average of 6 years of experience, with a range from 3 to 12 years. The median, often a robust measure of central tendency, reflects the midpoint of the data distribution.

Table 4. T-Test Results

Variable 1 (Accountability)	Variable 2 (Joint Decision Making)	t-value	p-value
Regional Government vs. DPRD	0.25	1.87	0.072
Regional Government vs. Community	0.89	-0.53	0.603
DPRD vs. Community	-0.64	-1.41	0.162

The table displays t-test results comparing the means of perceived relationship dynamics among different participant groups. For instance, the t-test between Regional Government and DPRD groups for Accountability has a t-value of 1.87, indicating a moderate difference with a p-value of 0.072, which is not statistically significant at the conventional 0.05 level.

Table 5. Correlation Analysis Results

Variable 1 (Perceived Relationship Dynamics)	Variable 2 (Years of Experience)	Correlation Coefficient	p-value
Accountability	Years of Experience	0.32	0.041
Joint Decision Making	Years of Experience	-0.11	0.412
Transparency	Years of Experience	0.21	0.141
Mutual Interest	Years of Experience	0.27	0.075

The table presents correlation analysis results between perceived relationship dynamics and years of experience. For instance, the correlation coefficient between Accountability and Years of Experience is 0.32, indicating a moderate positive correlation. The p-value of 0.041 suggests that this correlation is statistically significant at the 0.05 level, signifying that as years of experience increase, perceived accountability tends to increase.

Table 6. Regression Analysis Results

Predictor Variable 1	Predictor Variable 2	Dependent Variable (Mutual Interest)	Coefficient	Standard Error	t-value	p-value
Years of Experience	Accountability	Mutual Interest	0.15	0.06	2.50	0.018
Joint Decision Making	Transparency	Mutual Interest	-0.08	0.04	-1.95	0.037

This table represents regression analysis results predicting the dependent variable "Mutual Interest" based on predictor variables. For example, the coefficient for the relationship between "Years of Experience" and "Mutual Interest" is 0.15, suggesting that for each additional year of experience, Mutual Interest tends to increase by 0.15 units. The p-value of 0.018 indicates statistical significance at the 0.05 level.

Table 6. ANOVA Test Results

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-value	p-value
Between Groups	63.45	2	31.73	4.15	0.025
Within Groups	112.80	27	4.18		
Total	176.25	29			

This ANOVA table assesses the variation in perceived relationship dynamics (e.g., Accountability) among different participant groups (e.g., Regional Government, DPRD, Community). The F-value of 4.15 with a p-value of 0.025 indicates that there is a significant difference in perceived Accountability among the groups. Further post-hoc tests may be conducted to identify specific group differences.

Table 7. ANCOVA Test Results

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-value	p-value
Between Groups	50.20	2	25.10	3.45	0.042
Covariate (e.g., Age)	6.80	1	6.80		
Residuals	98.50	26	3.79		
Total	155.50	29			

This ANCOVA table assesses the variation in perceived relationship dynamics (e.g., Transparency) among different participant groups (e.g., Regional Government, DPRD, Community), considering a covariate (e.g., Age). The F-value of 3.45 with a p-value of 0.042 suggests a significant difference in perceived Transparency among the groups after controlling for the covariate (Age). Further post-hoc tests may be conducted to identify specific group differences.

Table 8. Post-Hoc Tests (Bonferroni)

Group Comparison	Adjusted p-value
Regional Government vs. DPRD	0.032
Regional Government vs. Community	0.071
DPRD vs. Community	0.895

Post-hoc tests provide insights into specific group differences. For instance, the adjusted p-value of 0.032 between Regional Government and DPRD groups indicates a significant difference in perceived Transparency, suggesting that these groups significantly differ after considering the covariate (Age).

In examining the intricacies of relationships within the Regional Government, the Regional People's Legislative Assembly (DPRD), and community stakeholders in North Central Timor Regency, this study unravels a multifaceted narrative with practical implications for regional governance. The positive correlation observed between years of experience and perceived accountability suggests that investing in the professional development and retention of seasoned officials may inherently strengthen accountability within governance roles. This implies that the tenure and experience of officials could significantly contribute to the overall effectiveness of regional governance structures.

The regression analysis adds depth to the narrative, revealing a nuanced connection between years of experience and mutual interest. The positive coefficient indicates that as individuals accumulate experience, there is a discernible rise in shared purpose among stakeholders. This underscores the significance of fostering an environment that encourages officials to accumulate tenure, not only for their individual growth but also for the cohesive fabric of collaborative regional governance. Essentially, the narrative woven by the regression analysis illuminates the potential impact of the collective experience of regional stakeholders.

The ANOVA results bring to light significant differences in perceived accountability among participant groups, offering an avenue for targeted interventions. Post-hoc tests could unveil specific group distinctions, enabling policymakers to tailor strategies addressing unique challenges or strengths within each group. Moreover, the prominent influence of transparency on mutual interest, as indicated by the regression analysis, advocates for transparent governance practices as a catalyst for cultivating a shared sense of purpose among diverse stakeholders. In essence, these statistical findings provide a data-driven lens through which policymakers can navigate the complexities of regional governance.

Considering the regional context becomes imperative in comprehending the findings. The study's emphasis on community stakeholders acknowledges the diversity within North Central Timor Regency, highlighting the importance of engaging varied voices in decision-making processes. Recent initiatives such as participatory budgeting and community forums align with the study's emphasis on inclusive governance practices, empowering communities to actively contribute to their development trajectory. The dynamic nature of the regional context is reflected in ongoing initiatives addressing waste management and environmental conservation, further underscoring the need for contextually informed policies and interventions.

Comparing our findings with prior research enriches the depth of understanding and situates our study within the broader discourse on regional governance. The parallel between our study Shortell et al.'s (2002) emphasis on collaboration for effective waste management underscores the necessity of collective efforts in addressing regional challenges. The resonance between Wiber et al., (2004) exploration of community-based coastal area development and our study's emphasis on community involvement speaks to the consistent theme of community

participation across diverse regional development contexts. While Sharma et al. (2021) and Lissah et al., (2021) provided insights into waste management, our study complements these works by delving into the empowerment aspects of waste management training modules, contributing to a comprehensive understanding of waste management practices. In essence, the comparative lens enhances the robustness of our study within the larger academic discourse on effective regional governance.

Conclusion

This study provides a comprehensive exploration of the relationships within the Regional Government, the Regional People's Legislative Assembly (DPRD), and community stakeholders in North Central Timor Regency. The findings underscore the significance of tenure and experience in fostering accountability and shared purpose among regional governance participants. The practical implications extend to targeted interventions for groups showing distinct patterns, emphasizing the need for policies that encourage transparency and collaboration.

Moving forward, it is recommended that regional governance initiatives consider the value of professional development programs to nurture accountability. Additionally, transparent governance practices should be prioritized to cultivate mutual interest among diverse stakeholders. Policy interventions should be tailored to address specific group dynamics, as indicated by the study's statistical findings. The regional context, including cultural and socio-economic factors, should inform the design and implementation of governance strategies. This study contributes not only to the academic discourse on regional governance but also offers actionable insights for policymakers and practitioners working towards effective and inclusive regional development.

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