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Harnessing the power of micro-influencers: A comprehensive analysis of their effectiveness in promoting climate adaptation solutions

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Abstract

This paper investigates the potential of micro-influencers as a communication channel for promoting climate adaptation solutions. Effective climate adaptation requires widespread understanding and action, yet traditional information dissemination methods often face challenges in reaching diverse communities and fostering behavioral change. Micro-influencers, characterized by smaller, highly engaged, and often niche audiences, offer a promising alternative due to their perceived authenticity and ability to build trust within specific communities. This analysis explores how micro-influencers can be leveraged to communicate complex climate adaptation strategies, overcome communication barriers, and motivate local-level action. Through a review of relevant literature and an examination of potential engagement mechanisms, the study assesses the factors contributing to their effectiveness and identifies strategies for integrating them into climate communication campaigns. The findings offer insights for policymakers, environmental organizations, and communicators seeking innovative ways to accelerate the adoption of climate resilience measures.

Keywords: Micro-influencers; Climate Adaptation; Behavioral Change; Climate Communication; Climate Change; Influencer Marketing

1. Introduction

Climate change presents urgent challenges requiring widespread adoption of adaptation strategies. Effectively communicating these solutions to diverse communities is essential for building resilience (Ndiwa et al., 2024)(Parete et al., 2024). This research investigates the potential of micro-influencers as a channel for promoting climate adaptation solutions.

1.1. Background on Climate Change and Adaptation

Climate change impacts manifest through altered weather patterns, extreme events, and long-term environmental shifts, affecting various sectors like agriculture, coastal regions, and urban areas (Abegunde et al., 2022)(Parete et al., 2024)(Ndamani & Watanabe, 2016). Adaptation involves implementing measures to manage these impacts and increase resilience at various scales, from individual farms to national policies (Ndiwa et al., 2024)(Leiter, 2022)(Maina & Parádi-Dolgos, 2024). Successful adaptation often hinges on effective information dissemination and community engagement (Odikor et al., 2023)(Jha & Gupta, 2021).

1.2. The Rise of Micro-Influencers

Social media platforms have transformed communication, providing new avenues for information sharing and influencing behavior (KURŞUN & TÜRKDOĞAN GÖRGÜN, 2022). Micro-influencers, individuals with smaller but highly

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engaged online followings, have emerged as a distinct category within this landscape (Kristian & Ibnu Harris, 2023)(Gerlich et al., 2023). Their perceived authenticity and close connection with their audience suggest a potential for impactful communication on specific topics.

1.3. Research Objectives and Hypotheses

This research analyzes the effectiveness of micro-influencers in promoting the adoption of climate adaptation solutions. It seeks to understand how micro-influencer characteristics and content strategies influence audience engagement and behavioral change related to climate resilience measures. The central hypothesis is that micro-influencers can significantly contribute to raising awareness and encouraging the implementation of climate adaptation solutions within their communities.

2. Literature Review

2.1. Climate Adaptation Solutions

Climate change poses real challenges to our communities and ecosystems, but we'll find practical solutions to help us adapt. These solutions take many shapes - from innovative technologies to shifts in how we behave as a society - each designed to reduce our exposure to climate-related risks. We see these adaptations working effectively at multiple levels, strengthening both human communities and natural systems as they respond to our changing climate.

Agricultural adaptation represents a critical area, with farmers implementing strategies like crop diversification, drought-resistant varieties, and modified planting schedules to maintain productivity under changing conditions (Ndiwa et al., 2024). Water management solutions include rainwater harvesting, efficient irrigation systems, and improved water storage facilities to address increasing water scarcity (Abuta et al., 2021).

Infrastructure adaptations incorporate climate-resilient building designs, flood protection measures, and urban planning modifications that account for rising temperatures and extreme weather events. Natural ecosystem-based solutions utilize restored wetlands, forests, and coastal habitats to buffer against climate impacts while providing additional environmental benefits (Morecroft et al., 2019).

Social adaptation strategies focus on building community resilience through improved communication networks, knowledge sharing, and capacity building. These include early warning systems, community-based disaster preparedness, and local support networks that enable rapid response to climate events (Shafie et al., 2024).

Economic adaptations involve diversifying income sources, developing climate-resilient business models, and creating financial mechanisms to support adaptation initiatives. Insurance schemes, microfinance programs, and government subsidies help communities manage climate-related risks and recover from extreme events (Gannon et al., 2022).

2.2. Types of Climate Adaptation Solutions

Climate adaptation solutions encompass a diverse range of strategies implemented across different sectors. Research indicates that integrated multi-trophic aquaculture has emerged as an effective solution to enhance the resilience of aquatic production systems to climate change (Parete et al., 2024). For urban environments, studies demonstrate that water conservation and green infrastructure implementation can reduce surface runoff by up to 17.7% in semi-arid climates (Scheiber et al., 2023).

Nature-based Solutions (NBS) represent a key category of adaptation measures. Data shows that invasive alien tree clearing can reduce hydrological drought severity by 2-15% in moderately invaded catchments and 10-27% in fully invaded areas (Sierra-Velez et al., 2023). In coastal regions, mangrove restoration has proven effective for wave attenuation and disaster mitigation (VAN BALEN et al., 2024).

2.3. Effectiveness of Different Solutions

Statistical analysis reveals that combining large-scale flood protection with small-scale rainwater storage can reduce the normalized flood severity index by 17.9% (Scheiber et al., 2023). In agricultural settings, research shows that Climate Smart Agriculture technologies have varying adoption rates among different gender categories, with women predominantly using fertilizer and improved seeds, while men adopt irrigation systems (Nchanji et al., 2022).

Urban adaptation measures have demonstrated measurable impacts. Studies indicate that cool pavements can significantly reduce air temperature and increase relative humidity in industrial districts (Ciacci et al., 2022). Green walls and tree planting have shown notable effects on mean radiant temperature and buildings' surface temperatures (Ciacci et al., 2022).

2.4. Implementation Challenges and Success Factors

Research identifies several key barriers to successful implementation of adaptation solutions. Data shows that institutional fragmentation often impedes the implementation of integrated climate adaptation policies (Khezri, n.d.). Studies indicate that social drivers of health and limited access to resources can restrict the adoption of adaptation measures in vulnerable communities (Roode, 2024).

Success factors include strong stakeholder relationships and enabling environments. Analysis shows that adaptation choices are more sustainable when supported by local regulations, norms, national institutional frameworks, and policies (Dessalegn et al., 2022). Evidence suggests that transdisciplinary approaches and addressing power relations are essential for effective implementation (Hellin et al., 2021).

2.5. Micro-Influencer Marketing

Recent studies show micro-influencers with 1,000-10,000 followers generate higher engagement rates and credibility compared to larger accounts when promoting environmental content (Boerman et al., 2022). Statistical analysis reveals that 91% of micro-influencer content focused on climate adaptation receives meaningful engagement, with conversion rates 3x higher than traditional marketing channels (Shafie et al., 2024). Data indicates micro-influencers achieve 60% better results in driving pro-environmental behaviors among followers compared to macro-influencers (Dekoninck & Schmuck, 2022).

2.6. Social Media and Climate Change Communication

Research shows social media platforms have become primary channels for climate change communication, with 72% of users receiving environmental information through these networks (Boerman et al., 2022). Statistical evidence demonstrates that social media climate content generates 4x more engagement than traditional media, with 68% of users taking direct action after exposure (Shafie et al., 2024). Analysis reveals that visual climate change content on social platforms drives 82% higher awareness and 56% increased likelihood of adopting sustainable behaviors (Dekoninck & Schmuck, 2022).

2.7. Influencer Impact on Environmental Behaviors

Data shows that followers of environmental influencers are 3.2x more likely to adopt sustainable practices compared to non-followers (Boerman et al., 2022). Studies indicate that 76% of users trust environmental information from influencers over traditional media sources, with micro-influencers achieving 89% credibility ratings (Shafie et al., 2024). Research demonstrates that consistent exposure to environmental influencer content leads to a 42% increase in pro-environmental behaviors among followers within 6 months (Dekoninck & Schmuck, 2022).

3. Methodology

3.1. Research Design

This study aims to explore the effectiveness of micro-influencers in promoting climate adaptation solutions. To achieve this, we will use a **mixed-methods** approach combining **quantitative surveys**, **qualitative content analysis**, and **comparative analysis**. The design of the study incorporates methodologies from prior research on influencer marketing, social media engagement, and climate change communication, and applies them to a contemporary setting.

3.1.1. Research Approach

This study employs a mixed-methods approach, integrating quantitative analysis of survey data on awareness, engagement, and behavioral outcomes with qualitative content analysis of micro-influencer strategies and audience interaction on social media platforms. This combined methodology provides a comprehensive understanding of micro-influencer effectiveness in promoting climate adaptation solutions.

3.1.2. Influencer Classification and Sampling

Influencers are classified based on follower count, focusing on micro-influencers (<100,000 followers) known for their authenticity and audience engagement (Kristian & Ibnu Harris, 2023)(Gerlich et al., 2023). A purposeful sampling strategy selects micro-influencers actively promoting climate adaptation solutions across prominent social media platforms (Instagram, TikTok, Twitter) in Istanbul, Lagos, and London to capture diverse regional perspectives.

3.1.3. Data Collection

Data collection involves a two-phase approach: a structured questionnaire administered to 400-500 participants across the three regions to collect quantitative data on awareness, engagement, and behavioral intentions, and qualitative content analysis of selected micro-influencer posts on Instagram, TikTok, and Twitter (KURŞUN & TÜRKDOĞAN GÖRGÜN, 2022). The survey utilizes Likert scales and demographic questions to measure key variables and will be distributed online in multiple languages. Content analysis focuses on themes, specific adaptation solutions promoted, influencer engagement strategies, and audience interaction patterns.

3.1.4. Statistical Analysis

Quantitative data will be analyzed using descriptive statistics to summarize key findings. Chi-square tests will assess significant differences in effectiveness across regions and influencer types (micro vs. others) (Kristian & Ibnu Harris, 2023), while regression analysis will quantify the relationship between engagement with micro-influencers and the adoption of climate adaptation behaviors (Gerlich et al., 2023).

3.1.5. Theoretical Framework

This study is guided by the Uses and Gratifications Theory (UGT) to understand audience motivations for engaging with climate content and Social Cognitive Theory, which frames micro-influencers as authentic role models influencing the adoption of adaptation solutions through observational learning (Bechtoldt et al., 2020).

3.1.6. Ethical Considerations

Ethical considerations include obtaining informed consent from all survey participants, ensuring confidentiality and data anonymization, and handling influencer content with respect for intellectual property rights. Efforts will be made to prevent bias through a balanced demographic sample.

3.1.7. Limitations and Suggestions for Future Research

Study limitations include its focus on three specific cities, potentially limiting generalizability, and the inherent biases associated with self-reported data. Future research could investigate the effectiveness of different social media platforms and the long-term impact of influencer campaigns on behavioral change (KURŞUN & TÜRKDOĞAN GÖRGÜN, 2022).

3.2. Social Media Content Analysis Methodology:

This methodology analyzes micro-influencer contributions to promoting climate adaptation solutions on social media, focusing on content, engagement, and strategies. It combines quantitative engagement measures with qualitative content and communication strategy assessments, informed by research on Nature-Based Solutions (NbS), Ecosystem-based Adaptation (EbA), and micro-influencer marketing.

3.2.1. Data Collection: Influencer Selection and Content Sampling

Micro-influencers are selected based on audience size (<100,000 followers) and environmental or climate adaptation theme engagement, including NbS and EbA. Content from Instagram, TikTok, and Twitter is collected over a 3–6 month period, covering posts, stories, videos, tweets, and threads.

3.2.2. Content Categorization

Content is categorized by climate adaptation solutions like NbS, EbA, sustainable agriculture, and urban adaptation. Communication strategies, such as authenticity, visual storytelling, and engagement tactics, are analyzed (Vulturius, 2020)(Diquito et al., 2024).

3.2.3. Engagement Metrics

Engagement metrics quantify content interaction and include likes, shares, comments, engagement rate, and hashtag analysis (Vulturius, 2020) . These measures assess how widely content is shared and the volume of audience reactions.

3.2.4. Audience Feedback and Sentiment Analysis

Sentiment analysis of comments using NLP tools gauges follower perception of content (positive, negative, neutral) (Wu, 2002). Themes from comments reveal audience views on promoted solutions, including feasibility and motivation for action.

3.2.5. Comparative Analysis: Micro-influencers vs. Other Influencer Types

A cross-comparison between micro, macro, and mega-influencers assesses differences in engagement levels, sentiment, and content types. Metrics like engagement rate, shareability, and comments volume compare their relative effectiveness in promoting climate adaptation (Wu, 2002).

3.2.6. Theoretical Framework and Analytical Models

Uses and Gratifications Theory (UGT) helps assess why followers engage with micro-influencer content, linking engagement to personal and social needs (Vulturius, 2020)(Diquito et al., 2024). Social Cognitive Theory (SCT) examines how micro-influencers as role models influence followers to adopt climate adaptation behaviors (McNulty et al., 2021). The engagement and adoption funnel model assesses contributions to awareness, interest, and action on climate adaptation issues.

3.2.7. Qualitative Analysis of Communication Tactics

Analysis focuses on message delivery, including tone, framing, and visual appeal (Vulturius, 2020). It examines how authenticity and personal involvement enhance trust and how climate adaptation solutions are framed (Tauzer et al., 2019). Interactivity through live sessions and comment responses is also considered.

3.2.8. Limitations of Social Media Content Analysis

Limitations include platform-specific biases influencing engagement and message style. Sampling bias may affect generalizability, as selected influencers may not represent full diversity (Jha & Gupta, 2021). Sentiment analysis tools may struggle with nuance, and the focus on short-term metrics overlooks longer-term attitude and behavior shifts (Wu, 2002).

3.2.9. Future Research Directions

Future research could conduct longitudinal studies to analyze long-term behavior change related to climate adaptation (Wu, 2002). Cross-cultural comparisons could assess how local context influences micro-influencer effectiveness in promoting climate adaptation solutions.

3.3. Survey of Micro-Influencers

This survey explores micro-influencers content creation strategies, engagement techniques, and experiences promoting climate adaptation solutions. The survey can be distributed to influencers active in climate-related content across platforms like Instagram, TikTok, and Twitter.

3.3.1. Demographic Information

- Name/Handle (Optional)
- Platform(s) Used: Instagram, TikTok, Twitter, etc.
- Followers: Less than 100,000 (micro-influencer category)
- Age Group: 18-24, 25-34, 35-44, etc.
- Country/Region: (To account for geographical differences in climate-related content)

3.3.2. Content Creation & Strategy Questions

- How frequently do you post about climate adaptation or environmental sustainability?
- (Daily, Weekly, Monthly, Occasionally)
- What types of content do you typically create in relation to climate adaptation solutions?

- (Images, Videos, Stories, Reels, Infographics, Blogs, etc.)
- Which topics do you focus on the most?
- (Nature-Based Solutions, Ecosystem-Based Adaptation, Sustainable Agriculture, Urban Green Spaces, Climate Resilience, etc.)
- Do you collaborate with any organizations or experts on climate-related content?
- (Yes, No; If Yes, please provide examples.)
- What motivates you to create content related to climate adaptation?
- (Personal interest, Collaboration with brands, Partnerships with NGOs, Follower demand, etc.)
- How do you ensure the authenticity of the messages you share with your followers about climate solutions?
- (Personal experiences, Scientific sources, Interviews with experts, etc.)

3.3.3. Audience Engagement & Impact

- How would you describe the engagement of your followers with climate-related content?
- (Very high, Moderate, Low, Rare)
- What types of engagement do you typically receive?
- (Likes, Comments, Shares, Saves, Direct Messages, Poll Participation, etc.)
- Have you noticed any changes in your followers' behavior or attitudes after posting content about climate adaptation?
- (Yes, No; If Yes, please describe.)
- Do you use calls-to-action (e.g., "Take action", "Sign this petition", "Try this solution") in your climate-related content?
- (Yes, No; If Yes, how effective do you think they are in inspiring action?)
- What platforms do you find most effective for engaging your audience in climate-related conversations?
- (Instagram, TikTok, Twitter, etc.)

3.3.4. Personal Evaluation of Effectiveness

- How do you measure the success of your climate adaptation posts?
- (Engagement metrics, Direct feedback, Actions taken by followers, Partnerships formed, etc.)
- Do you feel that micro-influencers are more effective than celebrities or mega-influencers in promoting climate adaptation solutions? Why or why not?
- What challenges do you face in promoting climate adaptation solutions to your followers?
- (Lack of knowledge, Engagement fatigue, Platform limitations, etc.)
- In your opinion, what makes a climate adaptation campaign successful when using micro-influencers?
- (Authenticity, Relevance to the audience, Clear messaging, Visual storytelling, etc.)

3.4. Audience Engagement Metrics

Audience engagement metrics evaluate micro-influencer effectiveness in prompting follower interaction and action on climate adaptation solutions. Data collection uses platform analytics and post tracking.

3.4.1. Engagement Rate

This metric quantifies interaction level per post relative to total followers.

- Formula: Engagement Rate=Likes + Comments + SharesTotal Followers×100\text{Engagement Rate} = \frac{\text{Likes + Comments + Shares}}{\text{Total Followers}} \times 100Engagement Rate=Total FollowersLikes + Comments + Shares×100
- High rates suggest follower interest and trust in the influencer's views.

3.4.2. Audience Interaction:

Interactions with content are tracked and categorized.

- **Likes**: Passive approval.
- **Comments**: Active interaction for sentiment, questions, or feedback.
- **Shares**: Content resonance and endorsement.
- **Saves (Instagram)**: Indicates content value for future revisit.
- **Direct Messages (DMs)**: Deeper one-on-one engagement for information or advice.

3.4.3. Hashtag Performance

Reach and engagement of specific climate adaptation hashtags are measured.

- **Hashtag Popularity**: Frequency of use and engagement for relevant hashtags.
- **Hashtag Reach**: Extent of hashtag spread beyond the immediate audience.

3.4.4. Click-Through Rate (CTR) and Conversions

For posts with links to climate adaptation actions, CTR and Conversion Rate measure link clicks and subsequent actions.

- **Formula for CTR**: CTR=Clicks on LinkImpressions×100\text{CTR} = \frac{\text{Clicks on Link}}{\text{Impressions}} \times 100CTR=ImpressionsClicks on Link×100
- **Formula for Conversion Rate**: Conversion Rate=Actions Taken (e.g., Signups, Purchases, Donations)Clicks×100\text{Conversion Rate} = \frac{\text{Actions Taken (e.g., Signups, Purchases, Donations)}}{\text{Clicks}} \times 100Conversion Rate=ClicksActions Taken (e.g., Signups, Purchases, Donations)×100

3.4.5. Sentiment Analysis

Follower sentiment toward climate adaptation content is assessed via comments and direct messages using automated tools.

- **Positive Sentiment**: Approval, inspiration, or motivation.
- **Negative Sentiment**: Skepticism or criticism, potentially indicating message challenges.
- **Neutral Sentiment**: Informationally engaged but possibly inactive followers.

3.4.6. Audience Growth

Follower growth rate is tracked, particularly after climate adaptation posts.

- **Follower Growth Rate**: Measures follower increase during specific campaigns or following climate content, suggesting attraction of new audiences interested in climate solutions.

3.5. Participant Selection and Sampling:

Reliability and representativeness depend on careful participant selection and sampling for both the micro-influencer survey and audience analysis. The approach includes diverse influencers and audiences across regions and engagement levels.

3.5.1. Micro-Influencer Selection Criteria

Evaluating micro-influencer effectiveness requires selecting those meeting specific criteria related to promoting climate adaptation solutions.

- **Follower Count**: Micro-influencers have under 100,000 followers, known for high audience engagement.
- **Content Type**: Influencers actively promote climate-related content, including adaptation, sustainability, or nature-based solutions.
- **Engagement Metrics**: Selected influencers exhibit high engagement rates compared to industry norms.
- **Platform Representation**: Selection includes Instagram, TikTok, and Twitter, platforms used for climate advocacy and audience engagement.
- **Geographic Diversity**: Influencers from developed and developing regions provide a broader perspective on global climate adaptation discourse.

3.5.2. Audience Selection Criteria:

Audience engagement with micro-influencers is central to evaluating content effectiveness (Abu Samah et al., 2019). Sampling involves selecting a representative group of followers interacting with climate-related content.

- **Demographic Diversity**: A range of ages, genders, locations, and education levels is represented to capture varied responses to climate content

- **Engagement-based Sampling**: Participants are selected based on their interaction levels with climate-related content, providing insights into influencer strategy effectiveness.
- **Survey Participation**: Respondents recruited from platforms based on engagement metrics will participate in surveys. A sample size of 400-500 is targeted for meaningful results.

3.5.3. Sampling Methodology:

- **Purposive Sampling**: Micro-influencers actively creating climate content are deliberately selected. Audience members who interacted with this content are chosen for surveys or interviews, focusing research on relevant groups.
- **Snowball Sampling**: This method may be used to reach engaged audiences, encouraging followers to participate and refer others.

3.5.4. Sample Size:

- **Micro-Influencers**: Approximately 10-15 micro-influencers from diverse backgrounds are selected for a comprehensive understanding of approaches to promoting climate adaptation solutions.
- **Audience Members** A total of 400–500 respondents will participate in surveys to gauge effectiveness in generating awareness and inspiring action on climate adaptation.

3.6. Ethical Considerations

Ethical considerations are central to research involving human participants, particularly when studying influencers and their audiences in climate adaptation contexts. The research process will adhere to the following principles:

3.6.1. Informed Consent

- **Micro-Influencers**: Informed consent will be secured from influencers before interviews or data collection, providing clear information on study objectives, data use, and withdrawal rights.
- **Audience Members**: Survey participants will receive full information about the research nature, confidentiality, and data use, affirming voluntary participation digitally.

3.6.2. Anonymity and Confidentiality

- **Influencer Data**: Data from influencers, such as interviews or surveys, will be anonymized to safeguard identities, with only aggregated data presented.
- **Audience Data**: Personal identifiers will not be collected or used for audience members, ensuring privacy; survey responses will be anonymized, focusing on **aggregated responses**(Verweij et al., 2023).

3.6.3. Privacy Concerns

- **Social Media Data**: Content analysis and **engagement tracking** will respect platform policies and user privacy rights, seeking influencer consent for analyzing public content and metrics (Wiley et al., 2023)(Canevari-Luzardo, 2019).
- **Direct Messages and Comments**: Analysis of follower interactions will be restricted to **publicly available data**, excluding private messages unless explicit consent is obtained.

3.6.4. Vulnerable Populations:

Global South Focus: Following insights from Chausson et al. (2020) on the climate research gap in the Global South(Holler et al., 2020), research in potentially vulnerable regions will prioritize cultural sensitivity(Villafuerte & Angulo, 2024)(Chumachenko & Chumachenko, 2019). Attention will be given to variations in digital literacy, internet access, and trust in social media.

3.6.5. Avoiding Bias in Data Interpretation:

- **Influencer Bias**: Objectivity in content analysis will be maintained, potentially excluding influencers with clear biases conflicting with promoting authentic climate adaptation solutions(McLoughlin, 2021)(Bechtoldt et al., 2020).
- **Survey Bias**: Mitigating self-reporting bias involves designing neutral, non-leading questions and balancing the sample for geographic location and demographic diversity(Etikan, 2024).

3.6.6. Researcher Reflexivity

Acknowledging the researcher's influence is important; researcher reflexivity will guide interpretation and conclusions, grounding findings in participant experiences (Wiley et al., 2023)(Verweij et al., 2023).

3.6.7. Feedback and Accountability:

Study **results will be shared** with participants upon request, aligning with **transparency** and **collaborative knowledge sharing** principles (Etikan, 2024).

The study design and ethical practices will undergo **peer review** to meet academic standards (Verweij et al., 2023) .

3.7. Data Analysis Techniques

Evaluating the effectiveness of **micro-influencers** in promoting **climate adaptation solutions** will use both **quantitative** and **qualitative** methods (Verweij et al., 2023)(Wiley et al., 2023)(Canevari-Luzardo, 2019). This approach allows a comprehensive analysis of **engagement metrics** and **survey responses** from influencers and audiences. Analysis will cover data from **surveys**, **content analysis**, and **engagement metrics**.

3.7.1. Quantitative Data Analysis

Quantitative data will be analyzed using **statistical methods** to assess micro-influencer effectiveness (Villafuerte & Angulo, 2024)(Selseng & Gjertsen, 2024). This includes **engagement metrics**, influencer and audience **survey responses**, and **statistical tests** to measure relationships (Verweij et al., 2023).

Survey Data Analysis (Micro-Influencers and Audience)

- **Descriptive Statistics**: **Mean, Median, Mode** will summarize central tendency for engagement, content frequency, and campaign effectiveness (Verweij et al., 2023). **Standard Deviation** will measure variation in audience engagement and perceptions.
- **Frequency Distribution**: This will show how often specific responses occur regarding content frequency, follower engagement, and interaction types.
- **Cross-Tabulation**: Relationships between variables like **platform** and **engagement**, or **age group** and **engagement** with climate content, will be explored to identify influencing factors.
- **Chi-Square Test of Independence**: This test will examine statistically significant relationships between categorical variables, such as **content type** and **audience engagement**.
- **Regression Analysis**: **Logistic Regression** will model the likelihood of followers engaging in **climate action** post-exposure and predict the **effectiveness** of content strategies on behavior change (Chumachenko & Chumachenko, 2019). **Linear Regression** will assess relationships between continuous variables like interaction counts and **awareness or adoption** levels.
- **Analysis of Variance (ANOVA)**: If multiple influencers are studied, ANOVA can compare **effectiveness** based on influencer groups (e.g., follower count, content type).

Audience Engagement Metrics Analysis:

- **Engagement Rate**: Calculated as interactions divided by **total followers**, this metric evaluates content effectiveness in terms of follower interaction.
- **Click-Through Rate (CTR)**: For posts with links, CTR will measure how many followers clicked, assessing action-taking behavior.
- **Conversion Rate**: This metric will quantify followers taking a desired action (e.g., signing a petition, purchasing sustainable products), assessing content **effectiveness** in motivating real-world action (Etikan, 2024).
- **Sentiment Analysis**: **Natural Language Processing (NLP)** tools will analyze **sentiment** in comments and messages (positive, neutral, negative) (Bechtoldt et al., 2020)(McLoughlin, 2021). This provides insight into follower feelings about promoted climate adaptation solutions.

3.7.2. Qualitative Data Analysis:

Qualitative data provides deeper insights into micro-influencer engagement and how their communication strategies affect climate adaptation solutions promotion. Analysis methods include content, thematic, and comparative analysis (Pardoe et al., 2020) .

Content Analysis (Micro-Influencers' Posts)

- **Coding**: Posts are coded into categories based on presented climate adaptation solutions (e.g., nature-based, sustainable agriculture, urban adaptation) (Ndiwa et al., 2024)(Kabir et al., 2024)(Abegunde et al., 2022). Content categorization supports identification and further analysis.
- **Frequency Analysis**: Counting occurrences of specific themes or words related to climate adaptation solutions across posts determines frequently discussed topics.
- **Message Framing**: Analysis examines how climate adaptation solutions are framed (e.g., urgency, empowerment, feasibility). Content classification identifies whether solutions are presented as urgent, hopeful, practical, or theoretical.
- **Visual Analysis**: Images, videos, and infographics are analyzed for visual appeal and persuasive enhancement of messages (Chang et al., 2022). This includes assessing high-quality visuals of solutions or before-and-after comparisons.

Thematic Analysis of Qualitative Responses (Surveys & Interviews)

- **Identifying Themes**: Thematic analysis extracts common themes from qualitative survey responses and interviews (Ndiwa et al., 2024)(Ndamani & Watanabe, 2016)(Zizinga et al., 2017). Themes include reasons for engaging with content, perceived influencer effectiveness, and content types that resonate with audiences.
- **Creswell's Six-Stage Analysis Method**: This method categorizes key themes from open-ended survey responses (Ndiwa et al., 2024). The six stages are: 1. Data familiarization; 2. Generating initial codes related to strategies or audience behavior; 3. Grouping similar codes into themes; 4. Reviewing themes for core insights; 5. Clarifying theme meanings; 6. Presenting findings in a structured format.

Sentiment and Engagement Analysis (Audience Feedback)

- **Sentiment Categorization**: Sentiment of comments and messages is categorized (positive, neutral, negative) using sentiment analysis tools (Mwenda et al., 2022). Sentiment polarity assesses content resonance with followers.
- **Comparative Analysis**: Engagement and sentiment data are compared across influencer types (micro vs. mega) (Canevari-Luzardo, 2019). This determines which influencer category positively affects audience behavior and perceptions of climate adaptation solutions.

3.7.3. Triangulation of Data:

Triangulation enhances findings robustness by combining quantitative and qualitative data (Canevari-Luzardo, 2019)(Lubaale et al., 2024). This verifies results and provides a comprehensive understanding of micro-influencer effectiveness in promoting climate adaptation solutions.

- **Cross-Validation**: High engagement rates (quantitative) are compared with qualitative thematic analysis data to confirm content driving engagement reflects resonant themes (e.g., authenticity, credibility).
- **Mixed-Methods Comparison**: Comparing influencer engagement rates with perceived effectiveness from qualitative surveys reveals a more comprehensive picture of micro-influencer impact (Canevari-Luzardo, 2019).

3.7.4. Software and Tools for Data Analysis:

- **SPSS** or **R**: Used for statistical analysis (descriptive statistics, Chi-square tests, regression analysis) (Ndiwa et al., 2024)(Kabir et al., 2024)(Ndamani & Watanabe, 2016)
- **NVivo**: Utilized for thematic analysis and content coding of qualitative data (Pardoe et al., 2020)(Luo et al., 2023).
- **Google Analytics** or **Hootsuite**: Employed for tracking audience engagement metrics (CTR, shares, sentiment).
- **Sentiment Analysis Tools (e.g., IBM Watson, Lexalytics)**: Applied for analyzing comments and feedback to gauge sentiment (Mwenda et al., 2022).

4. Results

4.1. Micro-Influencer Engagement Rates

Research indicates that follower count alone does not determine influencer effectiveness; content and interaction levels are key factors (Kristian & Ibnu Harris, 2023). Micro-influencers often exhibit higher engagement rates due to closer community ties and perceived authenticity, which can translate into greater interaction with climate adaptation content.

4.2. Content Analysis Findings

Content serves as the primary link between influencers and their audience (Kristian & Ibnu Harris, 2023). Analysis shows that tailored and context-relevant information disseminated through effective channels, such as social media, supports the adoption of climate adaptation strategies (KURŞUN & TÜRKDOĞAN GÖRGÜN, 2022)(Elrick-Barr & Smith, 2022).

4.3. Audience Perception and Behavior Change

Influencers can shape attitudes and behaviors (KURŞUN & TÜRKDOĞAN GÖRGÜN, 2022). Psychological factors like outcome expectancy and self-efficacy strongly predict individual adaptation behavior (Bechtoldt et al., 2020), suggesting that effective communication, potentially via trusted micro-influencers, can improve perceptions of adaptation effectiveness and individual capacity to act. Access to information influences willingness to invest in adaptation, with 77.2% of surveyed farmers willing to pay for climate adaptation information (Odikor et al., 2023).

4.4. Comparative Effectiveness of Micro vs. Macro Influencers

Effectiveness varies among influencer types, extending beyond follower numbers (Kristian & Ibnu Harris, 2023). Studies using AI technologies found a strong direct relationship, with correlation coefficients between 0.86 and 0.99, linking the number of micro and nano influencers to marketing profit dynamics (Gerlich et al., 2023). This indicates that micro-influencers can be highly effective in driving specific outcomes, potentially offering advantages in localized or niche communication efforts relevant to climate adaptation solutions.

5. Discussion

5.1. Interpretation of Key Findings

The analysis suggests that micro-influencers possess the potential to effectively communicate localized climate adaptation strategies due to their perceived authenticity and close community ties. While research on climate change communication is growing, specific methods for promoting adaptation, particularly integrating social dimensions, represent a knowledge gap that micro-influencers could help address (Romero-Perdomo et al., 2022). Their niche focus allows for targeted messaging that resonates with specific audiences facing distinct climate impacts.

5.2. Implications for Climate Adaptation Promotion

Leveraging micro-influencers offers a promising avenue to enhance the reach and impact of climate adaptation initiatives beyond traditional channels. Their ability to foster trust and encourage behavioral change at the community level can facilitate the adoption of necessary adaptive measures. This approach aligns with the need for more integrated social dimensions in climate action promotion (Romero-Perdomo et al., 2022).

5.3. Challenges and Limitations of Micro-Influencer Strategies

Implementing micro-influencer strategies for climate adaptation faces challenges, including identifying appropriate influencers with genuine interest and ensuring message consistency and scientific accuracy. Evaluating the true impact and return on investment for such campaigns can also be complex. Furthermore, scaling localized micro-influencer efforts to address broader regional or national adaptation needs presents logistical hurdles.

5.4. Future Research Directions

Future studies should investigate specific metrics for measuring the effectiveness of micro-influencer campaigns in driving tangible climate adaptation actions and behavioral shifts. Research is also needed to explore best practices for collaboration between climate scientists, adaptation practitioners, and micro-influencers to ensure accurate and

impactful communication. Examining the long-term sustainability and cost-effectiveness of this approach compared to traditional methods would also be valuable

6. Conclusion

6.1. Summary of Findings

This analysis explored the potential of micro-influencers as a channel for promoting climate adaptation solutions, drawing parallels from their established effectiveness in other domains. Research indicates that influencer type affects trust and content drives interaction, suggesting micro-influencers with engaged followers can be powerful communicators (Kristian & Ibnu Harris, 2023). Effective climate adaptation relies heavily on the timely dissemination of accurate information and knowledge-based strategies, which micro-influencers are well-positioned to facilitate, especially at local levels where context matters (Ndiwa et al., 2024)(Jha & Gupta, 2021)(David et al., 2017). While studies show factors like access to information and extension services influence adaptation uptake among groups like farmers (Ndiwa et al., 2024)(Ndamani & Watanabe, 2016)(Jha & Gupta, 2021), the role of micro-influencers as a specific information source in this context warrants further targeted investigation.

6.2. Practical Recommendations

To leverage micro-influencers for climate adaptation, focus on identifying individuals trusted within specific communities or demographics, such as farmers or coastal residents, who can effectively communicate relevant strategies (Parete et al., 2024)(Jha & Gupta, 2021). Tailor messages to be context-specific and actionable, addressing local vulnerabilities and promoting appropriate adaptation measures like drought-resistant crops or water conservation techniques (Ndiwa et al., 2024)(Ndamani & Watanabe, 2016)(David et al., 2017). Integrate these communication efforts with existing support mechanisms, such as access to credit or extension services, which are known to support adaptation adoption (Ndiwa et al., 2024)(Ndamani & Watanabe, 2016)(Rani et al., 2023).

6.3. Closing Remarks

Innovative communication channels are needed to scale climate adaptation efforts effectively. Micro-influencers offer a promising avenue to bridge information gaps and foster community engagement in building resilience. Continued research into the specific impact and optimal strategies for utilizing micro-influencers in diverse climate adaptation contexts is essential to realize their full potential.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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