Article

Harnessing Social Media for Climate Action in Developing Countries: A Case Study of Egypt

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Abstract: Like many developing nations, Egypt is facing a climate crisis due to its agricultural dependence and the Nile Delta's vulnerability. Despite government plans for sustainable development, recent infrastructure projects have resulted in large-scale green space removal. Effective communication about environmental issues can spark pro-environmental behavior and citizen activism. This study explores social media's potential to bridge this gap in Egypt. Utilizing Facebook AB testing with a limited budget, we reached a significant 2.3% of Egypt's online population (nearly 2 million users). This study explored message framing, with findings showing that rational posts resonated best while fear appeals had minimal impact. Social media's cost-effectiveness and message-framing consideration provide a strategic approach for NGOs to reach a large audience and encourage climate action in Egypt.

Keywords: climate change; sustainability; communication appeals; Facebook advertising; pro-environmental behavior; non-governmental organizations; climate action

1. Introduction

Climate change poses a significant threat, particularly to developing nations. While international conferences like COP26 (Conference of the Parties) [1] in 2021 addressed climate mitigation strategies (e.g., emissions targets, renewable energy) [2], the challenge lies in effective communication and instigating behavioral change. This research explores the potential of digital solutions for promoting a circular economy and sustainability in developing countries, using Egypt as a case study. The African continent, which is heavily reliant on agriculture, faces a disproportionate impact from climate change. Egypt's Nile Delta is a prime example, identified by the Intergovernmental Panel on Climate Change (IPCC) as highly vulnerable [3]. Selwin Hart, Special Adviser to the UN Secretary-General, highlighted the disproportionate impact of global warming on Africa, particularly in terms of its adverse effects on agriculture [4]. Schilling et al. [5,6] projected that Egypt, Morocco, Tunisia, and Algeria are expected to experience severe temperature increases, leading to drought and water shortages. In the same vein, Driouech et al. [7,8] anticipated extreme climate changes in the MENA region. Hamelin and Nwankwo [9,10] showed that reduced precipitation and increased temperature in Morocco are the main drivers of the decline of the cedar forest. On a national level, Egypt, like many other countries, is significantly affected by climate change, experiencing increased temperatures, changes in rainfall patterns leading to more extreme weather events, rising sea levels threatening its crucial Nile Delta, and land degradation that reduces its agricultural capacity [11–13]. This was recently confirmed by Abuzaid and Abdelatif [14], who conducted research using satellite imagery on the north Nile Delta region of Egypt, covering an area of 8607.13 km^2. Their findings reveal that 72% of the area can be classified as critically sensitive to desertification, with 70% being highly critical and 2% moderately critical. Egypt's population growth (109.3 million

in 2022) is another critical concern leading to the country facing a severe water shortage, with a deficit of about 20 BCM [15].

Extensive research conducted on climate change in developed nations has established a solid foundation of knowledge and understanding [12–17], enabling the development of broader and more comprehensive communication strategies that target a wider range of audiences and issues. In contrast, developing countries often face limitations in resources, infrastructure, and competing priorities, resulting in less research, a lack of understanding regarding climate change [12], and, consequently, reduced communication on climate change and its issues. Given these circumstances, there is a clear need for more targeted communication strategies, specifically for strategies that tailor messages, methods, and channels to reach specific audiences and address the unique challenges associated with combating climate change [12].

In developing countries, non-governmental organizations (NGOs) frequently spearhead efforts to raise awareness about climate change, particularly in the absence of substantial government initiatives [6–8]. Recent empirical research conducted worldwide underscored the fundamental role of environmental non-governmental organizations (eNGOs) in climate communication. These organizations play a crucial role in raising awareness and conducting educational campaigns to address climate change [18]. Digital solutions present a promising opportunity to enhance their outreach and influence by leveraging the high social media usage among young people in these regions [6–8]. Research shows that social media is a primary source of information for youth in both developed and developing countries, with people in poorer countries being just as likely to use it for news as those in wealthier nations [19]. This trend extends to news about climate change, as evidenced by the global movement spearheaded by Greta Thunberg [20]. Beginning in 2018, young people worldwide engaged in protest activities organized through social media, advocating for government action on climate change [20].

Developing countries often face challenges in raising environmental awareness and promoting sustainable practices due to limited resources [21]. Digital tools offer a promising solution, reaching a vast number of people at a generally low cost compared to traditional methods [20]. This empowers NGOs to maximize their impact on a tight budget. This study investigates not only what emotional framing works best within social media messaging for fostering engagement and pro-environmental behavior (PEB) amongst the Egyptian public concerning climate change but also what a limited budget can achieve in terms of reach. Employing Facebook A/B testing as the primary metric for engagement, the study conducts a comparative analysis to evaluate the effectiveness of messages utilizing hope, fear, or a rational appeal in raising awareness and promoting sustainable practices. By analyzing how message framing influences user engagement on a cost-effective platform like Facebook, this research can provide valuable insights for NGOs seeking to maximize their outreach and impact with limited resources.

2. Local and Global Initiatives Relating to Climate Change in Egypt

In recent years, Egypt has launched a significant tree-planting initiative in regions like Giza, Alexandria, and the Nile Delta, supported by both governmental and non-governmental institutions, including the Egyptian Ministry of Environment [4]. One such NGO, "Greenish," founded in 2017, has actively promoted environmental awareness, particularly regarding climate change, through its events and workshops [22,23]. Egypt's commitment to addressing climate change is evident from its bid to host the 27th Climate Change Conference, subsequently confirmed in November 2021 [24,25].

NGOs have emerged as key players in raising climate change awareness and are often more effective than governments due to their agility and ability to leverage resources efficiently. In developing countries, where traditional media coverage of climate change has been limited [26], NGOs have emerged as a crucial force in raising public awareness, leveraging social media as a key tool [27,28]. Their primary objective is to educate the public about the challenges posed by climate change [29]. To achieve this, NGOs have adopted

various communication strategies, including collaborating with governments, publishing educational content, and launching social media campaigns [29–31]. These efforts often involve highlighting the consequences of climate change, advocating for policy changes, and empowering individuals to take action [32]. Studies by Vu et al. [33] and Takahashi et al. [32] explore how NGOs tailor their messaging strategies to different audiences. For instance, NGOs in China focus on daily life impacts, while those in Africa emphasize agricultural and economic consequences [34,35]. The importance of cultural sensitivity in messaging is underscored by research in Tanzania and the Philippines [36,37]. NGOs in these regions must navigate cultural beliefs to effectively communicate climate risks through social media. Individuals' education levels, cultural backgrounds, and personal experiences all influence their understanding of climate change messages [38,39]. This highlights the critical role of media in providing clear and engaging information [40,41].

NGOs have traditionally favored social media platforms like Twitter for climate change communication due to their cost-effectiveness. This allows them to tailor messaging strategies to resonate with different audiences, considering cultural beliefs and individual backgrounds [27,28,32,33]. However, research on social media's effectiveness in influencing green behavior remains limited [42,43]. This limitation stems from the fact that much of the existing research on climate change attitudes has primarily focused on Western countries [44,45]. As a result, there is a gap in understanding how individualistic differences within populations of the MENA region influence their response to social media's green messages. This highlights the need for further exploration in this area.

3. Materials and Methods

Understanding how individuals respond to different messaging strategies is crucial for effectively communicating the urgency of climate change. To initiate this process, the awareness of climate change among Egyptians will be evaluated using big data. The Internet has significantly expanded communication avenues for governments and NGOs, allowing for cost-effective and widespread engagement with the public [46,47]. Monitoring public interest in climate change can be accomplished by analyzing online search behavior through tools like Google Trends, which tracks the popularity of search queries over time and location [48]. Google Trends anonymizes and aggregates search data, providing insights into the relative search interest for specific keywords or topics. The first phase of the study involves analyzing the search trends for "sustainability" and "climate change" in Egypt and the USA from March 2019 to March 2024, aiming to gauge the level of interest in climate change among both populations.

In the next phase, a field experiment will be conducted using Facebook AB testing to assess the effectiveness of different advertising appeals in promoting climate change awareness. While business researchers often resort to controlled laboratory experiments for their high internal validity, these settings can suffer from artificiality, data contamination, and a disconnect between the study and real-world management concerns [49,50]. Field experiments address these limitations but traditionally demand significant time and resources. In this context, a field experiment involves testing an intervention (the ad appeals) in a real-world setting, such as the Facebook platform. This approach ensures results are more generalizable to real-world social media use, as opposed to a controlled lab environment. Although controlled laboratory experiments boast high internal validity (confidence in the cause-and-effect relationship) [51], their artificiality and potential for data contamination often limit their generalizability to real-world scenarios [49]. Field experiments mitigate this by testing interventions within an authentic environment, mimicking actual user behavior. In this study, the Facebook platform serves as our real-world setting, providing a more ecologically valid assessment of user responses to climate change messaging [50]. Facebook AB testing bridges this gap by furnishing an alternative online field setting that is both ecologically valid and allows for testing manipulated variables within user-facing stimuli (like ads) [49]. This method enables advertisers to assess different ad creatives, audiences, or placements to determine which approach yields better engagement or conversion rates.

User engagement, measured by the number of clicks, reactions, comments, and shares, serves as the primary metric. Facebook AB testing was selected for its suitability in this study due to several reasons: it eliminates algorithm optimization bias, provides a natural online field setting where participants are unaware of the variables being tested, minimizes bias since the target population is randomly assigned, eliminates hidden incentives or risks of cheating, provides a highly representative and externally valid sample that can be generalized to the population, and ensures even splits and comparable statistics among different versions of the measured variable [50,51].

To ensure a strategic and cost-effective approach, we considered findings from Raudeliūnienė et al. regarding social media advertising campaign budgets and evaluation timeframes [52]. While their study indicates a typical expert spends over €1000 (approximately $1178 USD), our primary goals were to optimize ad creatives through AB testing and test the feasibility of large-scale brand awareness with a limited budget. Therefore, a budget of $500 allows for a focused exploration of different ad approaches within Facebook's AB testing functionality. This aligns with the 8% of experts who allocate similar budgets to optimize ad creatives [52]. Raudeliūnienė et al. study also suggests that most experts require 2–3 workdays to assess campaign effectiveness [52]. Given our AB testing focus, a campaign duration was planned to be under 15 days, which falls within this timeframe, enabling sufficient data collection to analyze user engagement metrics (clicks, reactions, comments, shares) and determine the most effective ad appeals. Extending the campaign beyond this period might not yield significantly more insights while incurring additional costs.

At the campaign level, a single campaign was established through Facebook Ads Manager, comprising three ad sets. The campaign's objective, set to "reach" within the campaign settings, aligns with the initial stage of Facebook promotional efforts, denoted as "awareness." Given the study's focus on fostering awareness regarding climate change through persuasive social media communication, the most suitable objective was deemed to be "awareness." This selection instructs Facebook to optimize campaign performance to maximize exposure to as many individuals as possible within the target audience, specifically targeting Facebook users in Egypt to analyze their responses to the study's advertisements (Appendix A, Table A1).

At the ad set level, three ad sets were created with identical settings across all parameters. These settings encompassed the daily budget ($10 per ad set), duration (13 days from October 31st to November 12th), age range (18–45 years), gender (males and females), language (all languages), geographical location (Egypt), and educational level (including various options such as in college, college graduate, etc., from specified universities). Ad placement was configured to include multiple Facebook placements, such as News Feed, Videos Feed, Facebook Marketplace, etc. The study aimed to reach a general population in Egypt to broaden awareness while applying specific targeting parameters. These parameters included age targeting (18–45 years) to encompass millennials and Gen Z, known for their high social media activity, gender and language inclusion to maximize reach within the chosen age bracket, and an additional layer of targeting focusing on education level. Users with college or university education (including graduates and current students) were prioritized to improve data quality, ensure content comprehension, and optimize budget allocation. This educational filter aimed to enhance data quality, ensure user understanding of the ad content, and effectively allocate a fixed budget to reach a qualified audience.

Summary of Targeting and Reach

The AB test ran for 13 days (October 31st–November 12th) with a daily budget of $10 per ad set, resulting in a total campaign budget of $30. Based on Facebook's estimates with these targeting settings, the potential audience size ranged from 12 to 15 million users, with each ad set reaching between 48,000 and 139,000 people daily.

A Facebook page was set up with a description of the study, a consent debriefing, a contact email, and appropriate content relevant to promoting climate change mitigation. Both unique clicks and link clicks were then monitored. Unique click accounts for each

distinct individual clicking on the ad, regardless of repetition, while link clicks specifically measure clicks that lead to the designated link within the ad.

Ad Creative Design: The experiment utilized three distinct ad creatives, each targeting a different emotional response: fear, hope, and rationality.

Fear Appeal: This ad aimed to evoke feelings of loss, threat, and damage through the portrayal of a degraded landscape. Text incorporated words associated with negativity according to Ali et al. [53], such as "loss", "fear", and "damage" (translated into Arabic for the target audience) (Figure 1).
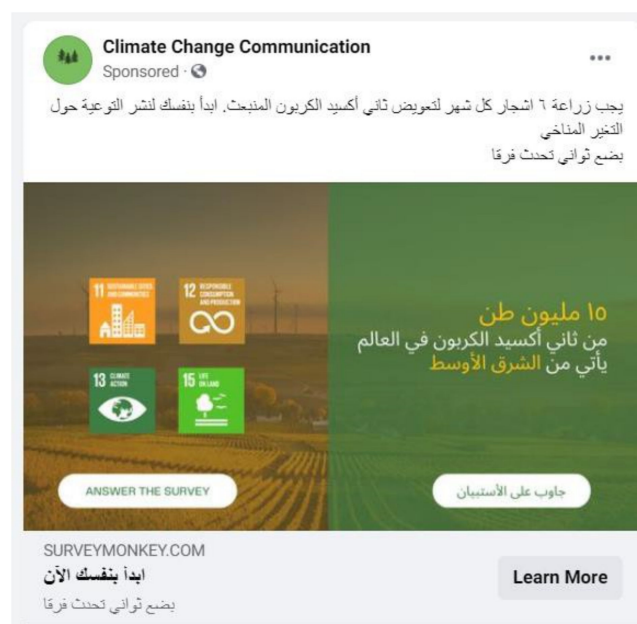

Figure 1. Facebook Fear Appeal ad. English Translation: Ad copy (Above the image): Isn't it alarming? We cannot abandon trees anymore. There is no planet B. Help us reduce climate change effects. Participate now and start with yourself to mitigate climate change. Text in the image (Right end Side): You will miss it when it is gone.

Hope Appeal: This ad featured a smiling child to evoke optimism and a sense of the future. Text employed words linked to positivity in the Ali et al. [53] study, including "hope" and "compassion" (translated into Arabic) (Figure 2).
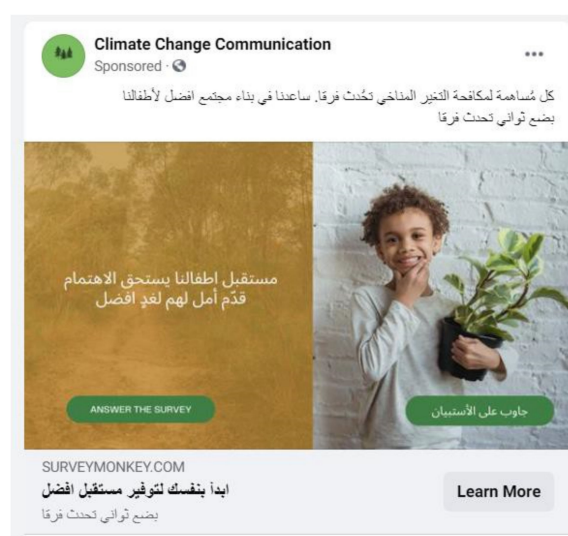
Figure 2. Facebook Hope Appeal ad. English Translation: Text in the image (Left end Side): Your children's future is worth it. Provide them hope for a better future. Ad copy (Above the image): Every contribution to mitigating climate change makes a difference. Help us build a better community for a better future. Participate now and start with yourself to spread awareness. It will only take a few seconds.

Rational Appeal: This ad presented information and statistics about climate change using neutral colors and landscapes to avoid triggering emotional responses (Figure 3).

Figure 3. Facebook Rational Appeal ad. English Translation: Text in the image (Right end Side): 15 M. tonnes of world CO_2 emissions come from the Middle East. Ad copy (Above the image): It demands planting 6 trees every month to balance out CO_2 emissions. Participate now and start with yourself to spread awareness. It will only take a few seconds.

Pilot-Testing and Manipulation Check: To ensure the effectiveness and clarity of the ad creatives, a pilot test was conducted with approximately 30 participants. Feedback was collected through face-to-face meetings, online discussions, or phone calls. During the pilot testing phase, participants were exposed to all six versions of the ads, featuring two variations for each appeal: fear, hope, and rational. The participants were then divided into two groups for the manipulation check:

Group 1: Favorite Ad Selection: Participants selected their preferred ad (the one they were most likely to click on) and indicated their perceived emotional response (fearful, hopeful, or rational) to the message. They subsequently completed a survey based on their chosen ad, which included the following questions to address two main areas: (1) Clarity and Emotional Response: Did participants understand the ad's message and feel the intended emotion (fear, hope, or rational)? (2) Ad Preference and Engagement: Which ad did they prefer and why, providing insights into what elements might resonate best with the target audience?

- What emotional response did you perceive from the chosen ad (fearful, hopeful, rational)?
- Do you find the message of the ad compelling?
- Are there any improvements you would suggest for the chosen ad?

Group 2: Appeal Recognition: This group focused on identifying the intended emotional appeal of each ad (fear, hope, or rational) by answering specific questions regarding their perceptions of the ads' messaging, design, and emotional impact, including:

- Do you find the message fearful, hopeful, or objective?
- Does the text complement the design?
- Do you like the artwork and characters in the ads, and how do they make you feel?

Based on the feedback from both groups, three ad designs (one for each appeal) were chosen for the main Facebook experiment. These selections reflected designs that participants consistently identified as clearly portraying the intended fear, hope, or rational appeal. Following the pilot test, minor adjustments were made to the chosen ads based on participant comments. These adjustments included modifying the background color for fear appeal ads to be less bright, decreasing the background image opacity for rational appeal ads to improve clarity, and adding keywords explicitly addressing climate change mitigation to the text of all ad appeals.

4. Results

4.1. Climate Change Awareness in Egypt vs. the United States

The analysis revealed a significant positive correlation (B = 0.0195, SE = 0.0016, $p < 0.001$) between search interest for "sustainability" and time in Egypt. This indicates a steady increase in public awareness of sustainability issues over the past five years. The model explained approximately 36% of the variance in search interest for sustainability in Egypt. Similarly, the USA showed a significant positive correlation (B = 0.0156, SE = 0.0013, $p < 0.001$) between search interest for "sustainability" and time, with the model explaining 35% of the variance. These findings suggest a growing public recognition of the importance of sustainability in both countries.

However, the analysis of "climate change" search trends revealed a difference between the two countries. In Egypt, a significant positive correlation (B = 0.0014, SE = 0.0002, $p < 0.001$) was found between search interest and time, indicating an increase in searches for "climate change" as time progressed. This suggests a notable rise in climate change awareness among Egyptians during the study period. Conversely, the relationship between search interest for "climate change" and time in the USA was not statistically significant (B = −0.0002, SE = 0.0001, $p = 0.057$). This implies a lack of a clear upward or downward trend in American search behavior related to climate change over the past five years. This analysis of Google Trends data suggests a growing public concern for both sustainability and climate change in Egypt. The USA, however, showed a rising interest in sustainability but lacked a clear trend in climate change search behavior. These findings illustrated in Figure 4 (e.g., B = 0.0195, SE = 0.0016, $p < 0.001$ for sustainability in Egypt) are valuable insights about public awareness of environmental challenges.
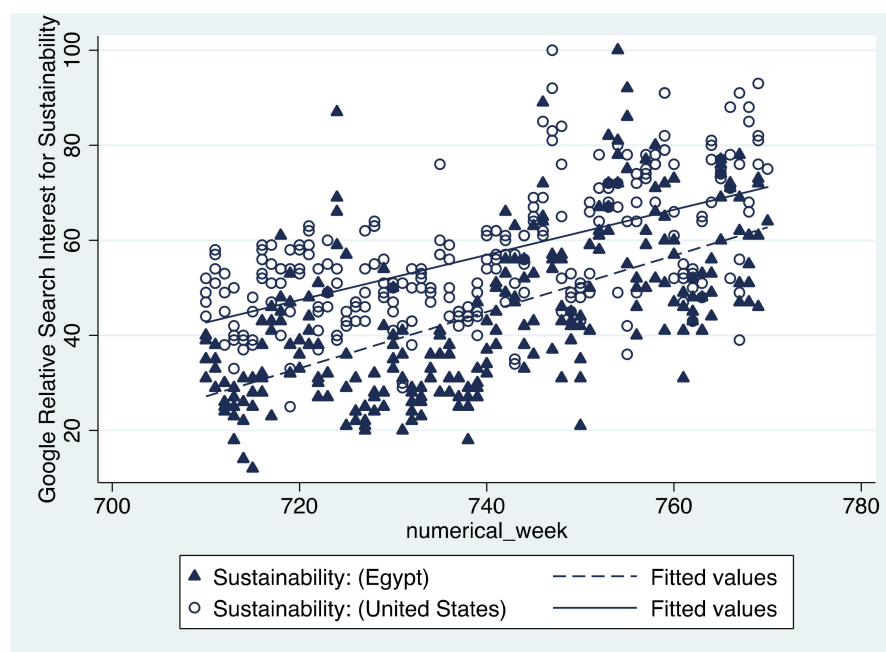

Figure 4. Google Trends Analysis–Egypt.

4.2. Demographic Analysis of Facebook Climate Change Ads

Summary of Facebook Climate Change Awareness Campaign Results (Table 1): The campaign, with a budget of $377 evenly divided among three ad variations, reached a total of 1,825,893 users. The hope appeal ad predominantly reached men, comprising 60% of its audience, and focused on users aged 18–24 and 25–34, with 18% and 23% representation, respectively. Similarly, the fear appeal ad reached a significant portion of men, around 390,000 users, with a concentration in the age groups of 25–34 and 35–44. Conversely, the rational appeal ad had slightly more balanced gender representation and targeted users across various age groups, with notable engagement from individuals aged 18–24 and 25–34.

Table 1. Summary of Facebook demographic distribution for the Climate Change Awareness Campaign.

Ad Variation	Total Users Reached	Men Reached	Women Reached	Age Group (18–24)	Age Group (25–34)	Age Group (35–44)	Age Group (45+)
Hope Appeal	616,547	370,992	244,555	18%	23%	18%	2%
Fear Appeal	613,000	390,000	221,264	17%	25%	20%	Remaining
Rational Appeal	596,608	367,256	229,352	19%	23%	19%	2%

4.3. Engagement by Appeal Type

All social media ads achieved similar click-through rates, around 0.3% (Table 2). However, user engagement varied by emotional appeal: The ads had varying levels of engagement, with the rational appeal receiving the highest number of post reactions (58), followed by the fear appeal (28) and the hope appeal (44). Additionally, the rational appeal had the most post shares (4) and one post save, indicating higher user engagement and potential for organic reach. Overall, click-through rates were similar, but the rational appeal generated the most clicks and engagement, indicating a user preference for straightforward information. However, engagement across all ads remained low (minimal shares, comments, and saves), suggesting users might passively consume the information without actively sharing it.

Table 2. Summary of Facebook Engagement Results for the Climate Change Awareness Campaign.

Ad Variation	Total Clicks	Unique Clicks	Link Clicks	CPC	Unique CPC	Link CPC	Unique CTR	Post Reactions	Post Shares	Post Saves
Hope Appeal	1773	1738	1044	$0.07	$0.07	$0.12	0.28%	44	0	0
Fear Appeal	1799	1755	1111	$0.07	$0.07	$0.11	0.29%	28	4	0
Rational Appeal	2080	2026	993	$0.06	$0.06	$0.13	0.34%	58	4	1

5. Discussion: Climate Change Awareness and Communication on Social Media: Hope, Fear, or Facts?

5.1. Public Awareness and Communication Strategies in Egypt

While a knowledge gap on climate change undoubtedly exists within the Egyptian public [20], it is inaccurate to portray Egyptians as entirely uninformed. Google Trends data reveals a positive trend in searches for "sustainability," indicating a growing interest in environmental issues. However, the situation in the USA presents a stark contrast. Here, despite a similar rise in "sustainability" searches, a clear upward trend for "climate change" is absent. This disparity might be attributed to the prevalence of social media misinformation within the US. A study by Gounaridis and Newell [54] found that nearly 15% of Americans do not believe in climate change, fueled by a coordinated social media network exploiting events and influential figures like Donald Trump to sow doubt about scientific consensus. This underlines the crucial role that social media platforms must assume in combating

misinformation by delivering messages that effectively foster resilience to misinformation among the audience.

5.2. Egypt's Growing Climate Awareness

An analysis of online search trends suggests a growing awareness of climate change in Egypt. This is evidenced by a notable increase in searches for "climate change" compared to the past. This trend aligns with positive national efforts to address the issue, such as Egypt's hosting of COP27 and the establishment of the National Adaptation Strategy (NAS) [3,24–54]. However, challenges persist. Recent large-scale demolitions of green spaces for road expansion highlight a potential disconnect between government actions and public concerns [55,56]. Citizen activism opposing these projects further emphasizes the growing public interest in environmental protection [57]. Learning from successful communication strategies used in the West could be beneficial for Egypt. Research suggests that effective climate change messaging goes beyond simply providing information; the message itself needs to resonate with the audience [26]. Culturally relevant communication delivered through appropriate channels is crucial. This is especially important in developing countries like Egypt, where building resilience against misinformation requires effective social media campaigns that promote positive attitudes towards climate change.

Therefore, the next step of this study investigated the impact of emotional appeals (hope, fear, and rationality) on user engagement with social media climate change advertisements.

5.3. Younger Audience Drawn to All Ad Variations in Marketing Campaign

All three ad variations (hope, fear, and rational) reached a similar number of total viewers. However, a clear trend emerged regarding age groups. The 18–24-year-olds showed the strongest engagement with all the ads, consistently reaching around 18–19% of viewers in that age group. This suggests the messaging might be more effective for younger audiences compared to those over 35. This aligns with existing research that shows teenagers and young adults are more receptive to environmental advertising on social media [58], while older demographics may be less interested in climate change messages.

5.4. Optimizing Climate Messaging: Hope, Fear, or Facts for Climate Action?

While click-through rates (CTR) remained similar across all appeals (around 0.3%), the results revealed valuable insights into user behavior and content preferences.

The hope appeal, despite reaching the most viewers (616,000 users), did not translate to higher engagement. It generated the fewest clicks, reactions, shares, and saves. This finding contradicts a recent study from Indonesia [59], which explored the impact of messages that use hope or fear, framed either globally or locally, on promoting pro-environmental behavior. Participants evaluated climate change posters with different message framings. The study examined how threat (fear) and hope appeals, presented in global and local contexts, influenced people's attitudes and intentions toward protecting the environment. The results showed that both fear and hope messages can significantly influence people's attitudes and intentions, but the effectiveness depends on how the message is framed. Specifically, the Indonesian study found that fear messages were more effective when the message focused on the global impact of climate change. Conversely, hope messages had a greater impact when they addressed local environmental issues.

Fear Appeal: Compared to hope, the fear appeal had a slightly smaller audience with a more male-dominated demographic (390,000 users, 25–44 years old). However, it generated slightly more clicks (1799) and reactions/shares (28 vs. 44 for hope). While fear can grab attention, its effectiveness seems limited. The negligible increase in clicks compared to hope suggests fear might not be a significantly stronger driver of user action. Additionally, fear appeal content was not shared substantially more (4 shares vs. 0 for hope). These findings align with ongoing discussions in climate change communication research regarding the potential for fear to lead to passive responses like avoidance, denial, or helplessness due

to the seemingly insurmountable nature of the threat, suggesting messages emphasizing hope might be more effective [60,61]. However, it is important to note that fear appeals have been shown to be successful in some health promotion campaigns, like encouraging healthy eating but not necessarily increasing physical activity [62].

Rational Appeal: Although reaching slightly fewer users (596,000) compared to hope, the rational appeal emerged as the most successful in driving engagement. Users exposed to the rational appeal displayed a clear preference for factual information, evidenced by the highest click-through rate (0.34%) and the most post interactions (58 reactions, 4 shares). This finding supports the work of some researchers who suggest that clear and concise factual information is highly effective in engaging users with complex issues like climate change [42,63]. Users exposed to the rational appeal not only clicked more frequently (2080 clicks) but also interacted more actively with the content through reactions and shares. However, these findings seem to contradict research suggesting human information processing, decision-making, and behavior are significantly influenced by emotions. Recent research emphasizes the crucial role of affective processes in facilitating cognitive function, highlighting the intricate link between emotions and cognitive/motivational processes [61]. Despite their impact, emotions are still identified as key drivers of responses to climate change.

5.5. A Call for Deeper Engagement

While click-through rates were similar across appeals, the overall level of engagement remained relatively low. The minimal shares, comments, and saves suggest a tendency toward passive information consumption. "Liking" a post requires less effort compared to actions like sharing, donating, or completing forms. This suggests a tendency towards passive rather than active support for climate change mitigation efforts. Users might be absorbing the information but not actively sharing it with their networks. This highlights a crucial gap in climate change communication—the need to move beyond clicks towards fostering active user participation. Future campaigns might benefit from stronger calls to action that encourage users to share information, participate in discussions, or take concrete steps toward sustainability [61].

5.6. Cost Considerations

The cost per click (CPC) remained consistent across all appeals (average CPC = $0.07), which is considerably lower than the global average CPC across industries ($1.72) [64]. Furthermore, the CPC for the fear appeal was lower than the average for "Environmental Protection" campaigns on Facebook ($0.58) [65]. This lower CPC suggests that climate change messaging, regardless of appeal type, may benefit from relatively favorable advertising costs on Facebook. With a budget of only $377, equally distributed among the three ad variations, the campaign reached nearly 2 million users (1,825,893). This is significant considering Egypt's internet penetration rate (71.9%), which is higher than that of neighboring countries (Algeria: 58%, Libya: 22%) [66]. This information can be valuable for practitioners and organizations developing communication strategies for climate change awareness campaigns. They can estimate campaign budgets and expected outcomes based on the study findings while also having a benchmark for campaign performance compared to global averages.

However, cost is just one factor in social media campaign effectiveness. Micro-targeting, a critical strength of platforms like Facebook, offers exciting possibilities. While research specifically on tailoring climate change communication is limited, parallel studies in health and environmental risk communication suggest promise. Meta-analyses show that tailoring health messages to individual beliefs about self-efficacy can significantly impact attitudes and behaviors [67]. With the rise of micro-targeting technology on social media platforms like Facebook, climate change communication can leverage this potential for personalization, potentially leading to greater effectiveness.

6. Conclusions

This study investigated the effectiveness of emotional appeals (hope, fear, and rational) in social media climate change messaging on Facebook. While click-through rates (CTR) were similar across all appeals, the results highlight some key insights: The study found factual messages sparked the most engagement on social media for climate change action (clicks, reactions, shares) [68]. Fear appeals saw slightly more clicks but minimal sharing [68]. Hopeful messages reached the most users but had the lowest engagement [68], suggesting passive information consumption and a need for stronger calls to action [68]. The campaign achieved a remarkable reach of nearly 2 million users (2.3% of Egypt's internet users) with a modest budget of $377, demonstrating the cost-effectiveness of social media for climate change awareness [66]. This highlights the value of social media for reaching a broad audience but emphasizes the need for content that goes beyond clicks, prompting active participation through stronger calls to action [68]

In conclusion, Facebook presents a powerful platform for targeted and insightful climate change communication. Its strength lies in the ability to reach large, specific audiences. Precise targeting based on location, demographics, and interests ensures messages resonate with the most receptive populations. Facebook Ads function as a feedback loop by providing a wealth of performance insights (CTR, page likes) on how users engage with the content. By analyzing this data, campaign managers can refine their messaging and optimize content for better engagement, ultimately fostering a deeper understanding of climate change issues. Digital tools like Facebook can be leveraged to raise awareness, encourage behavior change, and inspire a more environmentally conscious future, ultimately influencing government initiatives in this critical area.

7. Limitations and Future Research

A key limitation of this study is its focus on a single platform (Facebook) and a specific audience (Egypt). The results may not be generalizable to other social media platforms with different user demographics and content consumption patterns. Future research could explore the effectiveness of emotional appeals across different social media platforms. Furthermore, research into micro-targeting strategies could illuminate how personalization can be leveraged to enhance the effectiveness of climate change messaging on social media platforms like Facebook. By addressing these limitations and incorporating the insights gained from this study, future climate change communication campaigns can be better equipped to capture user attention, foster deeper audience engagement, and ultimately drive meaningful action.

Appendix A. Advertising Report: Understanding the Metrics

Table A1. This table summarises key metrics used to evaluate advertising performance, along with their purpose.

Term	Explanation	Usefulness
Ad Variation	Different versions of the ad tested	Helps identify the most effective ad format through A/B testing
Clicks (Total & Unique)	Total Clicks: This reflects the total number of times users clicked anywhere on the ad, regardless of whether it was the same user clicking multiple times. Unique Clicks: This measures the number of individual users who clicked on the ad at least once, avoiding inflated figures due to repeat clicks.	Total clicks represent how many times people clicked on the advertisement, regardless of whether it was the same person clicking repeatedly. This metric provides a general idea of how visible the ad was and how much overall attention it attracted. Unique clicks tell you how many individual users clicked on the ad at least once. This metric focuses on user engagement because it filters out repeat clicks from the same person and reflects the number of distinct people who interacted with the ad.
Link Clicks	Number of clicks directing users to a specific webpage	Measures effectiveness in driving traffic to a desired website
CPC (Cost-per-Click)	Average cost per ad click (total spend divided by total clicks)	Helps understand the return on investment (ROI) for advertising campaigns
Unique CPC	Average cost per click from unique users (total spend divided by unique clicks)	Assesses cost efficiency of reaching individual users
Link CPC	Average cost per click on a specific link within the ad	Provides insight into the cost of acquiring website traffic through the ad
Unique CTR (Click-Through Rate)	Percentage of users who saw and clicked the ad (unique clicks divided by impressions x 100%)	Indicates how well the ad resonates with the target audience and compels them to click
Engagement (Reactions, Shares & Saves)	User interactions with the ad: emoji reactions (likes etc.), sharing with others, and saving for future reference	Reflects user sentiment towards the ad (reactions), potential reach expansion (shares), and content value (saves)

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