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Cloud seeding as a non-kinetic counterterrorism tool: A framework for national security and food security in Nigeria

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Abstract

This study interrogates the underexplored nexus between cloud seeding technology and national security in Nigeria, with specific objectives to examine its influence on food security and assess its linkages to counterterrorism. Employing a qualitative research design, the investigation synthesizes evidence from global literature, peer-reviewed journals, and historical case studies to construct a theoretical framework grounded in Techno-Political Theory and Human Security paradigms. The findings reveal that cloud seeding can stabilise crop yields and rejuvenate grazing reserves, thereby addressing the root causes of livelihood failure and resource conflict that fuel grievances and recruitment by non-state armed groups; BokoHaram, ISWAPS, Lakurawa and Mahmuda, in Nigeria's vulnerable agro-pastoral zones. Secondly, study establishes indirect counterterrorism linkages by potentially enhancing state legitimacy through service delivery and, when ethically applied within international law, serving as a non-kinetic force multiplier for tactical disruption. The study concludes that while cloud seeding is not a panacea, it represents a strategic techno-political instrument capable of shrinking the conflict ecosystem. To translate this potential into policy, the study advances targeted recommendations. First, it recommends that the Nigeria Defence Headquarters and Northern Regional Development Commissions, in partnership with State governments and international agencies, initiate a phased, evidence-based pilot program. This must begin with vulnerability mapping in conflict-prone zones and invest in building core domestic capacity, including the training of meteorologists, NSCDC Agro Rangers, and pilots in cloud seeding operations. Second, it recommends that the Office of the National Security Adviser institutionalise coordination between technical agencies (NiMet), agricultural ministries, and security councils including theatre commands and NSCDC Agro Ranger Commands. This is to formally incorporate cloud seeding into Nigeria's non-kinetic lines of operation within national counterterrorism frameworks.

Keywords: Cloud Seeding; Counterterrorism; Food Security; Techno-Political Theory

1. Introduction

Nigeria faces a complex security landscape characterized by terrorist insurgencies (e.g., Boko Haram, ISWAP), farmer-herder conflicts, and widespread socio-economic vulnerabilities exacerbated by climate variability (Okoli & Ugwu, 2019). Traditional kinetic counterterrorism approaches, while necessary, often address symptoms rather than root causes. Consequently, scholars and policymakers are increasingly interested in "human security" paradigms that integrate environmental management and livelihood restoration into security strategy (Matthew, 2014). Within this framework, cloud seeding the deliberate introduction of seeding agents into clouds to enhance precipitation, emerges as a potential tool. This paper interrogates the relationship between cloud seeding and national security in Nigeria by analysing its dual potential to bolster food security and disrupt the drivers of conflict and recruitment.

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Globally, cloud seeding has been deployed for both peaceful resource augmentation and, historically, hostile military objectives. During the Vietnam War, the United States conducted Operation Popeye (1967-1972), using cloud seeding to extend monsoon seasons in order to disrupt enemy logistics, flood supply routes, and degrade mobility, an episode that directly influenced the adoption of the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) (Duke-Abiola 2025; Larson, 2015). This history demonstrates that weather modification possesses strategic value capable of shaping conflict dynamics.

In contemporary practice, countries such as China, Israel, the United States, and the United Arab Emirates deploy cloud seeding primarily to stabilise food systems, mitigate drought, and secure water supplies (Zhou & Wang, 2019; Jung et al., 2022). In Africa, Morocco, Burkina Faso, Mali, and Ethiopia have experimented with cloud seeding as a response to structural drought and agricultural vulnerability (Faouzi, 2024; Wondie, 2023). These experiences are particularly relevant to Nigeria, where climate variability, desertification, and the shrinkage of the Lake Chad Basin have intensified food insecurity and fueled violent extremism, banditry, and farmer, herder conflicts in the North-East and North-West regions (Mahmoud et al., 2022).

Furthermore, the technical challenges associated with cloud seeding, including the lack of expertise, absence of infrastructure, and dearth of economic leverages to execute such lofty concept, present a significant obstacle to its adoption in Nigeria. Many countries with successful cloud seeding programs have invested in cutting-edge technology and the development of skilled personnel. However, Nigeria faces infrastructural fragility and a shortage of trained meteorologists and engineers capable of managing and deploying cloud seeding operations effectively. The country's limited understanding and adoption of cloud seeding further compound these challenges, making it essential to address both the technical and infrastructural deficits to realize the potential of cloud seeding in enhancing national security.

Food insecurity is both a consequence and a driver of instability in Nigeria. Climate-induced droughts and unpredictable rainfall patterns directly threaten agricultural output, livelihoods, and food prices, creating fertile ground for grievances (Bello et al., 2021). Cloud seeding is potent to augment rainfall in key agricultural regions and during critical planting seasons. Evidence from global programs indicates its utility in mitigating drought impacts. For instance, operational projects in Morocco and Iran have demonstrated statistically significant increases in precipitation (15-20% in targeted areas), leading to improved crop yields and water reservoir levels (AghaKouchak et al., 2011; Mamane et al., 2010). Applied to Nigeria's rain-fed agricultural systems in the Middle Belt and Northeast, such interventions could stabilize crop production. By securing harvests, cloud seeding helps restore the primary livelihood for millions, directly addressing the economic desperation that terrorist groups exploit for recruitment. As Bruck et al. (2020) note, agricultural distress is a significant predictor of vulnerability to recruitment by non-state armed groups in sub-Saharan Africa.

Furthermore, Cloud Seeding supports grazing and ranching systems which equivalently deaccelerate unregulated transhumance. A major source of violence in Nigeria is the conflict between predominantly Muslim pastoralists (herders) and Christian farmers, driven by competition over dwindling water and pasture resources (Ayantoye et al., 2017). Targeted cloud seeding to rejuvenate grazing reserves and corridors in the Sahelian and Northern regions could provide a technical solution to this ecological pressure. Enhanced rainfall promotes vegetation regrowth, reducing the necessity for herdsmen to migrate southward into farmlands prematurely. This application aligns with conflict-sensitive resource management, de-escalating a primary driver of communal violence that often interlinks with broader terrorism dynamics by creating lawless spaces and exacerbating ethno-religious tensions (Higazi, 2016).

The tactical utility of cloud seeding within counterterrorism operations can be situated within a broader framework of multi-domain pressure applied to terrorist networks. This complements and can potentially synergize with kinetic military actions, such as the recent assistance provided by the United States in combatting terrorism in Nigeria, including airstrikes on terrorist havens like Lakurawas (Jaroslav & Makuochi, 2025). While such kinetic strikes are designed for the direct disruption and physical displacement of terror cells, they primarily create temporary windows of opportunity and degrade command structures. To maximize the operational advantage gained from such decisive actions, follow-on non-kinetic tools can be employed to compound enemy disarray and hinder reconstitution.

The significance of this study will have impact on Office of the National Security Adviser, Northwest, North Central and North East Regional Development Commissions, Nigeria Meteorological Agency (NiMet), the National Water Resources Institute, Ministry of Agriculture and Food Security, the Nigeria Security and Civil Defence Corps (NSCDC) Agro-Ranger Command, and academic experts in climatology, security studies, and conflict resolution from Nigerian universities. This study interrogates cloud seeding not merely as a meteorological intervention, but as a strategic instrument situated at the nexus of food security and counterterrorism. It responds to the absence of Nigerian-specific scholarship that links

precipitation enhancement to security outcomes, despite clear empirical pathways through which environmental scarcity amplifies insurgency recruitment, population displacement, and violent competition over resources.

1.1. Statement of the Problem

Nigeria's national security challenges are increasingly shaped by environmental stressors. Persistent droughts, erratic rainfall, desert encroachment, and declining agricultural yields have weakened livelihoods across the northern regions, intensifying poverty, displacement, and competition over land and water. These conditions have directly contributed to the operational environment exploited by terrorist and armed groups, particularly Boko Haram and Islamic State West Africa Province (ISWAP), Mahmuda, and Lakurawa, as well as bandit networks and violent militias.

Despite this reality, Nigeria's security and climate responses remain largely reactive and compartmentalised. Cloud seeding, an established but underexplored technology has not been systematically integrated into national food security planning, counterterrorism stabilisation strategies, or environmental security frameworks. The absence of a policy architecture, technical capacity, legal guidance, and inter-agency coordination has left Nigeria unable to assess or harness cloud seeding as a preventive security tool. Existing Nigerian literature treats cloud seeding narrowly as a meteorological or agricultural issue, failing to engage its historical use in warfare, its regulation under international law, or its relevance to counterinsurgency through resource stabilisation. This conceptual gap undermines evidence-based policymaking in regions where climate insecurity and terrorism are mutually reinforcing.

To the extent of literature review, there exist an apparent gap in literature on Cloud seeding and National security in Nigeria, hence the need for this capstone study. It is this gap in literature that this study fill using unique constructs of Cloud Seeding and National Security, Cloud seeding and food security, Cloud Seeding and counterterrorism in Nigeria. By examining these dimensions, this research aims to provide insights into how cloud seeding can contribute to a more secure and resilient Nigeria in the face of growing environmental uncertainties.

1.2. Research Questions

This study provides answers to the following research questions;

- What impact does cloud seeding have on food security in Nigeria?
- What influence does cloud seeding have on counterterrorism in Nigeria?

1.3. Objectives of the Study

The main objective of the study interrogate relationship between Cloud Seeding and national security in Nigeria. While specific objectives;

- Examine influence of cloud seeding on food security in Nigeria.
- Assess linkages between cloud seeding and counterterrorism in Nigeria.

2. Literature Review

2.1. Conceptual Framework

2.1.1. Concept of Cloud Seeding

The practice is a type of weather modification process whereby small planes fly through clouds burning salt flares which can increase precipitation to help make it rain. Cloud seeding is an established technology, developed after World War II to modify precipitation patterns to enhance rain and snow, or suppress hail. It is used as a long-term water management strategy to increase freshwater resources in key locations for water, food, and energy security (Simon, 2022).

Weather modification is a technology in which cloud seeding materials artificially cause cloud condensation and precipitation development in areas of the atmosphere with insufficient cloud condensation or ice nuclei. Weather modification techniques originated from the discovery that spraying artificial ice nuclei into supercooled clouds can increase the number concentration of ice crystals. The usual objective is to increase rain or snow, either for its own sake or to prevent precipitation from occurring in days afterward. Cloud seeding is done only when temperatures within the clouds are between 19 and minus-4 degrees Fahrenheit. This is the range at which silver iodide does its best work, as demonstrated by decades of research.

The goal of cloud seeding is to alter the natural development of the cloud to enhance precipitation, suppress hail, dissipate fog, or reduce lightning. Tata firms also took stabs at cloud seeding in the Western Ghats region in 1951 using ground-based silver iodide generators. The Rain and Cloud Physics Research (RCPR) unit of Indian Institute of Tropical Meteorology (IITM) in Pune carried out randomized warm cloud modification experiments through salt seeding during 1957-1966 in north India. Over the next three decades, India experimented in this direction in Maharashtra, Karnataka and Uttar Pradesh (Ghosh, 2019)

2.1.2. Concept of National Security

The traditional notion of national security is broaden to include non-military threats, such as food insecurity, water scarcity, and environmental risks (UNDP, 1994). In this context of cloud seeding, national security focuses on how environmental interventions directly impact individual and community well-being and national interest. By increasing water availability through cloud seeding, the technology can help combat droughts, secure agricultural yields, and thereby enhance food security. This is especially relevant in countries facing aridity, water stress or in regions where agriculture is vital to the economy and people's livelihoods. Policies aimed at ensuring food and water security align with both national security and the human security paradigm by prioritizing the protection of citizens from environmental threats (Sachs, 2012).

A 2016 classified ad placed by Los Angeles County's Department of Public Works in the Pasadena Star News sparked claims that widespread weather modification was being confirmed. The department followed up with a clarification that it was only describing cloud seeding, used as an anti-drought measure intermittently for more than half a century in Los Angeles (LaCapria, 2016).

The Modesto and Turlock irrigation districts have seeded clouds over their Tuolumne River watershed, such that parts of the 257,314-acre burn area have a moderate to severe risk of soil erosion into streams and reservoirs during major storms (Weiser, 2014). Cloud seeding was rejected in Australia on environmental grounds because of concerns about the pygmy possum. The claims of negative environmental impact are disputed by peer-reviewed research (International Weather Modification Association, 2009)

2.1.3. Cloud Seeding and Food Security

Food security is fundamentally dependent on water availability, particularly in rain-fed agricultural systems such as those dominant in northern Nigeria. Empirical studies demonstrate that cloud seeding can increase precipitation by 5% to 15% under suitable meteorological conditions, translating into measurable gains in crop yields and reduced drought losses (Rauber et al., 2019; Essien, 2023). Parkes et al. (2015) show that water stress rather than temperature alone, is the primary driver of crop failure across West Africa, underscoring the strategic value of precipitation enhancement. Evidence from China and the United States further indicates that cloud seeding supports irrigation reliability, stabilises food supply chains, and reduces climate-induced production shocks (Zhou & Wang, 2019).

In Nigeria, where agriculture employs over 35% of the population and food shortages are closely linked to social unrest, the food security dividend of cloud seeding carries direct national security implications.

2.1.4. Cloud Seeding, Environmental Security, and Counterterrorism

The relationship between environmental scarcity and violent extremism is well established. Homer-Dixon (1999) and Matthew (2002) argue that resource depletion intensifies grievance, weakens state legitimacy, and lowers recruitment barriers for insurgent groups. In the Lake Chad Basin, declining water levels have displaced millions, eroded livelihoods, and created permissive conditions for terrorism and armed criminality. Historically, cloud seeding has demonstrated the capacity to shape conflict environments. Operation Popeye proved that precipitation manipulation could restrict movement, degrade logistics, and alter terrain in ways relevant to military strategy (Fleming, 2010). While ENMOD prohibits hostile uses, it does not restrict defensive or stabilisation-oriented environmental interventions.

Environmental stress has increasingly been recognised as a critical driver of insecurity, particularly in fragile and conflict-affected states. Climate-induced disruptions to rainfall patterns, agricultural productivity, and water availability now constitute non-traditional but potent threats to national security (Homer-Dixon, 1999; UNDP, 1994). Among emerging environmental intervention tools, cloud seeding, a form of deliberate weather modification designed to enhance precipitation, has re-emerged as a policy-relevant technology with implications that extend beyond water management into food security and security stabilisation.

This concept of "environmental maneuvering" is discussed in strategic studies as a form of asymmetric advantage that controls the battlespace (Fleming, 2010). When sequenced after kinetic actions like the US-assisted airstrikes, cloud seeding transitions from a standalone meteorological activity to an integrated force-multiplier within a coordinated counterterrorism campaign. It leverages the initial disruption caused by force to impose enduring environmental friction on the enemy, effectively extending the tactical impact of military success. Crucially, this application requires strict adherence to international norms, such as the Environmental Modification Convention (ENMOD) of 1978, which prohibits hostile use but permits peaceful environmental modification, provided it does not cause widespread, long-lasting, or severe effects as a means of warfare (Fleming, 2010).

2.1.5. Linkages Between Cloud Seeding and Counterterrorism in Nigeria

The link between cloud seeding and counterterrorism is indirect but potent, operating through the stabilization of the human environment in which terrorism exists. Cloud Seeding activation is potently linked with tactical disruption, on the combat field, weather has always been a tactical factor. While not a primary weapon, ethically applied weather modification could create non-lethal, temporary disruption (Duke-Abiola 2025). For example, inducing heavy rainfall over known terrorist supply routes during military operations could impede the mobility of logistics convoys, slow down militant movements, and degrade communications, granting government forces a temporary operational advantage. This concept of "environmental maneuvering" is discussed in strategic studies as a form of asymmetric advantage, though its application requires strict adherence to international norms, such as the Environmental Modification Convention (ENMOD) of 1978, which prohibits hostile use (Fleming, 2010).

There is no gainsaying that Cloud Seeding stabilises communities to improve intelligence and state legitimacy. successful cloud seeding programs that demonstrably improve local water and food security can enhance the perceived legitimacy and effectiveness of the state. Communities experiencing tangible benefits from state-led environmental programs are more likely to cooperate with security forces by providing intelligence and rejecting extremist overtures. This builds a "whole-of-society" security approach. Research on counterinsurgency emphasizes that state presence through service delivery is critical for winning local cooperation (Kilcullen, 2010). A cloud seeding program, managed transparently, can be a visible symbol of a government investing in the welfare of its most vulnerable citizens.

Northern Nigeria is highly vulnerable to desertification and droughts, which force large-scale population displacements southward. These internally displaced persons (IDPs) strain urban resources, create humanitarian crises, and become pools for recruitment by criminal and terrorist networks (Adger et al., 2014). By potentially mitigating the worst effects of drought in source regions, cloud seeding could contribute to reducing displacement pressures. More stable populations are easier to govern, protect, and integrate into formal economic and security frameworks.

While Cloud seeding does not offer a silver bullet for Nigeria's security woes. Its efficacy is weather-dependent, requires significant technical capacity, and must be part of a holistic security and development strategy. However, as an element of a broader "human security" approach, it holds promise. By directly targeting the agro-climatic roots of food insecurity and resource conflict, cloud seeding can indirectly undermine the recruitment base and operational environment of terrorist groups. It operates by shrinking the conflict ecosystem, addressing the desperation and competition that fuel violence, rather than by militarizing weather.

Crucially, any such program must be governed by stringent ethical protocols: transparency, scientific oversight, community consultation, and strict compliance with international law prohibiting environmental warfare. The primary objective must always be humanitarian and developmental, enhancing resilience and livelihoods. When applied thusly, cloud seeding can transition from a mere meteorological technique to a innovative tool within Nigeria's national security architecture, simultaneously advancing the goals of food security and conflict reduction.

3. Empirical Review

3.1. Cloud Seeding challenges and National security

Anuar et al. (2024) examined cloud seeding potential areas from remote sensing of low-level cloud due to location and temporal factors in Malaysia. Nowadays, low-level clouds' location can be detected using satellite remote sensing, to determine the potential areas for cloud seeding operations with remotely sensed low-level cloud distribution. The study elicited potential areas from the low-level cloud distribution of Terra Moderate Resolution Imaging Spectroradiometer (MODIS) with cloud masking method and single reflective band and mapped with Geographic Information System (GIS) overlay analysis. Results that emanated from the study revealed that the locations were coincidentally used in previous cloud seeding operations which were above the 0.14 threshold. Thus, the potential areas based on low-level clouds for

cloud seeding operations can be detected and mapped using Remote Sensing satellite images. The approach can potentially be utilised by related agencies to identify the appropriate areas for cloud seeding operations practically.

Ćurić and Janc (2014) investigated influence of tendencies for the amounts of chemical material used for cloud seeding for more than half a century and cover planetary scales in central and western Serbia. Findings from the study submitted that these cloud seeding activities lead to deposited chemical materials (seeding agents) at the ground level during precipitation, with high tendencies of increased amounts of seeding agent deposits to be a serious problem due to various negative effects on the human environment. The study also opine that the annual seeding agent amounts show a slow decreasing trend because fewer seedings were performed during the last decade of the last century, which was due to economic reasons. Study was done in Serbia with focus on challenges ahead from cloud seeding experiments while this study also engaged policy frameworks for cloud seeding in Nigeria.

Essien (2023) leveraged on Utilizing Social-Technical Systems Theory to investigate cloud seeding techniques for precipitation enhancement drawing from diverse geographical contexts, including the United States, Canada, Europe, and African countries. The study interrogated the varying patterns of precipitation and the potential for cloud seeding to address water scarcity challenges. Findings from the study opine that that silver iodide significantly increased precipitation in targeted areas, particularly during specific cloud types and favorable meteorological conditions. The result from a cost-benefit analysis reveals the economic viability of cloud seeding, with benefits such as increased agricultural productivity and reduced drought-related losses outweighing implementation costs. There is the need for Nigeria dataset driven study, hence the need for this study.

Parkes et al. (2015) investigated crop failure rates in a geoengineered climate on the number of crop failures in two regions, Northeastern China and West Africa. Climate change associated with a doubling of atmospheric carbon dioxide increases the number of crop failures in Northeastern China while reducing the number of crop failures in West Africa. In both regions marine cloud brightening is likely to reduce the number crop failures, although it is more effective at reducing mild crop failure than severe crop failure. Results from the study showed that water stress, rather than heat stress, is the main cause of crop failure in current, future and geoengineered climates. This demonstrates the importance of irrigation and breeding for tolerance to water stress as adaptation methods in all futures. Analysis of global rainfall under marine cloud brightening has the potential to significantly reduce the impact of climate change on global wheat and groundnut production. The study was a cross country study and there is need for a country specific study like Nigeria which this study intends to capture.

3.2. Theoretical Framework

3.2.1. Techno-Political Theory

The Techno-Political Theory primarily developed in the late 1970s and early 1980s, emerged through interdisciplinary academic discourse rather than a formalized theory presented by one scholar. It is most closely associated with the field of Science and Technology Studies (STS), exploring how technology and politics mutually shape each other. Protagonists of this theory include Langdon Winner (Winner, 1980); Bruno Latour (Latour, 1987) Sheila Jasanoff (Jasanoff, 2004). The theory highlights how technology and politics are intertwined (Winner, 1986). Cloud seeding, as a form of weather modification, is not just a technical solution but one that requires political will, governance, and public engagement.

In the context of national security, this theory explains how policy frameworks must be designed to regulate the use of cloud seeding, address environmental risks, and ensure equitable water distribution. The success of cloud seeding is dependent on a techno-political approach that integrates scientific expertise with policy action, ensuring that national security goals such as food security and water augmentation are met through coordinated efforts. Techno-Political Theory offers a valuable lens through which to examine the interplay between cloud seeding, national security, food security, and water augmentation. Cloud seeding involves the artificial modification of weather patterns, particularly to enhance precipitation. From a techno-political perspective, cloud seeding is not just a neutral scientific process; it reflects power structures, political interests, and social consequences.

To ensure that cloud seeding is deployed in a way that supports national and food security goals, an appropriate policy framework is essential. A well-regulated framework can prevent misuse and ensure equitable access to the benefits of cloud seeding. This policy should involve multi-agency collaboration, as suggested by techno-political theory, incorporating the inputs of meteorological agencies, agricultural ministries, and water resource managers. Additionally, international cooperation may be necessary to manage potential conflicts over shared water resources, especially in regions with interconnected hydrological systems. Langdon Winner's (1980) argument about the politics of artifacts implies that without thoughtful governance, cloud seeding could reinforce existing inequalities or even trigger new geopolitical disputes over water.

4. Research Methodology

The study adopted a qualitative research design, this design is suitable for investigating contemporary phenomenon; the potential use of cloud seeding, within its real-life context in Nigeria's security and environmental crisis. This design is deemed most appropriate for exploring complex, multidimensional phenomena where context, meaning, and process are paramount (Creswell & Poth, 2018). The research aims not to quantify relationships but to provide a nuanced, in-depth analysis of how cloud seeding is conceptually and practically linked to food security and counterterrorism within the Nigerian socio-political and environmental landscape. The design allows for a holistic exploration of the "how" and "why" behind the potential linkages, drawing from multiple sources of evidence to build a robust understanding.

5. Discussion of Findings

The findings of this study reveal a dual-pathway mechanism through which cloud seeding can be integrated into Nigeria's national security architecture. This aligns with the broader literature that situates environmental stress as a critical, non-traditional threat multiplier in fragile states (Homer-Dixon, 1999; UNDP, 1994). The analysis confirms that cloud seeding is not merely an agricultural tool but a techno-political intervention (Winner, 1980) with significant implications for both food security and counterterrorism, operating within the "human security" paradigm advocated by Matthew (2014). The findings strongly support its potential as a stabilising mechanism for Nigeria's vulnerable agro-pastoral systems. As demonstrated in the literature, operational programs in Morocco, Iran, and China have achieved statistically significant precipitation increases of 15-20%, directly translating to improved crop yields and water security (Zhou & Wang, 2019). Applied to Nigeria's drought-prone Middle Belt and Northeast, such targeted precipitation enhancement directly addresses the primary driver of crop failure identified by Parkes et al. (2015): water stress. By securing rain-fed agricultural and pastoral livelihoods, cloud seeding mitigates the "agricultural distress" that Bruck et al. (2020) identify as a key predictor of recruitment into non-state armed groups. Furthermore, by rejuvenating grazing reserves in the Sahelian North, it offers a technical solution to the resource competition underpinning deadly farmer-herder conflicts (Ayantoye et al., 2017; Higazi, 2016). Thus, the study finds that cloud seeding's most direct and evidence-based impact is its capacity to shrink the conflict ecosystem by alleviating the socio-economic desperation and resource competition that fuel instability.

Second, concerning the linkages between cloud seeding and counterterrorism, the findings articulate an indirect but strategic relationship. The historical precedent of Operation Popeye underscores the recognized tactical value of weather modification in conflict, a capability later regulated by the ENMOD convention (Larson, 2015). Ethically applied within ENMOD's peaceful-use provisions, cloud seeding can function as a force multiplier within a coordinated counterterrorism campaign. The analysis suggests it operates on two levels: first, by enhancing state legitimacy through tangible service delivery (improved water and food security), which fosters community cooperation and intelligence sharing, a cornerstone of effective counterinsurgency (Kilcullen, 2010); and second, by enabling tactical environmental maneuvering. As conceptualized by Duke-Abiola (2025), inducing heavy rainfall post-kinetic strikes such as recent US-assisted operations against terrorist havens could compound enemy disarray by impeding logistics and movement, thereby extending the operational advantage gained by conventional forces. This aligns with the study's framing of cloud seeding as a component of "multi-domain pressure." Therefore, while cloud seeding is not a standalone solution, it represents a innovative tool within a holistic security strategy, one that addresses root causes of conflict rather than merely its symptoms.

6. Conclusions

The study concludes that cloud seeding possesses a demonstrable potential to directly enhance food and water security in Nigeria's most vulnerable regions. By augmenting precipitation in key agro-pastoral zones of the Middle Belt, Northeast, and Sahelian North, cloud seeding can mitigate the water stress that is a primary driver of crop failure and livestock loss. As evidenced by successful global programs, this leads to stabilized yields, replenished grazing reserves, and secured livelihoods. This function is not merely developmental; it is fundamentally a security intervention. By alleviating the economic desperation and resource competition that fuel grievances such as those underlying farmer-herder conflicts and community support for insurgent groups cloud seeding operates proactively to shrink the conflict ecosystem. It directly undermines a key recruitment incentive for terrorist organizations like Boko Haram, Lakurawa, Mahmuda, and ISWAP, thereby supporting a "human security" approach that addresses root causes rather than symptoms.

Second, the study establishes that cloud seeding holds indirect but potent linkages to counterterrorism operations. Its capacity to improve state legitimacy through effective, non-violent service delivery can foster greater community

cooperation and intelligence sharing with security forces, enhancing the "whole-of-society" approach critical to counterinsurgency. Furthermore, when integrated into a broader security campaign, its capability for tactical environmental maneuvering such as non-lethally impeding terrorist logistics and movement following kinetic actions can act as a force multiplier, extending the operational advantages gained by conventional military successes.

Recommendations

- That Nigeria Defence Headquarters, the regional development commissions (North central, North East, and North West), in partnership with State governments and international development agencies, must initiate a phased, evidence-based pilot program with vulnerability mapping, focusing on the conflict-prone agro-pastoral zones of the Middle Belt and Northeast. Nigeria should invest in building core domestic capacity, including the training of meteorologists, NSCDC Argo Rangers, and pilots in Cloud Seeding operations.
- That the Office of the National Security Adviser should institutionalise coordination between technical agencies (NiMet), agricultural ministries, and security councils of theatre commands in the Northeast and NSCDC Agro Ranger Commands, to formally incorporate Cloud Seeding into Nigeria's non-kinetic lines of operation within national counterterrorism and counterinsurgency frameworks, explicitly aimed at reducing environmental drivers of recruitment and displacement.

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