Available online at: http://journal.uinsgd.ac.id/index.php/kh
Khazanah Hukum, Vol. 7 No. 3: 417-433

DOI: 10.15575/kh.v7i3.45356

From Innovation to Pandora's Box: Examining the Laws on Public Health Threats Emanating from Cloud Seeding

Paul Atagamen Aidonojie[1*], Esther Chetachukwu Aidonojie[1], Hassan Ismaila Adebowale[1], Maria Edet Umo[1], Godswill Owoche Antai[1]

[1]Kampala International University
*Corresponding Author Email: paul.aidonojie@kiu.ac.ug

ABSTRACT

The global community is increasingly concerned about climate change and has explored various scientific methods, including cloud seeding, as temporary mitigation measures. Cloud seeding is a weather modification technique that induces precipitation by injecting clouds with chemical substances such as potassium iodide and silver iodide. While this method appears effective in addressing water scarcity and climate-related challenges, it poses severe threats to public health that have not been adequately addressed through legal frameworks. This study examines the effects of cloud seeding on public health and explores the necessity for legal intervention. The research adopts a qualitative methodology, utilizing content analysis of scientific literature, policy documents, and case studies from both primary and secondary sources. Data were scrutinized through descriptive and analytical methods and presented graphically to illustrate key findings. The study reveals that cloud seeding poses significant public health risks, including water contamination, skin cancer or irritation, respiratory disorders, and ecological imbalances. These health hazards stem from the chemical agents used in the seeding process and their potential accumulation in water sources and ecosystems. Furthermore, the research identifies a critical gap in global public health legislation, as no international laws directly regulate cloud seeding practices concerning public health and safety. The study concludes that while cloud seeding demonstrates potential as a climate change mitigation tool, public health and safety must be prioritized. It recommends establishing a comprehensive global regulatory framework to ensure safe practices, conducting rigorous health impact assessments before implementation, and maintaining public transparency in weather modification initiatives. These measures are essential to balance environmental benefits with the protection of human health and ecological integrity.

Keywords: Cloud Seeding, Global, Public Health, Regulation

ABSTRAK

Perubahan iklim telah mendorong penggunaan metode ilmiah seperti penyemaian awan (*cloud seeding*) sebagai langkah mitigasi. Penyemaian awan adalah teknik modifikasi cuaca yang memicu presipitasi melalui penyuntikan zat kimia seperti kalium iodida dan perak iodida ke dalam awan. Meskipun efektif, metode ini menimbulkan ancaman serius terhadap kesehatan masyarakat yang belum ditangani secara memadai secara hukum. Penelitian ini mengkaji dampak penyemaian awan terhadap kesehatan masyarakat dan kebutuhan intervensi hukum. Penelitian menggunakan metodologi kualitatif dengan analisis konten terhadap literatur ilmiah, dokumen kebijakan, dan studi kasus dari sumber primer dan sekunder. Data dikaji melalui metode deskriptif-analitis dan disajikan secara grafis. Hasil penelitian menunjukkan bahwa penyemaian awan menimbulkan ancaman kesehatan berupa kontaminasi air, kanker atau iritasi kulit, gangguan pernapasan, dan ketidakseimbangan ekologis. Penelitian juga mengidentifikasi ketiadaan hukum kesehatan masyarakat global yang secara langsung mengatur penyemaian awan. Penelitian menyimpulkan bahwa meskipun penyemaian awan berpotensi untuk mitigasi perubahan iklim, kesehatan dan keselamatan masyarakat harus dipertimbangkan. Oleh karena itu, diperlukan kerangka regulasi global yang mapan, penilaian ketat terhadap dampak kesehatan masyarakat, dan transparansi publik dalam inisiatif modifikasi cuaca.

Kata kunci: Penyemaian Awan, Global, Kesehatan Masyarakat, Regulasi

Received: May 3, 2025; Revised: September 29, 2025; Accepted: October 18, 2025

INTRODUCTION

There is no doubt that the global environment is currently experiencing climate change as a result of global warming (Anani et al., 2025; Aidonojie et al., 2022). However, the global community has been conscious of the imminent dangers that may arise from climate change, most especially in the aspect of drought and prolonged drought (Ukhurebor & Aidonojie, 2021; Aidonojie & Francis, 2022). Hence, to curtail these challenges, there has been a current scientific discovery known as cloud seeding, which involves a scientific weather modification (Zou et al., 2019). Cloud seeding involves the introduction or release of chemical agents or substances into the atmosphere to generate artificial precipitation, which may result in rain, drizzle, or light rain, frozen droplets, and lumps of ice (Knowles & Skidmore, 2022). It must be noted that cloud seeding made use of some chemicals, which include: liquid propane, sodium chloride (NaCI), Silver iodide (AgI), Calcium chloride ($CaCI_2$), Potassium iodide (KI), and solid carbon dioxide (Bauerly et al., 2019). Cloud seeding is said to be beneficial in responding to and resolving challenges of water shortage, prolonged drought, the threat of devastation, and enhancing agricultural production.

Although the scientific discovery of cloud seeding is considered beneficial, however, concerns about its long-term impact on public health could be deleterious and pose a danger to the global community (Fidler & Gostin, 2020 As the practice becomes more widespread, scrutiny over the safety of the chemical substances used and their potential impacts on human health has intensified. In this regard, the danger and threat posed by cloud seeding to public health are a result of the chemical substances (Bloche, 2003). For example, the excessive use or exposure to excess potassium iodide and sodium chloride could result in or affect the functionality of the thyroid and soil salinity, respectively (Zhou et al., 2020). Also, scientific discovery has revealed why liquid propane could be flammable and pose a threat of suffocation in an enclosed area because it can displace oxygen when used in high concentrations (Bartlett & Sandland, 2013). However, calcium chloride could result in respiratory challenge when inhaled in large amounts, and silver iodide could result in water and soil pollution when accumulated in large quantities (Protásio, 2021). In this regard, it apt to state that where a community or individual has a long exposure close to cloud seeding zones it could result in neurological disorder, respiratory illness, skin irritation or disease and other several illnesses that may occur as a result of exposure to the chemicals use in cloud seeding over a long period (Aginam, 2005). Hence, this may in turn compound and complicate already existing challenges of public health that have yet to be resolved by the global community.

Scientific evidence suggests that changes in climate have made extreme weather events more intense, and cases of long spells of drought have undermined agricultural output, food insecurity, and the availability and quality of water (Ayodele & Nasir, 2019; Mbeli, 2019). All these perturbations would have direct impacts on public health, such as malnutrition, increased transmission of communicable diseases, and higher exposure to waterborne diseases. With that, cloud seeding is touted as a silver bullet to these climate-related challenges, yet, lacking proper governance, intentional chemical seeding of the atmosphere might introduce new ecological and health risks that build upon existing ones." Furthermore, the danger and threat posed by cloud seeding affects not only human public health directly, but could also indirectly through infected food crops and animal livestock consumed by humans. Furthermore, cloud seeding also has ecological effects, affecting public health (Burris et al., 2010). Changing weather patterns, interruption of natural precipitation cycles, and possible environmental degradation, which could result in the modification of habitats for human and wildlife cohabitation. Hence, these disruptions

could result in the breeding and introduction of new pathogens or the increased transmission of waterborne and vector-borne diseases (Burris et al., 2016). Concerning this, vulnerable populations such as children, the elderly, and ill individuals can be heavily affected. This gives weight to the notion that adverse health effects that could arise with cloud-seeding require emphasis, especially when the application extends to diverse climatological settings (Coggon, 2012).

Concerning the above, it can be argued that despite the public health challenges posed by cloud seeding and there are no global comprehensive public health laws that have significantly addressed the dangers and threats posed by cloud seeding to public health (Cohen, 2012). Although the only existing global laws concern the militarisation of cloud seeding during warfare. In this regard, no global environmental laws and public health laws have been developed to address the safe use of cloud seeding and ensure public safety against any imminent threat or dangers that may emanate from the reliance on cloud seeding in addressing climate change (Dash, 2019). In this regard, it suffices to state that this regulatory gap serves as a hindrance to conducting large-scale epidemiological studies and attempts to establish universal safety standards (Wing et al., 2018). Hence, without a binding comprehensive international regulatory framework and institutions to oversee the practice of cloud seeding, which involves weather modification activities, it could result in an unregulated expansion of cloud seeding programs, especially in areas or regions with limited scientific or regulatory capacity, thereby exposing the public health to potential threat and dangers (Fajardo et al., 2016). This, in essence, creates a legal vacuum, an environment where countries may engage in cloud seeding without scientific justification, robust oversight, and adequate health impact assessments.

It is concerning the above that this study examines the concept of cloud seeding and its potential threat and dangers to public health. The study also sought to identify the shortcomings and challenges concerning the existing public health regulatory framework as it concerns cloud seeding. The study will further advocate for the establishment of a unified global regulatory mechanism that prioritizes public health safety in using and relying on cloud seeding toward climate change mitigation.

RESEARCH METHOD

The study focuses on examining the threat and effects of cloud seeding on public health to strengthen global regulation and assessment of the threat and dangers posed by cloud seeding to public health. In this regard, to successfully embark on this research, the study relied on a doctrinal method of study with a heavy reliance on primary (such as global public health laws) and secondary sources of research materials (such as textbooks, journal articles, and other research material relevant to this research study. Doctrinal studies offer a defined schema for considering how global regulations may be harmonized with international obligations related to public health, specifically through the interpretation of treaties, conventions, and soft law, to promote the same objectives across different jurisdictions. In the context of cloud seeding and weather modification technologies, doctrinal studies can clarify how these practices of geoengineering engage with international law frameworks, including obligations relating to international environmental law to prevent transboundary harm and support ecosystem integrity, and human rights law, including a right to health, life, and a clean environment. By examining legal texts and judicial interpretation, doctrinal studies reveal the boundaries for the regulation of weather modification

to mediate scientific innovation with the need to protect public and environmental good, thus linking the applications of science with global legal standards and public health parameters.

Data obtained from the secondary and primary sources of research material were subjected to critical analytical review. The doctrinal methodology for this study begins with the organised gathering of relevant legal sources, creating a groundwork for the follow-up analysis. This step includes considering international treaties, conventions, and agreements that pertain to environmental protection, public health, and human rights, as well as regulations or guidelines from recognised institutions such as the World Health Organisation (WHO). Additionally, we must consider national legislative frameworks that regulate weather modification technologies, both directly and indirectly. Collecting these materials creates a comprehensive source corpus of legal sources to base this research on legal instruments that could tie cloud seeding practices to established legislative standards of global regulatory and public health systems.

The second phase of the method is a critical consideration of whether or not the identified legal sources are sufficient to address perceived risks and concerns raised by cloud seeding. This can investigate if the existing international legal regime has adequately evaluated the public health implications for human populations, the ecological consequences of climate change, and the liability of states or non-state actors participating in weather modification. Emphasis will be placed on examining gaps, overlaps or inconsistencies in international legal regimes. Finally, as the third methodology step, it is a legal comparison. This step allows for a comparison of the legislative approach of jurisdictions with and without regulatory frameworks for weather modification. By framing for review jurisdictions in which cloud seeding has, or uses, has been or is not problematic.

The essence of adopting a doctrinal method of study is to effectively theorise the concept of cloud seeding and its related dangers and threats posed to global public health, given the chemical component that is involved in it process or usage. Furthermore, it also aims to examine the existing global health laws as they concern the measures and strategies to combat the threat and dangers posed to public health in relying on cloud seeding for weather modification. Furthermore, to propose possible solutions that could strengthen the level of regulation in addressing the threat and dangers of cloud seeding to public health.

RESULTS AND DISCUSSION

The Scientific Concept of Cloud Seeding and Its Application

Cloud seeding involves a weather modification to increase the level of precipitation by artificially introducing substances into the atmosphere (Akinsulore et al., 2024; Aidonojie et al., 2024). The theory behind it is that there is water contained in droplets of clouds; some of them do not condense into a rain form due to unfavorable atmospheric conditions. Cloud seeding does this by introducing condensation nuclei to help the water vapor condense and form larger droplets that would be heavy enough to fall. This could typically involve using aircraft to spray it or ground generators, and has been used for increases in rainfalls, drought relief, hail reduction, and snowpack enhancement in mountains (Faunce & Watal, 2010). With changes in climatic variability and increased water scarcity, the importance of cloud seeding has risen quite dramatically. Considering how many parts of the globe experience prolonged seasons of dryness and erratic rainfall patterns, cloud seeding is now seen as a feasible short-term, temporary relief for the problem of water shortages (Singh, 2019). Countries such as China, the USA, the United Arab Emirates, and Australia have instituted cloud seeding strategies mainly to support and augment agricultural production, manage water resources more effectively, and reduce negative impacts

caused by severe weather events (Anani et al., 2023; Aidonojie et al., 2023). In addition, cloud seeding is given preference as an adaptable tool for maintaining food security and economic stability in arid and semiarid regions.

Beyond this, however, it has vast potential for improving global water security and disaster preparedness (Anani et al., 2024; Aidonojie et al., 2024). For example, it could impart moisture and help lessen fire risk in dry areas or those prone to wildfires. Adding snowpack through cloud seeding bolsters hydropower and storage capabilities in areas dependent on snow. Additionally, if done wisely, this could be used in adaptation strategies for climate change by providing water during climatically uncertain circumstances (Fidler, 1999). Its potential is great, but it should not be seen as an alternative to sustainable water management practices or long-term environmental conservation efforts. The effectiveness as well as the safety offered by cloud seeding heavily depend on the kind and quantity of chemicals used in the process. Silver iodide was and still is the most commonly used agent; this compound closely mimics the crystalline structure of ice in nature, and it promotes the formation of snow and subsequently rain (Fidler & Gostin, 2006). Other agents include potassium iodide, calcium chloride, liquid propane, and dry ice (solid carbon dioxide). In hygroscopic seeding, salts such as sodium chloride or magnesium chloride are applied to attract water vapor for droplet formation (Fleming, 2006). These chemicals are dispersed into clouds either directly by aircraft or through ground-based flares and rockets.

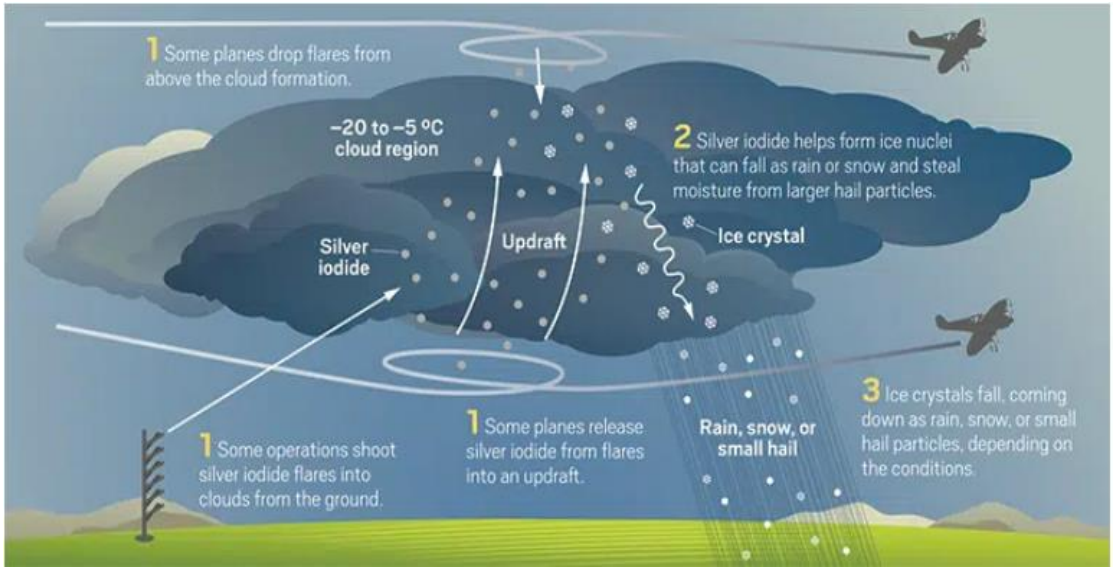

Figure 1: Process involved in Cloud Seeding (Source: Orkhan Huseynli, 2025)

Cloud seeding is a lengthy procedure involving many stages, beginning with the identification of appropriate conditions in the atmosphere and cloud masses that could support some precipitation. A meteorologist is engaged in weather monitoring on a real-time basis to understand moisture content in clouds, their wind flow, and temperature profiles. So, this is followed by assessing the properties of clouds (Gostin, 2000). After the clouds have been identified, the choice of chemical seeder may include glaciogenic agents such as silver iodide to catalyze the formation of ice crystals in cold clouds or hygroscopic agents such as sodium chloride to stimulate droplet

growth in warm clouds (Anani et al., 2023; Aidonojie et al., 2022). This preparatory step is extremely important to guarantee the efficacy and efficiency of the seeding operations. Cloud seeding may then be put into operation with either an airplane or a ground dispersion system (Gostin, 2010). Aerial flares or burners mounted on aircraft discharge the chemical agents directly into the clouds as the airplane flies through the clouds, so targeting well-moistened areas precisely. In addition, the ground generators placed on high-altitude locations ignite the chemicals so that particles rise into the atmosphere through updrafts (Herndon, 2016). When the particles enter the cloud, they act as nuclei that allow water vapor to condense or freeze, depending on temperature. This gives rise to larger droplets or crystals until they attain sufficient weight to precipitate. The process is continuously monitored in real-time to assess its success and possible impacts on the environment.

The technology of cloud seeding thus symbolizes a most promising way to address some of the foremost world environmental challenges, particularly those that relate to water insecurity and climate change (Herndon & Whiteside, 2017). However, determining if this glorious scheme would ever work depends on a dispassionate weighing of its benefits versus its risks and limitations. Gradual acceptance of cloud seeding as a water-replenishing strategy internationally would warrant the monitoring of chemicals used, transparent operations, and specific guidelines to uphold public health and environmental concerns (Hervey & McHale, 2004). The lack of regulations and scientific discussions may even return an outcome that can be worse than the anticipated benefits of this intervention in the day-to-day life of people.

Threat and Effect of Cloud Seed on Public Health

While cloud seeding has been regarded as a blessing to generate useful precipitation and mitigate droughts, several problems with public health that have become more evident over the years lurk (Aidonojie et al.,, 2024; Aidonojie et al., 2023). The technique, developed in the late 1940s, was mainly heralded in its early years for enhancing rainfall for agriculture and water resources management (Whiteside & Herndon, 2018). At the time, limited scientific knowledge and regulatory oversight meant that little attention was paid to side effects that may be associated with chemicals used. By then, cloud seeding was celebrated as an innovation with fewer known risks, and it was implemented widely with little or no public health assessments. Eventually, as cloud seeding activities began to spread worldwide through the 1970s and 1980s, concerns regarding the chemical agents began to arise, with concerns particularly aimed at silver iodide (Agathokleous et al., 2022). Silver iodide, although an effective precipitation Inducer, gets its characterization as a heavy metal that can accumulate in the environment. The studies began to indicate the possibility of silver iodide residues slipping off into the soil for further contamination of water sources and absorption into plants, thus creating avenues for bioaccumulation in humans and animals (Islam et al., 2020). Chronic exposure to elevated levels of silver has been linked with several disturbances, including argyria (a bluish-gray discoloration of the skin) and likely disturbances of kidney and liver functions (Jacobson & Hoffman, 2003).

Over the past decades, advancements in techniques of monitoring have increasingly allowed scientists to detect and track where these chemicals manifest themselves in the environment. Evidence suggests that in cloud seeding-pervasive areas, rainfall seeding chemicals contaminate drinking-water supplies and agricultural produce, which has severe health implications for host populations, particularly communities dwelling near such persistent seeding areas (Khera & Irshad, 2023). Long-term ingestion or even inhalation of agents of cloud seeding could result in respiratory

conditions, neurological disorders, and reproductive health problems. Vulnerable populations include children, the elderly, and individuals having previous chronic illnesses. Cloud seeding may also change natural weather patterns to indirectly affect public health (Kumar & Agnihotri, 2024). Artificially enhanced rainfall in one locality can mean suppressed precipitation somewhere else, thus destabilizing water availability at the regional scale. Flash floods and landslides have been instigated in certain scenarios by changes in weather, as with increased humidity, thus causing conditions favorable for creating environments indoors, all kinds of waterborne and vector-borne diseases (Mello et al., 2008). Standing pools of water caused by excessive rainfall favor mosquito breeding, which can lead to increased incidences of malaria and dengue fever in the population. These ecological imbalances are significant in causing other general health challenges that are usually ignored in debates about the modification of the weather (Powers & Faden, 2006).

Insufficient and a lack of comprehensive environmental impact assessments and public health studies remain an important challenge to be overcome. Almost all countries perform cloud seeding without transparency, public consultations, or long-term monitoring (Richards & Rathbun, 2008). Not much data has been generated on the cumulative effects of cloud-seeding chemicals over a period. Most studies available are either short-term or narrow and fail to capture the larger picture. There is also no globally applicable consensus or standardized methodology to assess the health risks of cloud seeding, hampering international cooperation in managing possible hazards (Taylor, 2004). Water resource improvement and management promises from cloud seeding, but at the same time, brings multiple public health threats that require immediate attention. All of these elements accumulate to an increasing, almost maddening level of concern: use of chemical agents, build-up in the environment, and indirect effect upon disease ecology. Improve regulatory systems, foster international scientific cooperation, and conduct reliable long-term studies on health to mitigate the threats (Powers & Faden, 2006). They, rigorous in their assessment and transparent in governance, allowing the safe realization of the potential without compromising public health.

Legal Regulation of Cloud Seeding as it Affects Public Health

The scientific discovery of cloud seeding no doubt seems to have gained global recognition towards Climate change mitigation. However, despite the relevance of cloud seeding, the health implications as it concerns its use are quite severe, given the chemical substances and composition that are involved in the use of cloud seeding. Despite the prominence and threat posed by cloud seeding to public health, there seems to be an absence of global public health Laws that tend to address the dangers and threats posed to public health by cloud seeding. Although there are several international public health Laws as it concerns securing the health safety of the general public. Some of these laws are addressed as follows.

It suffices to state that one notable and primary law as it concerns cloud seeding is the Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques. This convention came into force in 1977, though it seems not to focus on securing public health and management of cloud seeding as it concerns public health safety. However, the convention has several provisions that tend to regulate how cloud seeding should be utilized and should not be used as a military weapon for warfare. Article 1 of the convention seems to convey this point by stipulating that member states are prohibited from relying on and using any form of environmental modification process that may pose a long-term and widespread challenge, damage,

or destruction. Though this provision seems to be concerned with the use of weather modification for warfare, it can be interpreted to mean a potential means to secure public health during a wartime period which nations are like to utilise cloud seeding as a weapon of destruction. Furthermore, Article One could be interpreted to mean that it tends to preserve and protect the health ecosystem, such as air, clean water, and land, that are required to maintain a healthy standard of living. Hence, the use of cloud seeding as a military weapon to alter the natural state of the ecosystem to cause severe damage to a fellow warring nation is strictly prohibited. Furthermore, Article III of the convention further stipulates that the convention and its provisions therein shall not be an obstacle to the use of cloud seeding for incidents or purposes that are peaceful. However, this provision seems to have endorsed the use of cloud seeding irrespective of the dangers and threat it could pose to public health, with the excuse that the purpose of it use is peaceful. In essence, as long as the use of cloud seeding is peaceful, it is deemed permissible, irrespective of the fact that it may pose a negative impact on global public health.

However, the provision of Article III further stipulates that where a state conceives or has evidence that another state violates the obligation stipulated in the convention, it may lodge a formal report or complaint. It must be noted that the obligation therein is as provided in Article I, which prohibits the militarization of cloud seeding or any form of weather modification. In essence, where an individual is utilizing cloud seeding for a peaceful purpose and there is a severe resultant effect on public health, such a state has not violated in obligations under the convention. However, a notable provision of the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques is article V, which is considered very relevant to address the current trend and challenges posed on public health through the use of cloud seeding. This is concerning the fact that the provision stipulates that state parties to the convention are required to hold a conference after five years of the convention being adopted. The essence of the conference aims to review the convention operation. In this regard, this creates an avenue and possibilities of addressing the pressing challenge and threat cloud seeding or any form of weather modification poses to public health. Given this, the convention could be reviewed through this medium and incorporate an elaborate provision as it concerns the protection and securing of public health.

Also relevant to cloud seeding threat and dangers posed to public health is the World Health Organisation's International Health Regulations 2005. The regulation is a global binding law accepted by 196 countries, a law to address and cater for issues and challenges concerning cross-border global public health. Although this regulation was not specifically tailored to address the dangers and threats of cloud seeding to global public health. However, there are certain provisions of the regulation that, by implication and interpretation, relate to cloud seeding and the imminent danger poses to public health. For example, Article I of the regulation refers to public health risk as an event that could pose severe and adverse dangers to human health and is capable of spreading globally. In this regard, cloud seeding could be interpreted to fall within this definition, most especially when it utilises chemicals such as iodide silver that over-concentration, could affect water and air quality, and other chemicals that could result in cancer, respiratory illness, and other health challenges. In this regard, article VI of the regulation mandates that states always promptly inform the World Health Organisation of any health risk that is capable of cross border infection and requires a global health emergency. However, Annex 2 of the convention specifies the condition for assessment of disease that should warrant WHO notification as follows: i. The impact of the threat, II. Is the threat unusual, III? Is there a threat of global spread, IV? Will it result in a ban on

international movement? If this condition has been followed to assess the threat or danger posed by such illness, the state party is required to notify the WHO. However, Article 13 of the regulation requires member states to ensure a well-developed and strengthened healthcare system capable of responding to public health risks. However, one challenge of health risk posed by cloud seeding is that the health challenge posed may not warrant a state to draw the international community's attention for a prompt response. This is concerning the fact that the majority of the health threats of cloud seeding such as respiratory issues, cancer, skin irritation, liver and kidney disease, and ecological disruption. This health threat may be classified under non-communicable disease, which does not have a global spread or cross-border infection.

At the international institutional level, the World Meteorological Organization (WMO) provides the most authoritative regulatory and normative framework governing cloud seeding through its Weather Modification Statement of Guidance and the Guidelines for the Planning of Weather Modification Activities (WMO Report No. 1185, 2018). These documents, albeit non-legally binding, function as international standards widely acknowledged by states and research institutions. The guidelines specifically prescribe that all weather modification projects, including those for cloud seeding, must be studied scientifically, weighed for environmental impact, and monitored for potential effects on ecosystems and human health before execution. The WMO underlines the precautionary principle, reminding states that: `weather modification activities shall not create unacceptable risks to public health, safety, property, or the environment' (WMO, 2018, Sec. 2.3). Complementing this, the United Nations Environment Programme (UNEP), through its Governing Council Decision 14/14 on Weather Modification (1987), called for international oversight and transparency in weather modification activities; states were urged to monitor transboundary impacts and their potential impacts on ecological and human health. While neither of the WMO and UNEP instruments carries the force of treaty law, their provisions set internationally accepted standards of due diligence, thereby shaping state practice, and so strengthening the principle that weather modification should be subjected to heavy regulation to protect the public's health from unforeseen risks of chemical interferences with the atmosphere.

Another notable and relevant global law as it concerns the safety of public health is the Global Charter for Public Health, which is a collaborative initiative of the World Health Organisation and the World Federation of Public Health Association. The charter provides for the following main focuses, such as Governance, Protection, Prevention, Information and Advocacy, which a represented in a diagram below.

Figure 2: Key focus of the Global Charter for Public Health (Sources: World Federation of Public Health Associations (WFPHA) Global Charter for the Public's Health)

Concerning the above, it suffices to state that the charter provides means of ensuring global public health safety and the need for proper action against any threat to public safety and the health system. Although the charter wasn't specifically designed to address issues as it concerns the danger and threat posed by cloud seeding to public health. However, the charter could serve as a parameter for assessing the impact of cloud seeding on global public health. This is a concerning fact that the charter seeks adequate protection of public health against any harm that could be disastrous (Sabatino, 2010). Hence, it further required a proactive measure to be in place to address any potential threat (which could be interpreted to include the dangers and threats posed by cloud seeding) to public health. Furthermore, the charter clarified the need to ensure accountability, transparency, and inclusive governance in public health (Reisner et al., 2015). Which in essence required that cloud seeding should be adequately regulated with an idea public health law and policies, government, and various stakeholders must ensure transparency and accountability of the use of cloud seeding and its potential harm to public health.

Furthermore, as it concerns the global legal environmental framework on cloud seeding and public health. The Kyoto Protocol (1997) and the United Nations Framework Convention on Climate Change (UNFCCC, 1992) each provide a global framework that indirectly regulates cloud seeding-type activities by addressing the underlying concern of anthropogenic interference with the climate system and related environmental and public-health risks. Kyoto Protocol Article 2(1)(a) obligates Annexe I Parties to develop and implement policies to mitigate climate change by reducing greenhouse gas emissions while encouraging practices that reduce adverse effects on public health and the environment. The UNFCCC contains a similar requirement in Article 3(3), which obligates Parties to undertake precautionary measures to anticipate, prevent, or minimise causes of climate change and to mitigate its adverse effects, which includes risks to human health. Article 4(1)(f) also obligates Parties to promote and cooperate in supporting research and systematic observation of the climate system, which extends to technologies such as weather modification that are intended to affect processes in the atmosphere. Neither the Kyoto Protocol nor the UNFCCC explicitly refers to cloud seeding; however, obligations for precaution, actions for transparency, and protection of human health and ecosystems create a normative basis for regulating the use of chemicals for cloud seeding to ensure that states reduce the risk of climate change, risk of transboundary harm, and risk of harm to the environment.

However, it suffices to state that several countries have also adopted the scientific discovery of cloud seeding within their territory to address drought and hail challenges. However, these countries, such as China and the USA, seem to be among the countries that have not only adopted cloud seeding as a potential measure in addressing prolonged drought and hail, but also enacted national laws to coordinate and regulate its use within their territory. For example, China has adopted the Regulation on Administration of Weather Modification (Regulation No. 348, Decree of the State Council, in effect since 1 May 2002). The regulations suggest a tightly controlled administrative structure that governs how cloud-seeding activities shall be planned, permitted, and conducted, all of which can have implications for public-health measures. The Regulations provide that formal work plans for weather modification shall be developed by qualified local meteorological departments, in consultation with relevant administrative organs and with the approval of the people's government at the appropriate level. When cloud-seeding activities are executed in accordance with an approved work plan, such activities can be designated as "public welfare," and applicable costs can be borne by the government, thus embedding government

oversight and funding in the operational structure of the cloud-seeding activities as stipulated in Article 5. Also, Article 6 requires operators to then execute the cloud-seeding activities only under appropriate meteorological conditions and to fully incorporate "local needs for planning against and mitigation of disasters, and the results thereof". Further, Article 7 requires that local governments will conduct experts' assessments of the effects of cloud-seeding, and will organise local expert assessment panels as required. Additionally, the Regulations set out details of technical and safety control measures: organisations must meet some prescribed qualifications as stipulated in Article 9, operating personnel must be trained and examined before conducting any activities, use of anti-aircraft guns, rockets, or aircraft must be conducted only with approvals from controlled airspace and coordination with aviation authorities as contained in Articles 8 and 11. In addition, the transfer and storage of ordnance involved in some operations is subject to national weapons and explosives legislation as contained in Article 16. Together, these provisions provide an administrative, technical and inter-agency structure of oversight with a view to preventing operational error, accidental exposures, and requiring the government to review all incidents, all of which can limit operational risk to public health and ensure accountability.

However, despite these governance features, the Regulations do not give direct governance of public health risk, as they do not impose explicit provisions for health impact assessments, health monitoring, disclosure obligations or remediation obligations directed specifically at human health gaps that scholars caution may leave procedural and substantive protections short of what the international public health standard would require. Statutory emphasis on approved work plans, expert assessments, or qualified personnel does provide significant procedural safeguards (including, but not limited to, technical assessments of particulate agents, timing and method of dispersal), and the fact that the legislation categorizes the legal basis for state responsibility for prevention measures and responses indicates a public welfare approach is being considered; however, published analysis on China's expanding program indicates that domestic provisions still fall short of addressing procedural legal requirements under customary international norms (including cross-border notifications, cumulative assessment of risk factors, or independent health assessments) would not address trans-boundary and accountability risks to public health. In practice, this means that even though the Regulations give the administrative mechanisms (licensing, training, aviation safety, expert opinion) which can reduce most operation risks to manageable levels, there is room for additional stricter, health-oriented regulation mechanisms i.e., mandatory environmental and health hazard assessments, public notification of seeding agents and surveillance, and clear liability/compensation policies if cloud-seeding activities are to be subject to demanding public-health and international law standards.

Under the Arizona Revised Statutes Weather Control and Cloud Modification (Title 45, Chapter 9), cloud seeding and other weather modification activities are heavily regulated through a licensing and reporting framework designed to protect the environment and public health. Specifically, Section 45-1803 indicates that no individual or corporation, other than federal or state agencies, may engage in cloud modification before obtaining a license from the Director of Water Resources; this creates an obligation for oversight by the state before chemicals are applied to the atmosphere. License applicants must show that they meet qualifications established by statute, pay a received fee, and submit detailed plans of operations that describe the types of agents and methods of seeding that are going to be utilised as stipulated in Sections 45-1805–1806. Section

45-1808 not only establishes a license, but it also requires that the operators of those activities file regular reports which describe the chemical use, times, and locations of the seeding process; regular reporting will help provide some informal monitoring for health and environmental risks. Additionally, Section 45-1810 allows for the suspension and revocation of a license based on some "misconduct" or negligence of health or environmental reporting, thus establishing some accountability. While the statute mainly focuses on administrative licensing and control for these activities, the requirements for state authorization of the chemical use and continued reporting also provide some safeguards that protect public health, as the affected public may not be subjected to chemical agents without regulatory actions occurring.

Concerning the above, it suffices to reiterate that several global laws examined above clearly reveal that they tend to provide for the protection and safeguard of public health, but none directly address the potential harm that cloud seeding could pose to the global public health. Although with an implied interpretation of the above laws, they could be narrowly applied to cloud seeding and public health. In essence, it is required that for an effective protection and safeguarding of public health against the imminent threat and dangers posed by cloud seeding, there is a need for global public health laws to address this legal gap. However, China and the USA, which have adopted the concept of cloud seeding, have well-documented laws that address the concept of cloud seeding and public health impact.

Legal Issues and Challenges

The regulation of cloud seeding has exposed numerous complications as far as public health is concerned, and this is mainly due to the absence of any direct international legal framework that addresses public health implications (Swanson & Ibrahim, 2023). With cloud seeding defined as the dispersal of silver iodide, potassium chloride, or some other kinds of substances within the atmosphere in inducing precipitation, it is more commonly seen for weather states in continuing research, as it serves a further purpose as a climate intervention (Taylor, 2002). Nevertheless, it has now begun to be considered a more serious public health risk in terms of its interference with air and water quality. Despite increased usage and dangers attached, it is blatantly clear that there is neither a comprehensive global law nor an international instrument to properly regulate the cloud seeding practice in connection with health outcomes (Rothstein, 2002). This has now created enough scope for interpretation along national lines, with a significant lack of accountability against environmental and health impacts. Hence, before carrying out cloud seeding, national or international authorities must perform rigorous health-risk evaluations, including toxicological evaluation of seeding materials, modeling of probable routes of exposure, and monitoring of short- and long-term impacts on air, water, soil, and food chains (Oloworaran, 2023). Mechanisms should also include epidemiological studies and public-health monitoring to detect, prevent, and control adverse health effects on target groups and ensure that weather modification operations meet precautionary and safety standards.

The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques is one of the highly cited international instruments that slightly covers the environmental modification concerning cloud seeding (Nwedu, 2024). Since ENMOD prohibits the use of environmental modification techniques-whether this be weather modification-really, for military purposes or any hostile purposes, peaceful uses of such techniques are not prohibited, even if, under certain circumstances pose a health hazard. The interpretation of Article I brings concern

about environmental harm, which may, in an indirect manner, reach public health, while quite apparently, the focus is military. So, an example of limitation of health issues within the convention would be where Article III allows for peaceful applications of environmental modification, including cloud seeding, and hence, another framework would be required that is health impact-oriented at the expense of whichever purpose. Moreover, while health interventions of global scope, the WHO International Health Regulations (2005) do not specifically mention cloud seeding. However, the potential for including certain cloud-seeding activities with harmful chemicals in their ambit could be argued based on an expansive interpretation of public health risks articulated in Article I, as well as notification requirements provided in Article VI. However, with most public health issues associated with cloud seeding being non-communicable, such as respiratory problems, cancers, or even environmental degradation, they scarcely reach the WHO's threshold for international notification or emergency response. This speaks of an inherent structural limitation within extant global health laws, which really focuses on communicable diseases and therefore tends to exclude environmental health threats such as those posed by cloud seeding.

The Global Charter for Public Health, designed by the WHO along with the World Federation of Public Health Associations (WFPHA), provides a larger frame to cover areas such as governance, prevention, protection, and advocacy in public health. Although not legally binding, the charter may serve as a normative document for viewing the health consequences of cloud seeding. The principles of accountability, transparency, and inclusive governance, which are essential for steering and regulating environmental interventions such as cloud seeding, are a part of the calls made by the document. However, the major gap in this context is the absence of a binding international legal instrument tailored specifically for the regulation of cloud seeding along with its public health consequences. Hence, there is urgency in the creation of an international treaty or protocol that integrates environmental modification with public health law. A proactive and precautionary approach toward the use of these technologies for weather modification would thereby be ensured.

CONCLUSION

In a nutshell, while cloud seeding has emerged as a potentially valuable new development to curb several effects on climate change, such as drought and poor water availability, ultimately opens a Pandora's box of legitimate public health issues that cannot be left aside. The scientifically administered materials in cloud seeding, such as silver iodide, potassium iodide, and liquid propane, carry serious health risks, including respiratory ailments, neurological disorders, and contamination of water or soil; these effects would be exacerbated among more vulnerable populations, such as children, the aged, and immunocompromised individuals. Weather modification has triggered adverse disruptions, changed precipitation cycles, and caused an imbalance in ecosystems, which may aggravate the spread of vector and waterborne illnesses. Therefore, the unregulated enhancement of cloud seeding technologies without a well-grounded grasp of the long-term public health outcomes poses a serious ethical-medicine dilemma.

It suffices to state that, while both the United States (Arizona Revised Statutes, Title 45, Chapter 9) and China's Regulations on Administration of Weather Modification (Regulation No. 348) provide structured national frameworks for licensing, oversight, and accountability in cloud seeding, thereby indirectly guarding public health through administrative control, disclosure, and safety of operations in China, there exists virtually no comprehensive global regulation regarding the use of chemicals for

weather modification. The existing domestic laws attest to the ability of states to keep cloud seeding operations regulated within their territories, but the absence of an internationally binding framework transforms the very real transboundary risks, cumulative environmental impacts, and global public health concerns into a completely beggaring state. Thus, while these regulations in the U.S. and China illustrate different approaches to regulating cloud seeding having a bearing on public health, the critical governance gap caused by the non-existent binding global legal instruments undoubtedly underscores the urgent need for an international framework that will harmonize standards, secure precaution, and blanket the environment and human health.

Concerning the risks and threats posed by cloud seeding to public health, the lack of a truly comprehensive and enforceable global set of public health regulations for cloud seeding becomes a glaring legal deficiency that must be rectified as a matter of utmost urgency. Current international legal instruments prohibit only the militarization of weather modification and completely ignore civilian public health protections. This legal gap thus provides scope to wreak havoc with the indiscriminate use of potentially harmful practices and obstruct the basis on which standardized health impact assessments and epidemiological studies can be conducted. The study thus strongly recommends the development of a unified international regulatory mechanism requiring health risk assessments, environmental monitoring, and public transparency before and during cloud seeding operations. Such a legal framework would ensure that while cloud seeding goes right at Climate Adaptation, it does indeed go right in upholding fundamental rights to health and environmental safety for the present generation and in future generations.

REFERENCES

Agathokleous, E., Barceló, D., Rinklebe, J., Sonne, C., Calabrese, E. J., & Koike, T. (2022). Hormesis induced by silver iodide, hydrocarbons, microplastics, pesticides, and pharmaceuticals: Implications for agroforestry ecosystems health. *Science of the Total Environment, 820*, 153116. https://doi.org/10.1016/j.scitotenv.2022.153116

Aginam, O. (2005). *Global health governance: International law and public health in a divided world*. University of Toronto Press.

Aidonojie, P. A., & Francis, E. C. (2022). Legal issues concerning food poisoning in Nigeria: The need for judicial and statutory response. *Jurnal Media Hukum*, *29*(1), 65–78. https://doi.org/10.18196/jmh.v29i1.12595

Aidonojie, P. A., Adebayo, K. A., Eregbuonye, O., & Wakili, S. A. (2024). Breaking legal and socio-economic challenges to plastic waste regulation in Nigeria: Lessons learned from Singapore. *Yustisia*, *13*(1), 64–88.

Aidonojie, P. A., Aidonojie, E. C., Mulegi, T., & Eregbuonye, O. (2024). Legal issues concerning compulsory COVID-19 vaccination: Nigeria as a case study. *Golden Ratio of Law and Social Policy Review*, *3*(2), 74–83. https://doi.org/10.52970/grlspr.v3i2.349

Aidonojie, P. A., Ikubanni, O. O., Adebayo, A. K., Olujobi, O. J., & Mustafa, M. M. (2024). The role of digital and scientific technology in complementing global legal framework towards clean energy transition. *The Journal of Sustainable Development, Law and Policy*, *15*(3), 314–343.

Aidonojie, P. A., Okuonghae, N., & Ukhurebor, K. E. (2022). The legal rights and challenges of COVID-19 patients accessing private healthcare in Nigeria. *BESTUUR*, *10*(2), 183–197. https://doi.org/10.20961/bestuur.v10i2.68118

Aidonojie, P. A., Okuonghae, N., Moses-Oke, R. O., & Majekodunmi, T. A. (2023). A facile review on the legal issues and challenges concerning the conservation and preservation of biodiversity. *Global Sustainability Research*, *2*(2), 34–46.

Aidonojie, P. A., Ukhurebor, E., Oaihimire, I. E., Ngonso, B. F., Egielewa, P. E., Akinsehinde, P. O., Kusuma, H. S., & Darmokoesoemo, H. (2023). Bioenergy revamping and complementing the global environmental legal framework on the reduction of waste materials: A facile review. *Heliyon*, *9*(1), e12860. https://doi.org/10.1016/j.heliyon.2023.e12860

Aidonojie, P. A., Ukhurebor, K. E., Masajuwa, F., Imoisi, S. E., Edetalehn, O. I., & Nwazi, J. (2022). Legal implications of nanobiosensors concerning environmental monitoring. In R. P. Singh, K. E. Ukhurebor, J. Singh, C. O. Adetunji, & K. R. Singh (Eds.), *Nanobiosensors for Environmental Monitoring* (pp. xx–xx). Springer. https://doi.org/10.1007/978-3-031-16106-3_21

Akinsulore, A. O., Adejumo, O. A., & Aidonojie, P. A. (2024). Instream flow rights for protecting river ecology in Nigeria's bitumen zone: Learning from Uganda's experience. *JHR (Jurnal Hukum Replik)*, *12*(2). *(Add page numbers when available.)*

Anani, O. A., Abel, I., Osayomwanbo, O., Olisaka, F. N., Aidonojie, P. A., Olatunji, E. O., & Habib, A. I. (2023). Application of microorganisms as biofactories to produce biogenic nanoparticles for environmental cleanup: Currents advances and challenges. *Current Nanoscience*, *19*(6), 770–782.

Anani, O. A., Adama, K. K., Aidonojie, P. A., & Aregbor, O. (2024). Zooplankton and community phytoplankton: Influence of personal care products, legislative status, and possible remediation. In *Emergent Pollutants in Freshwater Plankton Communities* (pp. 80–93). Taylor & Francis (CRC Press).

Anani, O. A., Aidonojie, P. A., Aidonojie, E. C., & Anani, G. A. (2025). Current methods in the management and disposal of plastic wastes during COVID-19 pandemic. In O. A. Anani, M. Shahnawaz, M. A. Dar, & Z. Daochen (Eds.), *Plastic and the COVID-19 Pandemic* (pp. xx–xx). Springer. https://doi.org/10.1007/978-3-031-74769-4_3 *(Add page numbers when available.)*

Anani, O. A., Shah, M. P., Aidonojie, P. A., & Enuneku, A. A. (2023). Bio-nano filtration as an abatement technique used in the management and treatment of impurities in industrial wastewater. In *Bio-Nano Filtration in Industrial Effluent Treatment* (pp. 171–182).

Bartlett, P., & Sandland, R. (2013). *Mental health law: Policy and practice*. Oxford University Press.

Bauerly, B. C., McCord, R. F., Hulkower, R., & Pepin, D. (2019). Broadband access as a public health issue: The role of law in expanding broadband access and connecting underserved communities for better health outcomes. *The Journal of Law, Medicine & Ethics, 47*(2_suppl), 39–42. https://doi.org/10.1177/1073110519857310

Bloche, M. G. (2003). The invention of health law. *California Law Review, 91*, 247–263. https://doi.org/10.2307/3481329

Burris, S., Ashe, M., Levin, D., Penn, M., & Larkin, M. (2016). A transdisciplinary approach to public health law: The emerging practice of legal epidemiology. *Annual Review of Public Health, 37*(1), 135–148. https://doi.org/10.1146/annurev-publhealth-032315-021726

Burris, S., Wagenaar, A. C., Swanson, J., Ibrahim, J. K., Wood, J., & Mello, M. M. (2010). Making the case for laws that improve health: A framework for public health law research. *The Milbank Quarterly, 88*(2), 169–210. https://doi.org/10.1111/j.1468-0009.2010.00595.x

Coggon, J. (2012). *What makes health public?: A critical evaluation of moral, legal, and political claims in public health*. Cambridge University Press.

Cohen, N. (2012). Policy entrepreneurs and the design of public policy: The case of the National Health Insurance Law in Israel. *Journal of Social Research & Policy, 3*(1), 5–26.

Dash, B. (2019). Rain enhancement technology: Making sense of the "cloud seeding" program in India. *Bulletin of Science, Technology & Society, 39*(3–4), 33–42.

Dash, B. (2019). Rain enhancement technology: Making sense of the 'cloud seeding' program in India. *Bulletin of Science, Technology & Society, 39*(3–4), 33–42. https://doi.org/10.1177/0270467619882683

Fajardo, C., Costa, G., Ortiz, L. T., Nande, M., Rodríguez-Membibre, M. L., Martín, M., & Sánchez-Fortún, S. (2016). Potential risk of acute toxicity induced by AgI cloud seeding on soil and freshwater biota. *Ecotoxicology and Environmental Safety, 133*, 433–441.

Fajardo, C., Costa, G., Ortiz, L. T., Nande, M., Rodríguez-Membibre, M. L., Martín, M., & Sánchez-Fortún, S. (2016). Potential risk of acute toxicity induced by AgI cloud seeding on soil and freshwater biota. *Ecotoxicology and Environmental Safety, 133*, 433–441. https://doi.org/10.1016/j.ecoenv.2016.07.021

Faunce, T., & Watal, A. (2010). Nanosilver and global public health: International regulatory issues. *Nanomedicine, 5*(4), 617–632. https://doi.org/10.2217/nnm.10.29

Fidler, D. P. (1999). International law and global public health. *University of Kansas Law Review, 48*, 1–68.

Fidler, D. P., & Gostin, L. O. (2006). The new International Health Regulations: An historic development for international law and public health. *Journal of Law, Medicine & Ethics, 34*(1), 85–94. https://doi.org/10.1111/j.1748-720X.2006.00011.x

Fidler, D. P., & Gostin, L. O. (2020). *Biosecurity in the global age: Biological weapons, public health, and the rule of law*. Stanford University Press.

Fleming, J. R. (2006). The pathological history of weather and climate modification: Three cycles of promise and hype. *Historical Studies in the Physical and Biological Sciences, 37*(1), 3–25. https://doi.org/10.1525/hsps.2006.37.1.3

Gostin, L. O. (2000). *Public health law: Power, duty, restraint*. University of California Press.

Gostin, L. O. (2010). *Public health law and ethics: A reader* (2nd ed.). University of California Press.

Herndon, J. M. (2016). Human and environmental dangers posed by ongoing global tropospheric aerosolized particulates for weather modification. *Frontiers in Public Health, 4*, 139.

Herndon, J. M. (2016). Human and environmental dangers posed by ongoing global tropospheric aerosolized particulates for weather modification. *Frontiers in Public Health, 4*, 139. https://doi.org/10.3389/fpubh.2016.00139

Herndon, J. M., & Whiteside, M. (2017). Further evidence of coal fly ash utilization in tropospheric geoengineering: Implications on human and environmental health. *Journal of Geography, Environment and Earth Science International, 9*(1), 1–8.

Herndon, J. M., & Whiteside, M. (2017). Further evidence of coal fly ash utilization in tropospheric geoengineering: Implications on human and environmental health. *Journal of Geography, Environment and Earth Science International, 9*(1), 1–8. https://doi.org/10.9734/JGEESI/2017/38649

Hervey, T. K., & McHale, J. V. (2004). *Health law and the European Union*. Cambridge University Press.

Islam, M. S., Sarkar, T., Khan, S. H., Kamal, A.-H. M., Hasan, S. M. M., Kabir, A., ... & Hossain, A. (2020). COVID-19–related infodemic and its impact on public health: A global social media analysis. *The American Journal of Tropical Medicine and Hygiene, 103*(4), 1621–1629. https://doi.org/10.4269/ajtmh.20-0812

Jacobson, P. D., & Hoffman, R. E. (2003). Regulating public health: Principles and applications of administrative law. In R. A. Goodman, R. E. Hoffman, W. Lopez, G. W. Matthews, & M. A. Rothstein (Eds.), *Law in public health practice* (pp. 23–42). Oxford University Press.

Khera, G., & Irshad, S. M. (2023). From environmental management to risk governance: Air pollution case of Delhi, India. *International Journal of Environmental Technology and Management, 26*(1–2), 135–152.

Knowles, S., & Skidmore, M. (2022). Using weather modification to subdue severe weather. In S. Cutter, M. Skidmore, & K. Simmons (Eds.), *Handbook on the economics of disasters* (pp. 389–399). Edward Elgar Publishing.

Kumar, D., & Agnihotri, R. (2024). Air pollution control through technology: Effects on human health and legal systems. *Journal of Nehru Gram Bharati University, 13*(2), 28–42.

Mello, M. M., Pomeranz, J., & Moran, P. (2008). The interplay of public health law and industry self-regulation: The case of sugar-sweetened beverage sales in schools. *American Journal of Public Health, 98*(4), 595–604. https://doi.org/10.2105/AJPH.2007.117655

Nwedu, C. N. (2024). Exploring the legal and policy impact of the Russia-Ukraine war on energy security. *KIULJ, 6*(1), 27–49.

Oloworaran, U. E. (2023). An evaluation of the legal framework for resolving disputes in the digital ecosystem in Nigeria. *KIULJ, 5*(2), 50–64.

Orkhan Huseynli, "Unleashing the Power of Cloud Seeding: Navigating Potentials and Pitfalls", https://earth.org/unleashing-the-power-of-cloud-seeding-navigating-potential-and-pitfalls/, accessed 3rd of May, 2025

Powers, M., & Faden, R. R. (2006). *Social justice: The moral foundations of public health and health policy*. Oxford University Press.

Protásio, M. (2021). The regulation of geoengineering technologies: The case study of cloud seeding. *UNIO–EU Law Journal, 7*(2), 95–105.

Protásio, M. (2021). The regulation of geoengineering technologies: The case study of cloud seeding. *UNIO–EU Law Journal, 7*(2), 95–105.

Reisner, S. L., White Hughto, J. M., Dunham, E. E., Heflin, K. J., Glass Begenyi, J. B., Coffey-Esquivel, J., & Cahill, S. (2015). Legal protections in public accommodations settings: A critical public health issue for transgender and gender-nonconforming people. *The Milbank Quarterly, 93*(3), 484–515. https://doi.org/10.1111/1468-0009.12127

Richards, E. P., & Rathbun, K. C. (2008). Public health law. In *Public health & preventive medicine* (pp. 1259). McGraw-Hill.

Rothstein, M. A. (2002). Rethinking the meaning of public health. *Journal of Law, Medicine & Ethics, 30*(2), 144–149. https://doi.org/10.1111/j.1748-720X.2002.tb00378.x

Sabatino, C. P. (2010). The evolution of health care advance planning law and policy. *The Milbank Quarterly, 88*(2), 211–239. https://doi.org/10.1111/j.1468-0009.2010.00597.x

Singh, B. (2019). Profiling public healthcare: A comparative analysis based on the multidimensional healthcare management and legal approach. *Indian Journal of Health and Medical Law, 2*(2), 1–5.

Swanson, J. W., & Ibrahim, J. K. (2023). Picturing public health law research. In S. Burris et al. (Eds.), *Legal epidemiology: Theory and methods* (p. 189). CDC Foundation.

Taylor, A. L. (2002). Global governance, international health law and WHO: Looking towards the future. *Bulletin of the World Health Organization, 80*, 975–980.

Taylor, A. L. (2004). Governing the globalization of public health. *Journal of Law, Medicine & Ethics, 32*(3), 500–508. https://doi.org/10.1111/j.1748-720X.2004.tb01966.x

Ukhurebor, K. E., & Aidonojie, P. A. (2021). The influence of climate change on food innovation technology: Review on topical developments and legal framework. *Agriculture & Food Security*, *10*(1), 1–14. https://doi.org/10.1186/s40066-021-00327-4

Whiteside, M., & Herndon, J. M. (2018). Aerosolized coal fly ash: Risk factor for COPD and respiratory disease. *Journal of Advances in Medicine and Medical Research, 26*(7), 1–13.

Wing, C., Simon, K., & Bello-Gomez, R. A. (2018). Designing difference in difference studies: Best practices for public health policy research. *Annual Review of Public Health, 39*(1), 453–469. https://doi.org/10.1146/annurev-publhealth-040617-013507

Zhou, L., Liu, J.-M., Dong, X.-P., McGoogan, J. M., & Wu, Z.-Y. (2020). COVID-19 seeding time and doubling time model: An early epidemic risk assessment tool. *Infectious Diseases of Poverty, 9*, Article 1. https://doi.org/10.1186/s40249-020-00737-w

Zou, Y., O'Neill, S. M., Larkin, N. K., Alvarado, E. C., Solomon, R., Mass, C., ... & Liu, Y. (2019). Machine learning–based integration of high-resolution wildfire smoke simulations and observations for regional health impact assessment. *International Journal of Environmental Research and Public Health, 16*(12), 2137. https://doi.org/10.3390/ijerph16122137