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The Legality of Cloud-Seeding in the Jurisdiction of India

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ABSTRACT

Despite being carried out in India since 1951, cloud seeding, a weather modification technique that artificially induces rain to increase water supply, has not been thoroughly analysed with respect to its legality. Therefore, the main question this article addresses is whether cloud seeding is a lawful means of ensuring the right to water in India. To find reasonable answers, the legal principles of rightful purpose and rightful conduct are evaluated using doctrinal and normative methods to assess the legality. Additionally, qualitative content analysis is used to examine cloud-seeding operations in India. This article aims to address a research gap by providing a comprehensive legal analysis of previous scholarly work on cloud seeding. While earlier studies mainly focused on technological, environmental, or operational aspects, this article makes an innovative contribution by systematically compiling and analysing historical and current cloud-seeding experiments, with a focus on unresolved legal issues and their implications under Indian law.

Keywords: *Cloud-seeding, India, Right to water, Lawfulness, Rightful purpose, Rightful conduct*

I. INTRODUCTION

In quasi-federal India¹, the constitutional basis of the water right is implied by Article 21's 'right to life'², making it a state obligation. Confronted with the harsh reality of increasing water scarcity on the Indian peninsula, driven by population growth, water pollution, groundwater over-extraction, and climate change, States face the challenge of providing a continuous and stable water supply to ensure the fundamental human right to life. Historical trends in water scarcity in India show a sharp decline in per capita water availability, and recent reports from the Ministry of Jal Shakti (Ministry of Water Resources) project an average annual per capita

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¹ The Constitution of India 1950, Article 1 states, 'India, that is Bharat, shall be a union of States'. Even though India follows a federal system, it also possesses features of a unitary system of government. Therefore, it is appropriate to consider it a quasi-federal system. (n 136, 138, 139)

² *Id.* Article 21 reads, 'No person shall be deprived of his life or personal liberty except according to procedure established by law'. The Supreme Court of India has broadened the scope of this Article, with judicial interpretations including the water right, as further explained in Sections 2 and 4.

water availability of 1,486 m³ for 2021 and 1,367 m³ for 2031³. This aligns with efforts by national and State/Union Territory governments to artificially boost rainfall through cloud seeding to increase the water supply and bridge the water demand gap. This underscores the central dilemma of water rights for humanity and positions cloud seeding as a potential solution, despite the traditional alternatives i.e. desalination.

Cloud seeding is a weather modification method used to increase rainfall or mountain snowpack⁴. Therefore, cloud-seeding technology discussed in this article is limited to rain-inducing or rain-enhancing methods in India. To boost precipitation, cloud seeding involves introducing substances such as silver iodide (AgI), dry ice (Solid CO₂), sodium chloride (common salt, NaCl), calcium chloride (CaCl₂), liquid propane (C₃H₈), potassium chloride (KCl), urea, and others, into clouds using various aerial, ground-based, and drone-based seeding techniques. The first successful demonstration of cloud seeding was performed by I. Langmuir⁵ and Vincent J. Schaefer at the General Electric Research Laboratory in New York, who conducted the initial field test with dry ice in November 1946. This was followed by Bernard Vonnegut's discovery of silver iodide as an effective ice-nucleating agent in 1947⁶. These innovations laid the foundation for ongoing cloud-seeding experiments. The applications of cloud seeding include increasing rainfall during droughts, dispersing fog at airports, augmenting water supplies or replenishing reservoirs, enhancing groundwater, reducing air pollution⁷, and even mitigating hail damage or controlling rainfall during specific events, such as the 2008 Beijing Olympics⁸ and the British royal wedding of the Duke and Duchess of Cambridge in

³ See Press Information Bureau, *Per Capita Water Availability* (Ministry of Jal Shakti, 5 February 2024) <https://www.pib.gov.in/PressReleaseFramePage.aspx?PRID=2002726> last visited 28 August 2025.

⁴ See DRI, *Making it Snow: A Brief History and Review of the Science behind Cloud-Seeding* (DRI, 15 March 2023) <https://www.dri.edu/making-it-snow/> last visited 27 September 2025

⁵ Savita B. Morwal, B. Padmakumari, G. Pandithurai & J.R. Kulkarni, *The History of Cloud Seeding in India*, 17(2) BULL. OF IMSP (India Meteorological Soc., Pune Chapter) 7 (2018), <https://indipune.gov.in/imsp/Bulletins/BULLETIN%20OF%20IMSP%20Sept2018.pdf>.

⁶ See B Vonnegut, *The Nucleation of Ice Formation by Silver Iodide* [1947] 18 JOURNAL OF APPLIED PHYSICS 593 <https://ui.adsabs.harvard.edu/abs/1947JAP....18..593V/> last visited 28 August 2025

⁷ See Kushagra Dixit, *Can cloud seeding fix capital's bad air? Delhi govt. thinks so* (Times of India, 3 September 2024) <https://timesofindia.indiatimes.com/city/delhi/can-cloud-seeding-fix-capitals-bad-air-delhi-govt-thinks-so/articleshow/113002487.cms> last visited 23 August 2025; Also as winter approaches and following Diwali celebrations in October 2025, National Capital Region (NCR) Delhi's air quality had plunged to the 'severe' category where October 25, the Central Pollution Control Board (CPCB) recorded Delhi's overall Air Quality Index (AQI) at 259, placing it in the 'poor' category. In this backdrop, it is reported that Delhi aims to conduct artificial rain experiments next week, following a successful trial conducted in Burari. See Diksha Modi, *Delhi Pollution: How many planes will be needed for cloud seeding in the city?* (News 18, 25 October 2025) <https://www.news18.com/cities/new-delhi-news/delhi-pollution-how-many-planes-will-be-needed-for-cloud-seeding-in-city-ws-kl-9658242.html> last visited 29 October 2025.

⁸ See Guinness World Records, *First rain dispersal operation for an Olympic Games* (8 August 2008). <https://www.guinnessworldrecords.com/world-records/103665-first-rain-dispersal-operation-for-an-olympic-games> last visited 23 August 2025. This explains that the Beijing Municipal Meteorological Bureau launched 1,104 rain-dispersal rockets from 21 sites upwind of the city to precipitate rain before it reached the Bird's Nest stadium.

2011⁹. While these benefits are widely appreciated, concerns about their potential negative impacts remain, warranting further investigation and open debate. For example, soluble silver iodide may pose environmental and ecological risks and could affect human health¹⁰. Alterations in natural weather patterns may lead to unintended consequences¹¹, and water quality concerns arise regarding the total silver content in drinking water¹².

In this backdrop, this article endeavours to examine ways to bridge the gap between cloud seeding and its legal status, to ensure the right to water within Indian jurisdiction. Briefly, cloud seeding has been discussed in myriad scholarly works, covering technological, experimental, and operational approaches, as well as a few methods for assessing environmental impact, all of which have been widely used over the past seventy years. It is striking that, ever since, the literature has made it difficult to discern the legal significance of cloud seeding in academia; this article aims to address this apparent lacuna. Thereby, to find solutions for the problem question, whether cloud-seeding is a lawful method to ensure the right to water in India, the scope of the article is limited to the seldom scholarly work on the legal purview of cloud-seeding, rather than its long-considered social, environmental, and scientific perspectives.

This article, a synthesis of cloud-seeding attempts and their legality, uses the doctrinal and qualitative methods to analyse the legality of cloud-seeding attempts and the attempts themselves, respectively. The doctrinal (black-letter) approach focuses on legal rules and principles as found in the primary sources, i.e., case law, statutes, and regulations. As a method to ensure the right to water in explicating the lawfulness of cloud-seeding in India, in this article, the doctrinal method becomes major in divulging a descriptive and detailed evaluation on the legality of cloud-seeding with relevant case-laws, statutes and regulations related to the right to water, environment laws and cloud-seeding regulations in India, as well as available international legal sources on cloud-seeding. Moreover, normative analysis of laws related to the right to water and cloud seeding is used to evaluate existing cloud-seeding laws and practices against principles of rightful conduct and purpose, serving as the analytical benchmarks for assessing lawfulness in this article.

⁹ See Sahana Ghosh, *What is Cloud Seeding?* (Mongabay-India, 1 August 2019) <https://india.mongabay.com/2019/08/what-is-cloud-seeding/> last visited 22 August 2025

¹⁰ See Charles F Cooper and William C Jolly, *Ecological Effects of Silver Iodide and Other Weather Modification Agents: A Review* (1970) 6 WATER RESOURCES RESEARCH 88. <https://ui.adsabs.harvard.edu/abs/1970WRR.....6...88C/abstract> last visited 22 August 2025

¹¹ See Thomas P De Felice and others, *Extra Area Effects of Cloud Seeding—An Updated Assessment* [2014] 135-136 ATMOSPHERIC RESEARCH 193 <https://ui.adsabs.harvard.edu/abs/2014AtmRe.135..193D/abstract> last visited 23 August 2025

¹² See Agency for Toxic Substances and Disease Registry (ATSDR), *Toxicological Profile for Silver* (US DHHS, 1990) <https://www.atsdr.cdc.gov/toxprofiles/tp146.pdf> last visited 21 August 2025

To evaluate cloud-seeding operations in India, this article used a qualitative content analysis over discourse analysis. Content analysis supports gathering what is being said with an approach of a ‘bird’s eye’ viewpoint. In contrast, discourse analysis supports the construction of the meaning and social reality in the socio-cultural context. On the other hand, content analysis is ideal for analysing large datasets, while discourse analysis is ideal for analysing smaller datasets. In this paper, which aims to compile publicly available, non-classified cloud-seeding experiments conducted in India over the past seven decades since its first experiment in 1951, content analysis was used to collect all operational and experimental cloud-seeding data. This endeavour to gather more data aims to make a novel and up-to-date contribution to the literature by addressing the existing scholarly gap in a holistic analysis of cloud-seeding attempts.

The article proceeds as follows. Section 2 introduces the right to water in the Indian legal context, from ancient accounts of civilisations to the present-day development as a Constitutional and judicial rights-based approach. Section 3 provides a chronological evaluation of cloud-seeding attempts in India, including both experimental and operational/project-based efforts, emphasising the techniques, agents, and their applications, based on a qualitative content analysis of secondary sources. This component of the article structure also endeavours to elaborate on the historical, religious, and cultural context of weather modification methods in India since ancient times, thereby adding value to existing scholarly work. In Section 4, a critical overview of the law and policy of cloud-seeding on two dimensions; within the Indian jurisdiction and in comparison with the international domain is unfolded with doctrinal and normative analysis of the relevant legislations and the decisions of the Supreme Court of India and High Courts at the State/Union territory level¹³ while testing rightful purpose and rightful conduct as the analytical benchmarks of lawfulness to shed light on this component of the framework, followed by the concluding remarks.

II. THE RIGHT TO WATER IN INDIA

The initial step in analysing the overarching question of this article, the legality of cloud seeding, is understanding the concept of ‘water’ as a right. The reason for this argument is that precipitation, being the primary source of fresh water, in cloud seeding, clouds are artificially seeded to increase ‘water’ through precipitation. In this context, before considering cloud-seeding efforts, it is essential to examine the doctrine of the right to water in Indian

¹³ The Indian legal system is partly grounded in common law and relies on precedent. This article also refers to comments or observations in court decisions that are obiter dicta, that is, they are said in passing. They are not essential to the decision and do not form part of the ratio decidendi.

jurisprudence and its roots in the origins of humanity, including its connections to beliefs and subsistence.

As per Hinduism, at the beginning of the world, Brahma initiated creation in water by implanting its own seed in water¹⁴, and Vedic writing supports the fact, ‘water is the very breath of people’¹⁵. Perhaps, every ancient civilization survived on river banks where water source replicated as the thin ice of civilisations, i.e., Mesopotamia¹⁶(Sumerian) along the Tigris and Euphrates rivers, ancient Egypt set along the fertile Nile River, ancient Chinese civilization along the yellow and Yangtze River, Indus Valley (Harappa), Andean South American and Mexico’s Mayan civilizations along numerous river valleys. The greatest Indus Valley civilisation was located in the Indus and Ganges river systems in present-day India, and between the lost Sarasvati river system, now preserved in the Thar Desert. The discovery of the Harappa civilisation on the banks of the lost Sarasvati River, evidenced that across the Indus tradition, from around 7000 BCE to 300 BCE, with an estimated population of over five million people, larger than Egypt or Mesopotamia, lasted about thirteen centuries¹⁷. The collapse of the Indus Valley civilisation around 1700 B.C. is often blamed on the drying up of the river Sarasvati¹⁸, which further reinforces water as the heartland of human survival.

Moreover, the right to water in India traces back to the Vedic period (1500-500 BCE), as in the Rigveda and Atharvaveda, where water is called apah, a sacred and divine element. They worshipped the deity Varuna as the god of the waters, and access to rivers was considered a collective right¹⁹. In the Dharmaśāstra and Smṛiti period (500BCE – 500CE), water rights were treated as a common resource, ensuring equal access for agricultural and domestic use, and polluting water was punishable²⁰. During the Mauryan period (322-185 BCE), water rights were practised as State obligations, in which farmers had the right to use water for irrigation but were required to share it equitably²¹. During the Gupta and post-Gupta eras (4th to 12th century CE), inscriptions show that community-managed irrigation tanks and local sabhas and village

¹⁴ See SATYARTH NAYAK, *MAHAGATHA: 100 TALES FROM THE PURANAS* (HarperCollins 2022), 3.

¹⁵ See London Swaminathan, *Important Vedic Quotations on Rivers and Water* (Tamil and Vedas, 8 May 2014) <https://tamilandvedas.com/2014/05/08/important-vedic-quotations-on-rivers-water/> last visited 9 September 2025

¹⁶ The term ‘Mesopotamia’ itself means ‘between two rivers’.

¹⁷ See Sally Mallam, *Indus- Sarasvati Civilization: One of the Largest Civilisations of the Ancient World* (The Human Journey) <https://humanjourney.us/ideas/connecting-with-the-gods/indus-sarasvati-civilization/> last visited 28 August 2025

¹⁸ See Lesley Kennedy, *6 Early Human Civilizations* (History.Com, 9 August 2022) <https://www.history.com/articles/first-earliest-human-civilizations> last visited 28 August 2025

¹⁹ See Rigveda, mandala 10, Hymn 9; Atharvaveda, Book 1, Hymn 5

²⁰ See MANUSMRITI, *THE LAWS OF MANU* (G. Bühler tr., Clarendon Press 1886).

²¹ See L.N. RANGARAJAN (ED. & TR.), *KAUTILYA: THE ARTHASHASTRA* (Penguin Books India 1992), 200–03.

councils regulated water distribution²². During the medieval period (13-17th century CE), under Mughal rule, access to drinking water remained a basic right, though caste restrictions limited access to wells²³.

In this historical setting, the present Constitutional grounding of the right to water in India is implied in the lens of ‘right to life’ in Article 21²⁴ as a fundamental right. For example in Narmada Bachao Andolan case, where the building Sardar Sarovar Dam on the River Narmada was the subject matter, while focussing on environment and social impacts by particularly addressing guidelines to build the dam and the grievances of displaced communities, Supreme Court invoked Constitutional right to water as, ‘water is the basic need for the survival of the human beings and is part of right of life’²⁵ As commented by Narain, ‘the Indian Supreme Court has grappled with the question of whether the water right is best understood as an independent human right or as a subsidiary right necessary to achieve other economic and cultural rights’²⁶. In response, it is clear that India offers a rights-based approach to access to water, where the Supreme Court and High Courts have read access to clean and safe drinking water into Article 21 and required governments to protect, regulate, and prioritise drinking water²⁷. The Constitutional grounding of the right to water in India is implied under the ‘right to life’ in Article 21²⁸ reinforced by the Directive Principles of Articles 39(b)²⁹, 47³⁰ and 48A³¹ and the Constitution also obliges the State and all citizens to protect the environment³² and

²² See SHARMA R. N., WATER RIGHTS IN INDIA: HISTORICAL AND LEGAL PERSPECTIVES (Indian Law Institute 2006).

²³ See HABIB I, THE AGRARIAN SYSTEM OF MUGHAL INDIA 1556–1707 (Oxford University Press 1999).

²⁴ Constitution, *supra* note 1.

²⁵ *Narmada Bachao Andolan v. Union of India*, AIR 2000 SC 3751, (2000) 10 SCC 664 (Supreme Court of India, 18 October 2000) [74], <http://student.manupatra.com/Academic/Studentmodules/Judgments/MANU-SC-0640-2000-JUD.pdf>.

²⁶ Vrinda Narain, *Water as a Fundamental Right: A Perspective from India*, 34 VT. L. REV. 917, 919 (2010).

²⁷ *Municipal Council, Ratlam v Vardichand* (1980) 4 SCC 162 urged on municipal duties where failure to provide water for basic sanitation can breach fundamental rights; *Subhash Kumar v State of Bihar* (1991) 1 SCC 598 the Supreme Court has read the right to pollution free water into Article 21; *A P Pollution Control Board v Prof M V Nayudu (I)* (1999) 2 SCC 718, the court held that the right to access to drinking water is fundamental to life and that the State has a duty under Art.21 to provide clean drinking water to its citizens; *Delhi Water Supply & Sewage Disposal Undertaking v State of Haryana* (1996) 2 SCC 572 and *Hinch Lal Tiwari v Kamala Devi* (2001) 6 SCC 496 discussed about water allocation in terms of inter-governmental coordination where drinking water is given primacy.

²⁸ See Constitution of India 1950, art 21 which states “No person shall be deprived of his life or personal liberty except according to procedure established by law”

²⁹ *Id.* art 39 (b), states that “that the ownership and control of the material resources of the community are so distributed as best to sub-serve the common good;”

³⁰ *Id.* art 47, states that “the State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, the State shall endeavour to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health”

³¹ *Id.* art 48A, which states that “the State shall endeavour to protect and improve the environment and to safeguard the forests and wild life of the country”

further by the public trust doctrine³³. Evidently, judicial precedent in India on environmental law has given prominence to the public trust doctrine. As Sax explains, the public trust doctrine is a mechanism by which the general public can hold the State accountable for addressing resource management problems. He attempts to interpret public trust doctrine as a judicial technique to address the lack of action by legislative and administrative processes, thereby democratising state action. Thus, certainly criticism remains that public trust doctrine could encroach on private property rights, whereas, in response, Sax urged on balancing the doctrine against ‘needful development and industrialization’³⁴. Similarly, court held in *M C Mehta v Kamal Nath*³⁵ that in the Indian legal system based on English common law includes the public trust doctrine as part of its jurisprudence where the State is the trustee of all natural resources and the public at large is the beneficiary for public use and enjoyment of them. The State, as a trustee, has a legal duty to protect natural resources, and these resources, meant for public use, cannot be converted into private ownership.

Nevertheless, the prominent environmental law principles, i.e., the precautionary principle³⁶ and the polluter pays³⁷, have developed a rich jurisprudence that manifests the right to water in India. Furthermore, the Indian Easements Act 1882³⁸, the Water (Prevention and Control of Pollution) Act 1974³⁹, and the Environment (Protection) Act 1986 are key statutes relevant to the right to water in India. Moreover, in the administrative hierarchy, the Indian government’s National Water Policy⁴⁰, Central Water Commission⁴¹, and Ministry of Jal Shakti⁴² initiatives, i.e., Jal

³² The Constitution of India 1950, art. 51A (g) emphasize “to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures”

³³ *M C Mehta v Kamal Nath* (1997) 1 SCC 388 [34] court declared that in the Indian legal system based on English common law includes the public trust doctrine as part of its jurisprudence where the State is the trustee of all natural resources and the public at large is the beneficiary for public use and enjoyment of them. The State as a trustee is under a legal duty to protect the natural resources and these resources meant for public use cannot be converted into private ownership.

³⁴ See Joseph L. Sax, *The Public Trust Doctrine in Natural Resource Law; Effective Judicial Intervention* (1970) 68 MICH. L. REV. 471,474.

³⁵ *M C Mehta v Kamal Nath* (1997) 1 SCC 388 [34]

³⁶ *M.C. Mehta v. Union of India*, (1988) 1 SCC 471, AIR 1988 SC 1115 (Supreme Court of India, 12 January 1988) [17], concerned the pollution of the river Ganga and the Supreme Court reaffirmed the duty of the government under art. 21 to ensure a better quality of environment and ordered the government to improve its sewage system.

³⁷ *Vellore Citizens’ Welfare Forum v. Union of India* (1996) 5 S.C.C. 647 concerned compensation for victims of water pollution caused by tanneries.

³⁸ See the Indian Easements Act 1882, which was passed during the British rulers, its section 7 recognises the right of a riparian owner to unpolluted water.

³⁹ The Water Act 1974 has established Central and State Pollution Control Boards to take action against polluters.

⁴⁰ The first National Water Policy was adopted in September 1987 in response to a severe drought and was replaced by the National Water Policy 2002, which at clause 13 provides that private sector participation should be encouraged in the planning, development and management of water resources projects.

⁴¹ The Central Water Commission is the leading technical organisation of India in the field of water resources, attached to the Ministry of Jal Shakti.

⁴² The Ministry of Jal Shakti was established in May 2019 by merging the Ministry of Water Resources, River Development and Ganga Rejuvenation, and the Ministry of Drinking Water and Sanitation.

Jeevan Mission⁴³, are the core arms of the Indian national government in the ambit of water rights.

This section examined the rationale for, and the legality, foremost, of the right to water in the Indian jurisdiction, with detailed linkage of historical accounts to applicable statutory and procedural frameworks, to the present context, along with relevant legal principles and authorities, for the execution of the right to water in practice. These findings provide the basis for an appraisal of judicial practice regarding water rights in India.

III. CLOUD-SEEDING ATTEMPTS IN INDIA

Cloud-seeding attempts in India over the past seven decades are evaluated by focusing on two interrelated dimensions: 1) research or experimental attempts and 2) operations or project-based attempts. Besides, as stated in Section 1, this article aims to make a holistic and up-to-date contribution to the existing scholarly literature by chronologically compiling all publicly available Indian cloud-seeding attempts, categorised by research or operational focus. This component of the article has also contributed to an overwhelming focus in the preface on summarising a wide range of ancient knowledge and beliefs about cloud seeding.

Since ancient times, humanity has endeavoured to modify the weather through sacred rites to appease deities, employing various forms of prayer and sacrifice. Ancient Vedic rituals in India, i.e., Somayaga, were performed to appease the deity Indra⁴⁴, bring rain, and restore the seasonal harvest⁴⁵; and the Indra Vila festival during the Sangam period, conducted to honour the rain deity, Indra⁴⁶. Some even consider these traditional Yajñas as a form of ancient rainmaking, in which the ashes and gases from the fires were believed to act like present-day cloud-seeding agents⁴⁷. The Atharvaveda includes songs dedicated to Parjanya⁴⁸, a deity associated with rain clouds⁴⁹. In the Ramayana, the saga of Rishya Sringa's arrival⁵⁰ is a mythological episode

⁴³ Jal Jeevan Mission was initiated on 15 August 2019 to provide piped clean drinking water to all rural households by 2024.

⁴⁴ Indra is a Vedic deity of the sky and heaven.

⁴⁵ See Ravi Prakash Arya, *Vedic Meteorology* (Research Gate, 2006) https://www.researchgate.net/publication/236619785_Vedic_Meteorology last visited 27 August 2025

⁴⁶ See S.R. RAMANUJAN, *THE LORD OF VENGADAM: A HISTORICAL PERSPECTIVE* (Partridge Publishing 2014), 22, https://books.google.lk/books?id=rntPBAAQBAJ&dq=vendhan+indra&pg=PA22&redir_esc=y#v=onepage&q=vendhan%20indra&f=false.

⁴⁷ See Bharatvidhya, *Ancient Weather Science in India* (2019) <https://bharatvidhya.blogspot.com/2019/07/weather-science-india.html> last visited 27 August 2025

⁴⁸ Parjanya is a deity of rain, thunder, lightning, and the one who fertilises the earth.

⁴⁹ See A. A. MACDONELL, *VEDIC MYTHOLOGY* (Motilal Banarsidas 1995)

⁵⁰ See K. Vanadeep and M. Krishnaiah, *Atmospheric Science encrypted into the epic Raamaayana- A novel perspective* [2012] 5 (10) INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY. <https://www.slideshare.net/slideshow/atmospheric-science-in-ramayanavanadeep-k-49014654/49014654> last visited 27 August 2025

credited with bringing abundant rains, which symbolise ritual rainmaking. Across India even to-date, many communities practice symbolic and ritual acts intended to invoke rain, i.e. shadow puppet performances in Nallathangal in Tamil Nadu during drought season, water divination ritual in Jharkhand where burying water filled pots overnight to predict upcoming rainfall and Oraon women anointing sacred trees with water, Hos creating smoke canopies to mimic cloud cover, Mundas pelting stones to simulate thunder⁵¹. As per Kautilya's Arthashastra, a celestial method of rain prediction is explained as, "a forecast of the rainfall is made by observing the position, movement and cloudiness of Jupiter, from the rise, setting and movement of Venus, and from changes in the appearance of the Sun"⁵² Thereby, in the areas where the rainfall is marginal, as per the afore mentioned historical descriptions, it was believed to cause and predict rainfall by systematic approaches of human intervention.

Moving on to the present day, human interventions in rainmaking evidently date back to the 1950s, with the first experiment in cloud seeding in India, conducted by Tata Industrial Houses in the Western Ghats, using ground-based generators and Silver Iodide⁵³ and dry ice⁵⁴ in 1951. Later, S.K. Banerji⁵⁵ attempted in Calcutta in 1952 to disperse salt and silver iodide using hydrogen-filled balloons⁵⁶.

In 1953, under the recommendation of the Committee on Atmospheric Research of the Council of Scientific and Industrial Research (CSIR), a research unit "Rain and Cloud Physics Research" (RCPR) was established to undertake scientific studies on cloud physics and rainmaking, which was officially established at the National Physical Laboratory, New Delhi, in 1955⁵⁷, which subsequently transferred to the Indian Institute of Tropical Meteorology (IITM), Pune in 1967. Over the next three decades, India experimented in this direction in Maharashtra, Karnataka, and Uttar Pradesh⁵⁸.

In the 1960s, under the sponsorship of the CSIR for nearly a decade, warm cloud-seeding operations have conducted on randomized basis, from ground based propellers in three cities of

⁵¹ See Shruti Chakraborty, *Bring forth the rains! Indian folklore and tribal practices to invoke rainfall* (The Indian Express, 5 July 2018) <https://indianexpress.com/article/lifestyle/life-style/bring-forth-the-rains-indian-folklore-and-tribal-practises-to-invoke-rainfall-5243641> last visited 27 August 2025

⁵² See KAUTILYA, THE ARTHASHASTRA (L.N. Rangarajan ed. & tr., Penguin Books India 1992), 200.

⁵³ Savita B. Morwal, B. Padmakumari, G. Pandithurai & J.R. Kulkarni, *The History of Cloud Seeding in India*, 17(2) BULL. OF IMSP (India Meteorological Soc., Pune Chapter) 7 (2018), <https://imd pune.gov.in/imsp/Bulletins/BULLETIN%20OF%20IMSP%20Sept2018.pdf>, at 7–10.

⁵⁴ See Biswanath Dash, *Rain enhancement technology: Making sense of 'cloud seeding' program in India* [2019] 39 (3-4) BULLETIN OF SCIENCE, TECHNOLOGY & SOCIETY. <https://doi.org/10.1177/0270467620963708> last visited 13 September 2025

⁵⁵ The first Indian Director General of the Indian Meteorological Department.

⁵⁶ Ghosh, *supra* note 9.

⁵⁷ Indian Meteorological Society (IMS) Bulletin (n 55)

⁵⁸ Ghosh, *supra* note 9.

North India; for four monsoon periods at Jaipur (1960-66), six monsoon periods at Agra (1960-1965) and nine monsoon periods at Delhi (1957-66)⁵⁹. In one monsoon period, seeding was conducted from an Indian Air Force aircraft at Delhi. Results from 526 seeding days and 516 non-seeding days showed a 20% increase in rainfall⁶⁰. Orographic clouds have been seeded over the mountain ranges in South India at Munnar for two summer seasons⁶¹, but the results have not been published.

State governments' cloud-seeding attempts at the operational level commenced at the beginning of the 1960s, including Tiruchirapalli in South India (1962-64 and 1966-67), in Bhiwani and Hissar in Haryana (1973), Godhra, Gujarat (1972-74 and 1975), and Tamil Nadu (1975)⁶². Randomized salt-seeding experiments with a fixed control-target design were conducted using ground-based generators at Tiruvallur (near Madras) during the southwest and northeast monsoon (1973, 1975-1977) and the results of these experiments suggested that the rainfall on seeded days showed an increase of 32% during southwest monsoon season and a decrease of 17% during the northeast monsoon season⁶³.

The IITM Pune launched a warm-cloud modification experiment commenced in 1973 in the semi-arid region located to the east of Pune on the lee-ward side of the Western Ghat in Maharashtra⁶⁴, focusing on 11 summer monsoons (June-September) from 1973-1986 using an instrumented aircraft⁶⁵ with sodium chloride particles to enhance rainfall⁶⁶. It is also reported that a few clouds were seeded using aircraft 50 km off the Mumbai coast during the monsoon seasons of 1973 and 1974⁶⁷, during which radar and in-cloud electrical, microphysical, and dynamical observations were made⁶⁸. In July 1973 and 1974, IITM carried out cloud-seeding operations over the Rihand catchment in the state of Uttar Pradesh⁶⁹ to overcome the acute power shortage⁷⁰, reportedly increasing rainfall by 17-28 per cent⁷¹. In the summer of 1975, salt

⁵⁹ India Meteorological Department (IMD) (n 7)

⁶⁰ Dash, *supra* note 54.

⁶¹ *Id.*

⁶² India Meteorological Department (IMD) (n 7)

⁶³ *Id.*

⁶⁴ Indian Meteorological Society (IMS) Bulletin (n 55)

⁶⁵ See A S R Murty et al., *11-Year Warm Cloud Modification Experiment in Maharashtra State, India* [1998] <https://doi.org/10.48550/arXiv.physics/9812046> last visited 22 August 2025

⁶⁶ *Id.*

⁶⁷ See A.G. Pillai, R.S. Reddy, R. Vijayakumar, R.K. Kapoor, A.S. Ramachandra Murty, A. Mary Selvam & R.K. Ramana Murty, *Ground-Based Salt Seeding in Tamil Nadu State, South India, 1973-1977* (1983), <https://doi.org/10.54782/jwm.v13i1.50>.

⁶⁸ India Meteorological Department (IMD) (n 7) 8.

⁶⁹ Indian Meteorological Society (IMS) Bulletin (n 55)

⁷⁰ See R.K. Kapoor, K. Krishna, U.S. De, K.G.S. Nair, I.C. Talwar, S.K. Sharma & Bh. V. Ramana Murty, *Result of Operational Cloud Seeding Experiment over Rihand Catchment in Northeast India* (1981), <https://doi.org/10.54302/mausam.v25i3.5243>.

⁷¹ Dash, *supra* note 54.

seeding of warm cumulus clouds from aircraft over the Linganamakki catchment in Karnataka (southwest India) resulted in an average 20% increase in rainfall on seeded days⁷².

At State-level, Tamil Nadu's first operation during 1973-1977 by using a single ground-based generator by salt-seeding, which aimed to enhance rainfall during the northeast monsoon season⁷³ and later, Tamil Nadu's State-commissioned cloud seeding experiments under their principal 1980's programme conducted airborne seeding during severe droughts in the reservoirs of Poondi, Red Hills and Cholavaram catchments near Chennai (then Madras) thrice in 1984, 1985 and 1986 using silver iodide. The whole project was managed by Madras Metropolitan Water Supply and Sewerage Board⁷⁴ using twin-engined 'Piper Aztec' aircraft, and the operation was conducted by Walter Snell⁷⁵ and pilots Michael Holehouse in 1984 and 1985, and Michael Douglas in 1986 from M/s Atmospherics Inc. of California, United States⁷⁶. It was also reported to use silver iodide flares⁷⁷.

In 1992, the Brihan Mumbai Municipal Corporation (BMC) attempted cloud seeding over selected lakes to augment the city's drinking water supply, but the results were unsatisfactory⁷⁸. Moreover, the Mumbai-based Meckoni Enterprises conducted a ground-based generator experiment in 1992⁷⁹.

A revival of State-level operations is witnessed at the beginning of the millennium with the State of Karnataka Project Varuna (2003-2004, 2006, 2010 & 2012), Andhra Pradesh (2003-2009), and the State of Maharashtra (2004, 2009).

⁷² Bh. V. Ramana Murty & K.R. Biswas, *Weather Modification in India*, 46(3) J. OF THE METEOROLOGICAL SOC. OF JAPAN 160 (1968), https://doi.org/10.2151/jmsj1965.46.3_160.

⁷³ Pillai, *supra* note 67.

⁷⁴ Dash, *supra* note 54.

⁷⁵ The meteorologist who trained R.G. Subramaniyan in 1984, who later became the Director of the Indian Meteorological Society (IMS) Chennai Chapter.

⁷⁶ See R G Subramaniyan, *Memories of Cloud Seeding Operation at Chennai* (Indian Meteorological Society BREEZE, June 2017) https://mausam.imd.gov.in/chennai/imsimd/pdf/BREEZE_June2017.pdf last visited 5 September 2025

⁷⁷ *Id.*

⁷⁸ See IANS, *Maharashtra plans cloud seeding to combat monsoon blues* (Business Today, 3 June 2015) <https://www.businesstoday.in/magazine/cover-story/story/deficient-monsoon-maharashtra-plans-cloud-seeding-48739-2015-06-03> last visited 5 September 2025

⁷⁹ See Ashish Agashe, *Rain Makers: The cloud seeding business* (The Economic Times, 24 July 2009) <https://economictimes.indiatimes.com/india-emerging/rain-makers-the-cloud-seeding-business/articleshow/4813671.cms?from=mdr> last visited 7 September 2025

Project Varuna attempted cloud seeding for over 80 days at a budget of Indian Rupees (INR) 90 million⁸⁰ and was reported 95% successful⁸¹. Later, in 2006 & 2010, two other experiments were carried out in the Western Ghats of Karnataka⁸², using a ground-based technology of rain-rockets⁸³, known as the Chinese method⁸⁴, at a cost of INR 350 million⁸⁵. This was performed with the assistance of CSIR, upon the Karnataka Natural Disaster Monitoring Centre (KNDMC), selected Western Ghats, and the Linganaamkki and Supa catchments of the Sharavati River area⁸⁶. In 2012, the Cauvery basin Project⁸⁷ by the Karnataka government carried out an operational cloud-seeding experiment for 2 days in October to November using the 90-flare firing technique for INR 50 million⁸⁸, with seeding agents of dry ice and silver iodide contracted through Agni Aero Sports Adventure Aviation⁸⁹.

In Andhra Pradesh (2003-2009), operational cloud seeding carried out in rain-deficient districts became known as one of the largest cloud-seeding programs in South Asia, 'Indira Meghamadhanamu'⁹⁰. In 2004, the Andhra government established a Rain Shadow Development Department to assist the nine rain shadow districts in receiving artificial rain⁹¹ using predominantly the hygroscopic warm cloud-seeding method, where, in 2012, the Andhra

⁸⁰ See Amoolya Rajappa, *Karnataka launches cloud-seeding to increase rainfall, how effective is the technology?* (YouStory, 27 August 2017) <https://yourstory.com/2017/08/karnataka-cloud-seeding> last visited 23 August 2025; The cloud seeding operations used sophisticated technology, where calibrated radars locate rain-bearing cumulus clouds for seeding. Then followed aircraft fitted with chemical cylinders seeding moisture-laden clouds over rain-deficient catchment areas.

⁸¹ See Naheed Ataulla, *Cloud Seeding Successful in Karnataka* (Times of India, 2 October 2003) <https://timesofindia.indiatimes.com/city/bengaluru/cloud-seeding-successful-in-karnataka/articleshow/196568.cms>.

⁸² Particularly experimented near Linganamakki, Thippagondanahalli reservoirs, and Narayanapura dam.

⁸³ See Manu Aiyappa, *Cloud seeding is a failed mission in Karnataka* (Times of India, 15 June 2012) <https://timesofindia.indiatimes.com/city/bengaluru/cloud-seeding-is-a-failed-mission-in-karnataka/articleshow/14151806.cms> last visited 5 September 2025; Chitradurga, *Cloud seeding in drought-hit places* (The New Indian Express, 19 August 2010) <https://www.newindianexpress.com/states/karnataka/2010/Aug/19/cloud-seeding-in-drought-hit-places-179382.html> last visited 5 September 2025

⁸⁴ Under the rocket launching system, solid propellants consisting of an oxidiser (usually potassium nitrate) and fuel launch into the rain-bearing clouds. China had reportedly used this system to prevent rain by scattering clouds using chemicals during the 2008 Olympic Games; See Deccan Herald, *State all set to try Chinese method of cloud seeding* (22 July 2010). <https://www.deccanherald.com/india/karnataka/state-all-set-try-chinese-2501971> last visited 5 September 2025

⁸⁵ *Id.*

⁸⁶ See *Greens Allay Fears over Cloud Seeding* (The New Indian Express, Shimoga, 4 October 2010).

⁸⁷ Catchment areas of the Kabini, Cauvery, Hemavathy, and Mekedaatu basins.

⁸⁸ See Express News Service, *Cloud seeding: Karnataka minister, Meteorological Department in dark* (New Indian Express, 22 October 2012) <https://www.newindianexpress.com/amp/story/states/karnataka/2012/oct/22/cloud-seeding-karnataka-minister-meteorological-department-in-dark-417651.html> last visited 5 September 2025

⁸⁹ See Express News Service, *Cloud seeding: 90 flares injected into clouds* (New Indian Express, 4 November 2012) <https://www.newindianexpress.com/states/karnataka/2012/Nov/04/cloud-seeding-90-flares-injected-into-clouds-422158.html> last visited 5 September 2025

⁹⁰ Dash, *supra* note 54.

⁹¹ See *Time to Try Out Cloud Seeding in TN?* (The New Indian Express, 30 June 2009) <https://www.newindianexpress.com/states/tamil-nadu/2009/Jun/30/time-to-try-out-cloud-seeding-in-tn-63214.html>.

government even called for a global tender⁹². It is also reported that a new Centre for Atmospheric Sciences and Weather Modification Technologies (CEA & WMT) was established at Jawaharlal Nehru Technological University-Hyderabad to monitor and evaluate the program⁹³.

The State of Maharashtra (2004, 2009) inaugurated cloud seeding via Project Varsha in 2003 through Agni Aviation Consultants, spending over INR 540 million in 2003 and around INR 180 million in 2004⁹⁴, but the project was unsuccessful. In 2009 August, in Mumbai (Maharashtra), for 60 days, airborne seeding⁹⁵ and ground-based seeding mechanisms, “ground smoke” (a ritual or ground coalescing method), were experimented with, where both methods cost INR 80 million, including INR 500,000 -600,000 on ground smoke⁹⁶. However, the efficacy of both seeding techniques was unrevealed.

In 2009, the Cloud Aerosol Interaction and Precipitation Enhancement Experiment (CAIPEEX), led by IITM and the Indian Meteorological Department (IMD), helped revive Indian cloud-seeding operations with instrumented aircraft and later enabled targeted seeding trials. CAIPEEX is two-fold: 1) cloud-aerosol interaction and 2) precipitation enhancement. This proposed experiment is planned to be carried out in three phases. Phase I was devoted to intensive cloud and aerosol observations across different regions of India during May-September 2009. In Phase II, a precipitation enhancement experiment will be conducted by artificially seeding clouds in 2010 and 2011. Data analysis conducted in Phase III during 2011-2012⁹⁷. CAIPEEX IV, carried out in 2018 and 2019, was conducted over the rain-shadow region of the Western Ghats Mountains, particularly in the region of Solapur, Maharashtra, where 267 randomised samples of convective clouds seeding were tested⁹⁸, primarily to test the efficacy of hygroscopic cloud seeding in India⁹⁹. The importance of CAIPEEX IV lies in its adherence to

⁹² *Id.*

⁹³ Dash, *supra* note 54.

⁹⁴ See Jayashree Bhosale, *State to undertake cloud seeding to mitigate dry spell* (Economic Times, 15 July 2008) <https://economictimes.indiatimes.com/news/politics-and-nation/state-to-undertake-cloud-seeding-to-mitigate-dry-spell/articleshow/3234125.cms> last visited 5 September 2025

⁹⁵ See Sharad Vyas, *Cloud seeding from the air on cards* (Times of India, 18 August 2009) <https://timesofindia.indiatimes.com/city/mumbai/cloud-seeding-from-the-air-on-cards/articleshow/4904521.cms> last visited 5 September 2025

⁹⁶ See Clara Lewis, *Maharashtra's rain plan came under cloud 5 years* (Times of India, 4 August 2012) <https://timesofindia.indiatimes.com/city/mumbai/maharashtras-rain-plan-came-under-cloud-5-years/articleshow/15345407.cms> last visited 5 September 2025

⁹⁷ See Indian Institute of Tropical Meteorology (IITM), *CAIPEEX: Programme Structure* (2009) <https://www.tropmet.res.in/~caipeex/prog-structure.php> last visited 22 August 2025

⁹⁸ See Ministry of Earth Sciences, *Annual Report 2023-2024* https://moes.gov.in/sites/default/files/Annual-Report-English-2023-2024_12mp.pdf last visited 23 August 2025

⁹⁹ Prabhakaran, T., Murugavel, P., Konwar, M., Malap, N., Gayatri, K., Dixit, S.A., Samanta, S., Chowdhuri, S., Bera, S.K., Varghese, M., Rao, J., Sandeep, J., Safai, P.D., Sahai, A.K., Axisa, D., Karipot, A., Baumgardner, D., Werden, B.S., Fortner, E., ... Nanjundiah, R., *CAIPEEX – Indian cloud seeding scientific experiment* (BULLETIN

the World Meteorological Organisation (WMO) recommendations, as documented in a peer-reviewed report that included physical, statistical, and numerical investigations¹⁰⁰. CAIPEEX 2023 in the Lidar monsoon experiments campaign commenced on 30th May 2023 at Solapur to investigate aerosol vertical profiles and cloud characteristics¹⁰¹. It is also imperative to note that in 2023, CAIPEEX published an India cloud-seeding protocol¹⁰² and a template for catchment-scale programs.

While a cloud-seeding failed mission reported in Karnataka in the years of 2003¹⁰³, 2006-2010 and 2012¹⁰⁴ later, Karnataka launched Varshadhare in 2017, a randomized operational program operated between 21 August to 7 November developed under CAIPEEX program¹⁰⁵ investing over INR 350 million where Begaluru based Hoyasala Projects Pvt Ltd carried out seeding at the Cauvery, Tungabhadra and Malaprabha river basins for nearly two months¹⁰⁶. This increased localised rainfall by over 27.9 per cent¹⁰⁷, resulting in diverse rainfall patterns. Malnad and coastal areas received ample rainfall, while the Deccan Plateau in the north faces arid conditions¹⁰⁸. It is important to note that during Varshadharee, both glaciogenic and hygroscopic seeding methods were used by aerial means¹⁰⁹.

Though the Maharashtra government recommended that cloud seeding is a waste of money¹¹⁰ during the Project Varsha in 2003 and 2004, in April 2015, Maharashtra re-launched cloud-seeding, taking note of the deficit rainfall forecast in the perennial drought-prone region

OF THE AMERICAN METEOROLOGICAL SOCIETY, 2023) <https://doi.org/10.1175/bams-d-21-0291.1> last visited 23 August 2025

¹⁰⁰ *Id.*

¹⁰¹ Ministry of Earth Sciences, *supra* note 98.

¹⁰² Hygroscopic seeding of warm convective clouds.

¹⁰³ See Shetty B. A., *Cloud seeding: Will it succeed in Karnataka?* (Deccan Chronicle, 8 July 2017) <https://www.deccanchronicle.com/nation/current-affairs/080717/karnataka-cloud-seeding-will-it-succeed.html> last visited 23 August 2025

¹⁰⁴ Aiyappa, *supra* note 83.

¹⁰⁵ This project was developed under the Indian national CAIPEEX program, in which hygroscopic and glaciogenic seeding was carried out using the areal method. See also Kulkarni J.R., Morwal S.B. and Deshpande N.R., 'Rainfall Enhancement in Karnataka State Cloud Seeding Program "Varshadhare 2017"' [2019] 219 *ATMOSPHERIC RESEARCH* 65-76. <https://www.sciencedirect.com/science/article/pii/S016980951831175X> last visited 22 August 2025

¹⁰⁶ The 2017 project aimed at enhancing the possibility of rain by a mere 15-20%; Rajappa (n 85)

¹⁰⁷ See Rao M. M., *Report finds cloud seeding increased rain* (The Hindu, 22 July 2018) <https://www.thehindu.com/news/national/karnataka/report-finds-cloud-seeding-increased-rain/article24489592.ece> last visited 23 August 2025

¹⁰⁸ See Balakrishnan, M., Prakash, V.S., Kumar, P., & Murthy, C., *Rainfall enhancement through cloud seeding: a case study* (Witpress, 2018) <https://www.witpress.com/elibrary/wit-transactions-on-the-built-environment/184/36661> last visited 8 September 2025

¹⁰⁹ Kulkarni, *supra* note 105.

¹¹⁰ Bhosale, *supra* note 94.

Marathwada¹¹¹ Vidarbha and north Maharashtra¹¹², naming the project 'Prakalpa Varsha'¹¹³ using silver iodide¹¹⁴ with a cost of INR 300 million¹¹⁵. In 2019, with budget approvals, the Maharashtra State government, targeting rain-deficient areas of Marathwada, Solapur, and Osmanabad¹¹⁶, deployed aircraft for survey and seeding between July and August. However, it is reported that these operations overlapped with IITM CAIPEEX research flights over the Solapur region¹¹⁷.

Furthermore, discussions on possibilities of reviving cloud-seeding in Telangana is reported along with previous Andhra Pradesh undivided state programmes (2004-2009)¹¹⁸ However, no official reports found on cloud-seeding in Telangana despite a High Court decision (2016)¹¹⁹ that State refused to pay Agni Aviation on basis that results of the operations did not benefit the targeted drought hit areas¹²⁰, asserts cloud-seeding operations in Telangana in 2016.

Research on cloud seeding in India has received increased attention since 2018, with the Ministry of Earth Sciences (MoES) investing in data collection and experiments. i.e., spending INR 450 million on research in 2018 and INR 1000 million in 2019¹²¹.

Air pollution in Delhi has remained severe notwithstanding the constitutional protection of the environment under Article 21¹²². As a result, to overcome this issue, the recent pilots 2023-2025 in Delhi aimed at anti-pollution with IIT-Kanpur received Director General of Civil Aviation

¹¹¹ Diwase S., Sharma R. V., *Cloud seeding in Maharashtra* (Disaster Management Unit)http://www.tropmet.res.in/monsoon_workshop/24_pdf/RVSharma.pdf last visited 23 August 2025

¹¹² IANS, *supra* note 78.

¹¹³ Dash, *supra* note 54.

¹¹⁴ IANS, *supra* note 78.

¹¹⁵ See Sujit Mahamulkar, *Maharashtra: Rs 30 crore cloud seeding for drought-hit areas in August* (Times of India, 29 May 2019) <https://timesofindia.indiatimes.com/city/mumbai/maharashtra-rs-30-crore-cloud-seeding-for-drought-hit-areas-in-august/articleshow/69552572.cms> last visited 5 September 2025

¹¹⁶ See Press Trust of India, *Planes to Carry Out Cloud Seeding Reach Maharashtra – Weather Official* (NDTV, 23 July 2019) <https://www.ndtv.com/india-news/planes-to-carry-out-cloud-seeding-reach-maharashtra-weather-official-2074206> last visited 5 September 2025

¹¹⁷ See Bhavika Jain, *Maharashtra to start cloud seeding in rain-deficit Marathwada* (Times of India, 5 August 2019) <https://timesofindia.indiatimes.com/city/aurangabad/maharashtra-to-start-cloud-seeding-in-rain-deficit-marathwada/articleshow/70529110.cms> last visited 5 September 2025

¹¹⁸ See Deccan Chronicle, *Telangana state to revive YSR's cloud seeding* (Deccan Chronicle, 17 August 2014) <https://www.deccanchronicle.com/140817/nation-current-affairs/article/telangana-state-revive-ysr%E2%80%99s-cloud-seeding> last visited 5 September 2025

¹¹⁹ *Agni Aviation Consultants & Ors v State of Telangana & Ors*, W.P. No. 1135 of 2016 (High Court of Telangana, 21 April 2020) [1]

¹²⁰ See TNN, *Telangana: 13 years on, aviation firm to get Rs. 40 crore* (Times of India, 30 April 2020) <https://timesofindia.indiatimes.com/city/hyderabad/13-yrs-on-aviation-firm-to-get-rs-40cr/articleshow/75459525.cms> last visited 7 September 2025

¹²¹ Ghosh, *supra* note 9.

¹²² *Vanashakti v. Union of India*, 2025 INSC 718, Writ Petition (C) No. 1394 of 2023 (Supreme Court of India, 16 May 2025) https://api.sci.gov.in/supremecourt/2023/50009/50009_2023_3_1502_61809_Judgement_16-May-2025.pdf.

(DGCA) clearances¹²³, marking it as the pioneering state to secure aviation clearance, particularly for pollution mitigation through cloud seeding¹²⁴. The Operation was initially planned for early July but repeatedly postponed due to the active monsoon, and was finally reported to have been conducted from 30th August to 10th September 2025¹²⁵. The media reported that a modified Cessna aircraft using flare-based dispersal of silver iodide and salts¹²⁶ has been used as an agent, and that the Delhi government had approved a total budget of around INR 30 million¹²⁷.

In addition, Rajasthan announced India's first drone-based cloud-seeding trial in August 2025 in the Jamwa-Ramgarh area, near Jaipur, deploying 60 AI-driven drones¹²⁸ to disperse sodium chloride¹²⁹ and silver iodide. The project is a 30-day research and development (R&D) pilot mission, also called "HydroTrace"¹³⁰, conducted by the State Agriculture Department, with DGCA clearance for high-altitude drone flights, which caused the delay in execution¹³¹.

Arguably, cloud-seeding attempts in India seemed to lack transparency in their conduct, as evidenced by the 2019 Maharashtra monsoon mission, which overlapped with IITM's CAIPEEX IV (2018-2019)¹³² over the Solapur region, coinciding in both time and place. Therefore, at operational levels, it is recommended to maintain an open-source database of ongoing national and State-sponsored projects to avoid overlapping cloud-seeding experiments. On the other hand, this scenario indicates the absence of an umbrella governing body that

¹²³ Anshita Mehra, *Government Gets DGCA Nod for First-Ever Cloud Seeding Trials* (The Tribune, 2 July 2025) <https://www.tribuneindia.com/news/delhi/government-gets-dgca-nod-for-first-ever-cloud-seeding-trials/>.

¹²⁴ See TNN, *Cabinet gives nod to cloud seeding trials* (Times of India, 7 May 2025) <https://timesofindia.indiatimes.com/city/delhi/cabinet-gives-nod-to-cloud-seeding-trials/articleshow/120972816.cms> last visited 5 September 2025

¹²⁵ See Varun Bhandari, *Cloud Seeding Exercise in Delhi Postponed to August End* (Hindustan Times, 1 July 2025) <https://www.hindustantimes.com/cities/delhi-news/>.

¹²⁶ See TNN, *All clearances in place for artificial rain pilot* (Times of India, 18 June 2025). <https://timesofindia.indiatimes.com/city/delhi/all-clearances-in-place-for-artificial-rain-pilot/articleshow/121937755.cms> last visited 5 September 2025

¹²⁷ See Press Trust of India, *Delhi cabinet approves cloud-seeding trial proposal to tackle air pollution* (NDTV, 7 May 2025) <https://www.ndtv.com/india-news/delhi-cabinet-approves-cloud-seeding-trial-proposal-to-tackle-air-pollution-8356618> last visited 5 September 2025

¹²⁸ See India Today, *Rajasthan launches first-ever drone cloud seeding experiment for rain* (India Today, 12 August 2025) <https://www.indiatoday.in/information/story/rajasthan-launches-first-ever-drone-cloud-seeding-experiment-for-rain-key-details-2769959-2025-08-12> last visited 5 September 2025

¹²⁹ See ET Government Desk, *Rajasthan govt. begins drone-based cloud seeding trials to recharge Ramgarh Lake* (The Economic Times, August 2025) <https://government.economictimes.indiatimes.com/news/technology/rajasthan-launches-revolutionary-drone-based-cloud-seeding-trials-to-combat-water-scarcity/123280361> last visited 5 September 2025

¹³⁰ *Id.*

¹³¹ The Director General of Civil Aviation (DGCA) has given conditional approval to the private company conducting the trial to fly drones up to 10,000 feet; See also Ashish Mehta, *DGCA delay hits Raj cloud seeding project; agri min to speak to Centre* (Times of India, 19 August 2025) <https://timesofindia.indiatimes.com/city/jaipur/dgca-delay-hits-raj-cloud-seeding-project-agri-min-to-speak-to-centre/articleshow/123372659.cms> last visited 5 September 2025

¹³² Jain, *supra* note 117.

coordinates both national and State cloud-seeding efforts in India. However, at glance, though it seemed conversant to perform cloud-seeding in India due to numerous attempts in both national and State-level recorded over the last seven decades, in reality, the experiences of seeding clouds in India has no difference that to an unleashing of Pandora's Box, where thus far it has never failed to cause ambiguous results despite the promising scientific efforts.

IV. LAW AND POLICY FRAMEWORK FOR CLOUD-SEEDING IN INDIA

The existing literature identifies a significant gap in the legal status of cloud seeding in India, with available scholarly work limited to social and scientific perspectives. Accordingly, to determine the legitimacy, this section is dedicated to assessing cloud-seeding with relevant laws, and case laws within the jurisdiction of India and in comparison with the relevant legal sources of international law, as well as concurrently with the principles of rightful purpose and rightful conduct.

A. Within the jurisdiction of India

As categorically stated in the preceding sections of this article, cloud-seeding falls in the ambit of the water right, guaranteed under the right to life specified in Article 21 of the Constitution of India¹³³, which vehemently established that citizens of India are not treated as passive recipients of State benevolence, but as rights-holders with legal entitlements for water, i.e. cloud-seeding is examined in this article as a method to fulfil the legal entitlements for water. Further, India being a quasi-federal State¹³⁴, water is not exclusively a Union subject, but rather a matter of Concurrent jurisdiction with strong State-level control. The Seventh Schedule of the Constitution has distributed the subject matter of water among the State List¹³⁵, the Union List¹³⁶, and the Concurrent List¹³⁷. As per the Inter-State River Water Disputes Act 1956, intra-State¹³⁸ water is primarily a State subject, whereas inter-State¹³⁹ rivers and river valleys fall under the Union jurisdiction, when Parliament declares so in the public interest. This was further evident in *State of Karnataka v. State of Tamil Nadu*¹⁴⁰ regarding the Cauvery River dispute,

¹³³ *Subhash Kumar v. State of Bihar*, AIR (1991) SC 420, recognised the right to water under Article 21 of the Indian Constitution, 1950.

¹³⁴ The Constitution, *supra* note 1.

¹³⁵ Constitution, *supra* note 133 Seventh Schedule, List II (State List) Entry 17: "Water, that is to say, water supplied, irrigation and canals, drainage and embankments, water storage and water power.

¹³⁶ *Id.* List I (Union List) Entry 56: "Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest."

¹³⁷ *Id.* List III (Concurrent List) Entry 20: "Economic and social planning", which overlaps with water policies.

¹³⁸ Intra-State involves activities entirely within the boundaries of a single State.

¹³⁹ Inter-State activities involve activities across State borders or across multiple States.

¹⁴⁰ *State of Karnataka v. State of Tamil Nadu* (2017) 3 SCC 362

which affirmed Union power over inter-State rivers. In pragmatism, this is further evident in State-led independent cloud-seeding projects.

It is profound that India currently lacks specific legislation addressing cloud seeding, as the subject falls under a myriad of national and State-level environmental and regulatory frameworks. The Environment (Protection) Act, 1986, serves as the umbrella law governing environmental matters. The Water (Prevention and Control of Pollution) Act 1974 is also relevant to cloud seeding, as it governs testing its impact on water quality. The Air (Prevention and Control of Pollution) Act, 1981, governs activities that affect air quality, and cloud-seeding requires review by the Central Pollution Control Board (CPCB) due to chemical particulate emissions. The National Green Tribunal (NGT) Act 2010 enables legal challenges to environmental damage potentially caused by cloud seeding under the relevant air or water Acts. In the sphere where the Union Government has not enacted any specific law on cloud-seeding, but agencies, i.e., the IMD and IITM, provide scientific and technical support for cloud-seeding missions to State governments.

Evaluating the basis of cloud seeding within the overall regulatory framework of industries in India, first and foremost, understanding the ministerial and agency hierarchy is crucial. Accordingly, MoES under the union government appears to be the highest-level ministry responsible for cloud seeding, with IMD, IITM, and its CAIPEEX¹⁴¹ fully funded by MoES¹⁴². Further, approvals from various agencies, including the Union government, DGCA, the Union ministries of home and defence, and the Indian Air Force, are prerequisites for cloud seeding¹⁴³. Due to the use of aircraft- and drone-based cloud-seeding operations, the DGCA considers cloud seeding an aerial work operation. Therefore, operators must obtain flight clearances and comply with Controlled Airspace (CAR) or Visual Flight Rules (VFR) restrictions, as well as any special conditions, including aircraft age/airworthiness, sensitive-area restrictions, and Air Traffic Control (ATC) coordination. i.e., a 40-year-old aircraft was not granted permission to conduct cloud seeding in Bengaluru¹⁴⁴. Recent experiments in Delhi and Rajasthan illustrate DGCA protocols. India's first-ever drone cloud-seeding trial, conducted in Rajasthan in August 2025,

¹⁴¹ Acronym for "Cloud Aerosol Interaction and Precipitation Enhancement Experiment"

¹⁴² See Thara Prabhakaran, *Cloud Aerosol Interaction and Precipitation Enhancement Experiment (CAIPEEX): Recent Findings*, 40(1-2) VAYUMANDAL 5 (2014), http://imetsociety.org/wp-content/pdf/vayumandal/2014/2014_1.pdf.

¹⁴³ See Shetty B. A., *Cloud seeding: Will it succeed in Karnataka?* (Deccan Chronicle, 8 July 2017). <https://www.deccanchronicle.com/nation/current-affairs/080717/karnataka-cloud-seeding-will-it-succeed.html> last visited 23 August 2025

¹⁴⁴ See TNN, *40-year-old aircraft may not get DGCA nod for cloud seeding* (Times of India, 7 August 2017) <https://timesofindia.indiatimes.com/city/bengaluru/40-year-old-aircraft-may-not-get-dgca-nod-for-cloud-seeding/articleshow/59945990.cms> last visited 23 August 2025

was reportedly delayed due to the need for DGCA permission, as drones are only allowed to fly up to 400 feet. In contrast, the trial requires drones to operate at an altitude of 10,000 feet¹⁴⁵. Pilot cloud-seeding trials in Delhi 2025 also required clearances from multiple agencies, namely, CPCB and State Pollution Control Board (SPCB) for environmental impact, Ministry of Environment, Forest & Climate Change (MoEFCC), DGCA, Airports Authority of India (AAI), Bureau of Civil Aviation Security (BCAS) for aviation safety, MoES CAIPEEX, Ministry of Defence, Ministry of Home Affairs, and other relevant state departments. Further, at the State level, cabinet nod seemed mandatory.

In the realm of private corporations' involvement in large-scale cloud seeding in India, Agni Aviation Consultants Private Limited, Agni Aero Sports Adventure Academy Private Limited, Mumbai Meckoni Enterprises, and Hoyasala Projects Pvt Ltd appear to be the leading private entities at present. In fact, the very first Indian cloud-seeding experiment, executed by the Tata Industrial Houses in 1951, was also a private entity. However, the legality of private corporations' cloud-seeding activities has not yet been evaluated in the literature.

While not directly addressing the legality of cloud seeding in India, a few scholars have discussed the potential environmental impacts. Malik is concerned about potential environmental effects and the lack of proven effectiveness of cloud seeding; for example, in his discussion, he emphasises silver iodide as a hazardous and toxic pollutant¹⁴⁶. Davis has examined public safety concerns in weather-modification law and analysed legal regulations governing cloud-seeding activities¹⁴⁷. Correspondingly, Korneev et al. have focused on the environmental impact of cloud seeding and the pollution levels associated with the reagents used in precipitation modification¹⁴⁸.

It is significant to note that, at the union level, CPCB¹⁴⁹ and, at the state level, SPCB¹⁵⁰ are responsible for assessing environmental impact, i.e., in Maharashtra, MPCB; in Karnataka,

¹⁴⁵ Mehta, *supra* note 131.

¹⁴⁶ See Malik, S., *Cloud Seeding: Its Prospects and Concerns in the Modern World – A Review* [2018] 6 (5) International Journal of Pure & Applied Bioscience 791-796. https://www.researchgate.net/publication/328718655_Cloud_Seeding_Its_Prospects_and_Concerns_in_the_Modern_World-A_Review last visited 2 September 2025

¹⁴⁷ See Davis, R.J., *Black Clouds and Silver iodide: Public Safety and Weather Modification Law* [1991] 23 (1) The JOURNAL OF WEATHER MODIFICATION 63-66.

¹⁴⁸ See Korneev, V.P., Potapov E.I., Shchukin G.G., *Environmental Aspects of Cloud Seeding* [2017] 42(7) Russian Meteorology and Hydrology 477-483.

¹⁴⁹ The Central Pollution Control Board (CPCB) is a statutory body established under the Ministry of Environment, Forest and Climate Change (MoEFCC) of the Government of India on 22 September 1974 under the Water (Prevention and Control of Pollution) Act, 1974. It also operates under the Air (Prevention and Control of Pollution) Act 1981.

¹⁵⁰ SPCBs are statutory bodies established under the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act 1981 to implement environmental laws and regulations, to take measures to prevent and control water and air pollution within respective states.

KSPCB; and in Tamil Nadu, TNPCB. Even in the absence of specific environmental rules under the Environment (Protection) Act 1986, post-seeding assessments of water quality and the environment are required. Environment Impact Assessments (EIAs) for cloud seeding are mandatory for cloud-seeding experiments due to the silver iodide and salt residues used as seeding agents. Notably, in the case of *Vanashakti v. Union of India* (2025)¹⁵¹, the Supreme Court quashed the Standard Operating Procedure (SOP) 2021¹⁵² that allows for ex-post facto Environmental Clearances (ECs), affirming the landmark decision that retrospective approvals are incompatible with the EIA Notification of 2006¹⁵³, by emphasising the necessity for prior environmental assessments beforehand undertaking projects that may impact the environment.

The National Green Tribunal (NGT), established under Act No. 19 of 2010, exercises jurisdiction to enforce environmental rights and resolve environmental disputes; it functions as a special civil court, and its orders are binding; appeals lie only before the Supreme Court of India. The Tribunal is chaired by a judge of the Supreme Court or the Chief Justice of a High Court, headquartered in New Delhi, with its zonal benches in Bhopal, Pune, Kolkata, and Chennai¹⁵⁴.

With reference to judicial activism, the Supreme Court, NGT, and High Courts of India are empowered¹⁵⁵ to intervene and initiate proceedings without a formal petition under public interest litigation, a power known as suo moto cognizance. In 2021, the Supreme Court upheld the NGT's suo motu powers. Accordingly, it is possible to infer the applicability of the said jurisdiction to cloud seeding as well.

Case law on cloud seeding is scant in Indian jurisdictions, where few cases address the subject matter, yet cloud seeding remains legal. In *Agni Aero Sports Adventure Academy Private Limited and Ors. v. Indian Institute of Tropical Meteorology and Ors*¹⁵⁶ discussed the scope of judicial review in tender proceedings initiated by the respondent for the purpose of availing

¹⁵¹ *Vanashakti v. Union of India*, *supra* note 122.

¹⁵² The Ministry of Environment issued an SOP on 7 July 2021 for identifying and handling violations under the EIA Notification 2006, which was later reinforced via the 29 March 2023 memo. See MoEFCC, *Office Memorandum* (29 March 2023). https://environmentclearance.nic.in/writereaddata/OM/1527000066%241.%20_29_03_2023.pdf last visited 7 September 2025

¹⁵³ EIA Notification 2006 provides procedures for projects that require prior environmental clearances. See Ministry of Environment and Forests, *Notification* (14 September 2006) https://environmentclearance.nic.in/writereaddata/EIA_notifications/2006_09_14_EIA.pdf last visited 7 September 2025.

¹⁵⁴ See NATIONAL GREEN TRIBUNAL, *About Us*, <https://www.greentribunal.gov.in/about-us> (last visited Sept. 6, 2026).

¹⁵⁵ The Constitution of India, 1950: Article 32, “right to constitutional remedies before the Supreme Court,” and Article 226, “Power of High Courts to issue writs.”

¹⁵⁶ *Agni Aero Sports Adventure Academy Private Limited and Ors. v. Indian Institute of Tropical Meteorology and others*. W.P. 4257 (2010) and C.A. 1404 (2010) (High Court of Bombay, 2 July 2010) [2-3]

aviation support for its CAIPEEX II experiment. In *Agni Aero Sports Academy v. Agni Aviation Consultants & Ors*¹⁵⁷, a series of commercial suits and interlocutory orders dealing with aircraft leases, aircraft modification for cloud-seeding, and related recovery cases involving arbitration is discussed. In *Agni Aviation Consultants & Ors v. State of Telangana & Ors*¹⁵⁸, Telangana High Court ordered State of Telangana to pay INR 400 million to Agni Aviation for the conducted cloud-seeding operations in 2007 in the circumstances, where the State refused to pay stating that the results of the operations did not benefit the targeted drought hit areas of the State¹⁵⁹. Similarly, in *Agni Aviation Consultants Partnership Firm and Ors. V. D.Venkateshwar Rao and Ors*¹⁶⁰ held regarding the payment of three months' arrears of dues under cloud-seeding contracts in the years of 2007, 2008, and 2009.

In this backdrop, merely two landmark decisions on the legality of application of cloud-seeding reported with reference to the State of Uttarakhand, India; in the background of forest fires that have adversely affected 1012 hectares of land, the State of Uttarakhand and Ors held, 'State should also consider the possibility of creating artificial rain by cloud-seeding. Of course, this will have to be balanced with the distinct possibility that too much rain may also lead to landslides, a phenomenon to which the State is prone to'¹⁶¹. This pivotal decision encourages cloud seeding as a recourse to address forest fires while instructing authorities on measures to safely implement the mechanism and avoid further disasters, e.g., landslides caused by heavy rainfall. Thus, again, a contrast point of view was upheld in *State of Uttarakhand (2024)*¹⁶² where Supreme Court held that 'cloud-seeding or 'depending on rain-god' is not the answer to the raging forest fires in Uttarakhand and that authorities will have to take preventive measures to tackle the problem'¹⁶³ Thereby, it is plausible to suggest that this judgement underlines forest

¹⁵⁷ *Agni Aviation Consultants v. Agni Aero Sports Adventure Academy Pvt Ltd*, Co.P. No. 55 of 2010 (High Court of Karnataka at Bangalore, 24 January 2012).

¹⁵⁸ *Agni Aviation Consultants & Ors v State of Telangana & Ors*, W.P. No. 1135 (2016) (High Court of Telangana, 21 April 2020)

¹⁵⁹ See TNN, *Telangana: 13 years on, aviation firm to get Rs. 40 crore* (Times of India, 30 April 2020) <https://timesofindia.indiatimes.com/city/hyderabad/13-yrs-on-aviation-firm-to-get-rs-40cr/articleshow/75459525.cms> last visited 7 September 2025

¹⁶⁰ *Agni Aviation Consultants Partnership Firm and Ors. v. D.Venkateshwar Rao and Ors*. W.P. 1135 (2016) (High Court of Telangana, 2 June 2021)

¹⁶¹ *Protection of Forest Area, Forest Wealth and Wildlife due to devastation from extensive forest fires in the State of Uttarakhand v. State of Uttarakhand and Ors* W.P. (PIL) No 68 (2018) (High Court of Uttarakhand at Nainital, 07 April 2021) [3]

¹⁶² *State of Uttarakhand v. In re Protection of Forest, Environment, Ecology and Wildlife from Forest Fire*, Civil Appeal No. 1249 of 2019 (Supreme Court of India, 15 May 2024).

¹⁶³ See Deccan Herald, *Forest fires: Supreme Court pitches for preventive steps, says cloud seeding, 'depending on rain god' no solution* (Deccan Herald, 8 May 2024). <https://www.deccanherald.com/india/forest-fires-supreme-court-pitches-for-preventive-steps-says-cloud-seeding-depending-on-rain-god-no-solution-3013873> last visited 9 September 2025

fires as the crux by resembling the well-known quote ‘prevention is better than cure’ to the subject matter as in ‘controlling forest fires is better than cloud-seeding’.

On the other hand, in 2024 at the Rajya Sabha¹⁶⁴ when the operations of cloud-seeding questioned, the Minister of MoES answered that, ‘present scientific knowledge suggests artificial rain-making techniques involving cloud-seeding cannot be used as an alternative for bringing rain to rainfall deficit or drought areas’¹⁶⁵ This statement is contrary towards several experiments reported successful i.e. Over the Linganaamakki catchment (1975) showed an average 20% increase in rainfall on seeded days¹⁶⁶, project Varuna (2003-2004) reported 95% successful¹⁶⁷ and Varshadhare in 2017 reported to have increased rain by over 27.9%¹⁶⁸. Therefore, this article emphasis that either a lack of historical and up-to-date knowledge of experiments, a dislike of providing government assistance for cloud seeding, or the high cost of the experiments could have been the reasons behind this equivocal statement.

Dash argues that the legality of cloud seeding in India is unclear, as there is neither a dedicated central statute nor a national policy regulating peaceful weather modification¹⁶⁹. In the discourse on the lack of a national policy, in fact, practices have proceeded through State programs and national scientific missions; for example, CAIPEEX in 2023 published the Indian Cloud-seeding Protocol and a template for catchment-scale programs¹⁷⁰, explicitly codifying the prevailing guidelines through technical white papers and standardised project protocols. In addition, the lacuna of a national policy for cloud seeding was addressed with the launch of a centralised National Artificial Rain Project (NARP)¹⁷¹ in 2025, in collaboration with ISRO and private weather-tech start-ups. However, it is unclear whether NARP will serve as a national policy on cloud seeding in India or merely a project. This article reserves answering it for future research due to the limited availability of literature at this time. In addressing the debate on the lack of a comprehensive national law, it seemed the need of the hour to recommend formulating

¹⁶⁴ The Rajya Sabha is the upper house of the Indian Parliament, which is also known as the ‘Council of States’, and functions as the representative body of the States and Union Territories. The lower house of the Indian Parliament is the Lok Sabha (House of the People)

¹⁶⁵ See Ministry of Earth Sciences, *Rajya Sabha Unstarred Question No.1960, Answered 12 December 2024*, ‘Cloud seeding’ (Government of India, 12 December 2024) <https://moes.gov.in/sites/default/files/1960English.pdf> last visited 5 September 2025

¹⁶⁶ Indian Meteorological Society (IMS) Bulletin (n 54); Murty (n 75)

¹⁶⁷ Ataulla, *supra* note 81.

¹⁶⁸ See Rao M. M., *Report finds cloud seeding increased rain* (The Hindu, 22 July 2018) <https://www.thehindu.com/news/national/karnataka/report-finds-cloud-seeding-increased-rain/article24489592.ece> last visited 23 August 2025

¹⁶⁹ Dash, *supra* note 54.

¹⁷⁰ Prabhakaran et al., *supra* note 142.

¹⁷¹ See The United Indian, *Cloud Seeding in 2025: India to UAE Countries Lead the Way* (The United Indian, 30 June 2025) <https://theunitedindian.com/news/blog?cloud-seeding-artificial-rain&b=524&c=1> last visited 7 September 2025

a national law on cloud seeding in India, as has been done in other cloud-seeding-led countries, namely China, with its comprehensive national regulation¹⁷². Even though the United States has no single federal cloud-seeding statute, State-level regulations are available, i.e., Colorado's weather modification article in the Colorado Revised Statutes¹⁷³ and Utah's cloud-seeding to increase precipitation provisions¹⁷⁴. Further, New South Wales enacted a targeted Act, the Snowy Mountain Cloud Seeding Act No 19 of 2004, to authorise and regulate cloud seeding by Snowy Hydro Limited¹⁷⁵. Canada has a federal Weather Modification Information Act, and British Columbia's Weather Modification Act requires a provincial permit. There are also bilateral information agreements, e.g., the Canada–United States exchange on weather modification¹⁷⁶.

B. Appraisal with international sources

Even though this article is limited to the verge of Indian jurisdiction, the reason behind this section is to critically observe the transcending borders of the legality of cloud-seeding in India. Even though cloud-seeding lacks comprehensive global recognition, this article finds it imperative to compare and contrast it with available international legal sources to advance its objective: gauging the lawfulness of cloud-seeding by consulting the analytical benchmarks of internationally recognised environmental legal principles of rightful purpose and rightful conduct.

To commence with, India is a State party¹⁷⁷ to the Convention on the prohibition of military and any other hostile use of Environmental Modification Techniques (ENMOD) 1976¹⁷⁸ which prohibits military or other hostile use of environmental modification. Article II defines an environmental modification technique as 'any technique for changing through the deliberate

¹⁷² Regulations on the Administration of Weather Modification (Decree No 348 of the State Council of the People's Republic of China, 19 March 2002) <https://faolex.fao.org/docs/pdf/chn137408E.pdf> last visited 8 September 2025

¹⁷³ Colorado Revised Statutes tit. 36, art. 20 (Weather Modification), §§ 36-20-101 to 36-20-127 (notably § 36-20-108), <https://law.justia.com/codes/colorado/title-36/weather-modification/article-20/section-36-20-108/>.

¹⁷⁴ See Utah Division of Water Resources, *Cloud Seeding to Increase Precipitation Act, Utah Code Title 73, Ch 15 (Utah)* ss 3–4 (Utah Government, 2025) <https://le.utah.gov/xcode/Title73/Chapter15/73-15.html> last visited 8 September 2025

¹⁷⁵ See Snowy Mountains Cloud Seeding Act 2004 (NSW) No 19, <https://legislation.nsw.gov.au/view/whole/html/inforce/current/act-2004-019>.

¹⁷⁶ See Department of Justice, *Weather Modification Information Act, RSC 1985, c W-5* (Canada Justice Laws Website, 21 August 2025) <https://laws-lois.justice.gc.ca/eng/acts/W-5/page-1.html?txthl=act> last visited 8 September 2025; British Columbia Laws, *Weather Modification Act [RSBC 1979] Chapter 431* (British Columbia Laws, 5 December 1994). <https://www.bclaws.gov.bc.ca/civix/document/id/94consol18/94consol18/79431> last visited 8 September 2025

¹⁷⁷ See ICRC, *Convention on the prohibition of military or any hostile use of environmental modification techniques*, 10 December 1976 (ICRC) <https://ihl-databases.icrc.org/en/ihl-treaties/enmod-1976/state-parties> last visited 11 September 2025

¹⁷⁸ *Id.* ENMOD entered into force on 5 October 1978. Pursuant to its Article VII, the Convention is of unlimited duration.

manipulation of natural processes, the dynamics, composition or structure of the earth, including its biota, lithosphere, hydrosphere and atmosphere or of outer space', which includes the cloud-seeding technique within the purview of this convention. Thus, ENMOD does not ban peaceful weather modifications. For example, New Delhi tested benign cloud-seeding operations to improve air quality in 2025.

In addition, in 2010, WMO released guidelines for operational programmes regarding weather modification activities¹⁷⁹, which were last updated in June 2025¹⁸⁰. In the circumstances, it is well applauded that the Indian CAIPEEX IV follows the WMO recommendations¹⁸¹. Furthermore, a set of guidelines to augment precipitation, known as ASCE Manual No. 81¹⁸², provides guiding principles for the professional practice of cloud seeding in the United States, which was the latest third edition, published in 2016¹⁸³. In comparison with ASCE Manual No. 81 and the Indian cloud-seeding experiments, partial alignment is evident in two experiments, i.e., in Maharashtra (1973-1986), where the ASCE 81 requirement for a scientific basis for vertical cloud thickness and the use of favourable cloud properties are considered. Further, the ASCE 81 experimental design for the area crossover was similar. In CAIPEEX (2018-2019), ASCE 81 guidance on instrumentation and measurement was performed with rain gauges and aircraft, as well as modes of seeding, selection of agents, and seeding criteria guidance, which was used via hygroscopic seeding, use of generators, or aircraft¹⁸⁴. Even though Tamil Nadu's principal cloud-seeding operations (1984, 1985 and 1986) was conducted by pilots from M/s Atmospherics Inc. of California, United States¹⁸⁵ and Karnataka State's Varshadhare (2017) by Hoyasala Projects Pvt Ltd imported United States made aircrafts, whereas no account of evidence traced on following ASCE 81 (first edition 1983 or second edition 2006) standards in these missions.

In fact, besides WMO and ASCE 81, which have provided standardised guiding principles for cloud-seeding operations, neither has any effective binding power over adopting countries.

¹⁷⁹ See World Meteorological Organisation, *WMO: Documents on Weather Modification* (WMO, 22-24 March 2010) https://www.skywaterventures.com/uploads/7/0/6/1/70616003/wmr_documents.final_27_april_1.final.pdf last visited 8 September 2025

¹⁸⁰ See WMO, *WMO Statement on Weather Modification* (WMO, 14 June 2025). <https://wmo.int/content/wmo-statement-weather-modification> last visited 8 September 2025

¹⁸¹ Prabhakaran et al., *supra* note 142.

¹⁸² See Guidelines for Cloud Seeding to Augment Precipitation, *ASCE Manuals and Reports on Engineering Practice* (American Society of Civil Engineers, 2016). <http://ndl.ethernet.edu.et/bitstream/123456789/60459/1/1027.pdf> last visited 11 September 2025

¹⁸³ *Id.*

¹⁸⁴ See Parliament of India, *Parliament Question: Cloud Seeding* (Press Information Bureau, 23 July 2025) <https://www.pib.gov.in/PressReleaseDetailm.aspx?PRID=2147269> Accessed 7 September 2025; See also Murthy (n 67)

¹⁸⁵ See INDIAN METEOROLOGICAL SOC., CHENNAI CHAPTER, *BREEZE* (Newsletter), vol. 17, no. 1 (June 2017), https://mausam.imd.gov.in/chennai/imsimd/pdf/BREEZE_June2017.pdf.

Thereby, the consequences of non-realisation or violation of these guidelines are without avail before the law. However, the scope of application of ENMOD is broader, which legally binds the State parties. As discussed, it prohibits the military or other hostile use of cloud seeding but does not restrict it to peaceful purposes. Consequently, this article further identifies the lack of international law governing cloud-seeding activities, without delving into the scope of military or hostile use. For instance, peaceful cloud-seeding methods, which might cause transboundary precipitation, may ultimately have adverse effects on other States and are not governed by ENMOD. Therefore, as argued in the preceding section, although Indian jurisdiction lacks a central statute for cloud seeding, the same demand is evident in the international legal landscape as well.

V. ANALYSIS OF RIGHTFUL PURPOSE AND RIGHTFUL CONDUCT

To evaluate the legitimacy of cloud seeding in India, this article considers the international law principles of rightful purpose and rightful conduct as yardsticks. The principles of rightful purpose and rightful conduct are rooted in doctrines of constitutional, administrative, and environmental law. Thus, these principles are evaluated in depth on a constitutional, administrative, and environmental doctrinal basis to analyse the legality of cloud seeding in India.

A. Rightful purpose

Rightful purpose in constitutional law generally refers to the legitimate objective for which the State exercises a constitutional power. In other words, a governmental authority, i.e., legislature, executive, or administrative body, must exercise its powers only for the purpose for which the constitution or statute granted those powers. If its power is used otherwise, it is unconstitutional or invalid by the courts. In constitutional adjudication, courts therefore examine the purpose behind legislation or executive action to determine whether it is legitimate¹⁸⁶. The doctrine is often applied when courts examine misuse of discretionary power.

In administrative law, the scope of rightful purpose and abuse of power is that, even when an authority has legal power, exercising that power for an improper purpose is unlawful¹⁸⁷. Such actions violate constitutional principles such as the rule of law, equality, and due process. Moreover, in judicial review, courts commonly analyse legislative or executive purpose, considering it valid if it pursues a legitimate governmental objective, i.e., public health, national security, or environmental protection. However, if it lacks a legitimate purpose or is a disguised

¹⁸⁶ See MARK ELLIOTT AND ROBERT THOMAS, *PUBLIC LAW* (4th edn, Oxford University Press 2020) 185.

¹⁸⁷ See HWR WADE AND CF FORSYTH, *ADMINISTRATIVE LAW* (11th edn, Oxford University Press 2014) 356.

attempt to achieve an unconstitutional aim, courts may invalidate it¹⁸⁸. Modern constitutional jurisprudence often links rightful purpose to the proportionality and reasonableness test, in which courts ask: Is the law's objective legitimate? Is the measure suitable to achieve that objective? Is it necessary? Is the restriction proportionate to the aim pursued?¹⁸⁹ Thereby, a legitimate or rightful purpose is the first step in constitutional scrutiny.

Environmental legislation often grants governments broad discretionary powers, i.e., powers to regulate pollution, manage water resources, or protect biodiversity. In this backdrop, the principle of rightful purpose in environmental law ensures that these powers are exercised only to achieve legitimate environmental objectives¹⁹⁰. If environmental powers are used for a collateral or improper purpose, courts may invalidate the action. In the context of the doctrine of abuse of power, environmental authorities often exercise discretion when granting licenses, permits, or EIAs. Under the principle of rightful purpose, such decisions must be based on environmental considerations and statutory objectives¹⁹¹. Authorities cannot use environmental powers to favour particular economic actors or achieve unrelated political goals. Courts have the power to review such decisions under the improper purpose or abuse-of-discretion doctrines. The principle of rightful purpose also reinforces broader environmental governance principles, i.e., sustainable development, the precautionary principle, and the polluter-pays principle. Environmental regulations must therefore pursue legitimate environmental objectives while balancing economic and social interests. Courts in many jurisdictions apply the principle of rightful purpose when reviewing environmental administrative decisions. Courts invalidate an environmental decision if the authority acted for an improper or irrelevant purpose or the decision failed to pursue the statutory environmental objectives¹⁹². This ensures that environmental powers remain accountable, transparent, and directed toward ecological protection.

Within the established doctrinal framework of rightful purpose in constitutional, administrative, and environmental law, it is clear that to affirm the legality of cloud seeding, a legal authority conferred by the constitution or a statute is required. Although cloud seeding is presumed to fall within the scope of water rights protected under the right to life under Article 21 of the Indian

¹⁸⁸ See DAVID FELDMAN, *CIVIL LIBERTIES AND HUMAN RIGHTS IN ENGLAND AND WALES* (2nd edn, Oxford University Press 2002) 98.

¹⁸⁹ See AHARON BARAK, *PROPORTIONALITY: CONSTITUTIONAL RIGHTS AND THEIR LIMITATIONS* (Cambridge University Press 2012) 245.

¹⁹⁰ See PHILIPPE SANDS, JACQUELINE PEEL, ADRIANA FABRA AND RUTH MACKENZIE, *PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW* (4th edn, Cambridge University Press 2018) 206.

¹⁹¹ See ELIZABETH FISHER, BETTINA LANGE & ELOISE SCOTFORD, *ENVIRONMENTAL LAW: TEXT, CASES AND MATERIALS* (2d ed., Oxford University Press 2019), 198.

¹⁹² Wade and Forsyth, *supra* note 187.

Constitution, it is neither constitutionally nor legislatively recognized, at least as a means of securing those rights. According to the principle of rightful purpose in constitutional law, government authorities must act only within the bounds of the powers granted by the constitution or statute, and any misuse of these powers renders the action unconstitutional or invalid in the courts. Additionally, the principle of rightful purpose in administrative law states that exercising authority for an improper reason is unlawful. However, since India is a quasi-federal state, water is not solely a union subject but rather a matter of concurrent jurisdiction with substantial state-level control. With multiple State-level cloud seeding experiments in India, the absence of specific legislation on cloud seeding or weather modification activities at the State level compromises the legality of such activities' rightful purpose under both constitutional and administrative law. Next, the principle of rightful purpose in environmental law promotes the achievement of legitimate environmental objectives through discretionary powers in granting licences and conducting EIAs, and reinforces broader environmental governance principles, i.e., sustainable development, the precautionary principle, and the polluter-pays principle. In the Indian jurisdiction, EIAs are mandatory for cloud-seeding experiments due to the silver iodide and salt residues used as seeding agents. Notably, in the case of *Vanashakti v. Union of India* (2025)¹⁹³, the Supreme Court quashed the SOP 2021 that allows for ex-post facto Environmental Clearances (ECs), affirming the landmark decision that retrospective approvals are incompatible with the EIA Notification of 2006, by emphasising the necessity for prior environmental assessments before undertaking projects that may impact the environment. Thereby, the rightful purpose of cloud seeding under environmental law seems to be affirmed in EIAs in the Indian jurisdiction. However, in terms of fortifying environmental governance principles with reference to cloud seeding, this has not yet been addressed, as only a limited number of decided cases on cloud seeding are available.

B. Rightful conduct

Rightful conduct in constitutional law denotes that government officials must exercise their powers in accordance with constitutional principles and legal procedures. Even where the State possesses lawful authority, the manner in which that authority is exercised must remain consistent with constitutional values, i.e., legality, equality, and accountability. In constitutional democracies, rightful conduct requires that public authorities act within the limits of the law, that State actions respect fundamental rights and freedoms, and that decisions are taken fairly, rationally, and without arbitrariness¹⁹⁴. If the government conducts itself in violation of these

¹⁹³ *Vanashakti v. Union of India*, *supra* note 122.

¹⁹⁴ Elliott and Thomas, *supra* note 186, at 79.

standards, courts may declare such conduct unconstitutional through judicial review. The concept of rightful conduct is closely connected to the rule of law, which requires that all government actions must be governed by law rather than arbitrary discretion. Rightful conduct ensures that public officials do not misuse their authority and that the State remains subject to constitutional control. This principle demands: transparency and accountability in public decision-making, equal application of the law, and protection against arbitrary or abusive governmental action¹⁹⁵. Therefore, rightful conduct reinforces the constitutional idea that government is not above the law. Rightful conduct also requires that State authorities respect and protect fundamental rights guaranteed by the constitution. Government conduct that unjustifiably restricts rights may be invalidated. Thus, rightful conduct ensures that constitutional rights are not merely theoretical but practically enforced through lawful governmental behaviour¹⁹⁶.

Rightful conduct in administrative law is reviewed in courts. Courts often evaluate government conduct when determining whether a public authority has acted constitutionally. Judicial review examines whether the authority acted within its legal powers (legality), followed fair procedures (procedural fairness), and reached decisions that are reasonable and rational¹⁹⁷. In other words, courts supervise administrative conduct through judicial review, examining whether authorities have acted *ultra vires* (beyond legal powers), for an improper purpose, unreasonably or irrationally, and in breach of procedural fairness¹⁹⁸. If the authority's conduct fails to meet these standards, courts quash the decision, declare it unconstitutional, or grant other remedies. Moreover, a key aspect of rightful conduct is adherence to the principles of natural justice, which include: *audi alteram partem* (the right to be heard) and *nemo iudex in causa sua* (absence of bias). Administrative authorities must ensure that their conduct respects these procedural safeguards when making decisions affecting rights or interests¹⁹⁹.

Rightful conduct in environmental laws requires that actors whose activities affect the environment, i.e., governments, industries, and developers, operate within environmental regulations and standards to protect ecological systems and prevent environmental harm. Thereby, activities affecting the environment are carried out responsibly, lawfully, and with due regard to environmental protection and sustainable development²⁰⁰. Regarding environmental

¹⁹⁵ TOM BINGHAM, *THE RULE OF LAW* (Penguin Books 2011) 37.

¹⁹⁶ DAVID FELDMAN, *CIVIL LIBERTIES AND HUMAN RIGHTS IN ENGLAND AND WALES* (2nd edn, Oxford University Press 2002) 121.

¹⁹⁷ Wade and Forsyth, *supra* note 187, at 30.

¹⁹⁸ *Id.* (321).

¹⁹⁹ Paul Craig, *Administrative Law* (9th edn, Sweet & Maxwell 2021) 404.

²⁰⁰ Philippe Sands et al, *supra* note 190, at 217.

responsibility, proper conduct imposes duties on both state and private actors to prevent environmental degradation, including exercising environmental due diligence, preventing pollution and ecological damage, and managing natural resources responsibly. Further, States must ensure that activities within their jurisdiction do not cause environmental harm to other States or to areas beyond national jurisdiction²⁰¹. Rightful conduct also underpins modern environmental governance. Authorities must implement environmental policies transparently, fairly, and consistently with environmental objectives²⁰². This includes proper environmental licensing procedures, enforcement of environmental standards, and public participation in environmental decision-making. Failure to maintain rightful conduct may lead to legal liability, administrative sanctions, or judicial review. Rightful conduct is closely connected to the principle of sustainable development, which requires that development activities be carried out in ways that meet present needs without compromising the ability of future generations to meet their own²⁰³.

Evaluating the aforesaid in light of the legality of cloud seeding, it is understood that the principle of rightful conduct in constitutional law has close ties with the rule of law, which requires that all government actions must be governed by law rather than arbitrary discretion. However, due to a lack of direct constitutional or statutory recognition, cloud seeding activities have been carried out by both union and state governments for seven decades, a practice perceived as illegal and leading to arbitrary discretion. On the other hand, rightful conduct reinforces the constitutional principle that government is not above the law and requires that State authorities respect and protect fundamental rights guaranteed by the constitution. In this setting, water rights, which fall in the ambit of the right to life under Article 21 of the Indian Constitution, shall be the rule of law in the instant debate. Therefore, it is yet arguable that cloud seeding is a means of protecting water rights guaranteed by the Constitution. In the realm of administrative law, courts supervise administrative conduct through judicial review, examining whether authorities have acted *ultra vires*, for an improper purpose, unreasonably or irrationally, or in breach of procedural fairness. Against the backdrop of limited judicial matters regarding the legality of cloud seeding, this has not yet been a legal concern in judicial activism in India. However, in the absence of constitutional and statutory back-up, the cloud seeding authorities would be deemed to have acted *ultra vires*. Rightful conduct under environmental laws requires

²⁰¹ PATRICIA BIRNIE, ALAN BOYLE AND CATHERINE REDGWELL, *INTERNATIONAL LAW AND THE ENVIRONMENT* (3rd edn, Oxford University Press 2009) 143.

²⁰² Elizabeth Fisher et al, *supra* note 191, at 211.

²⁰³ ALAN BOYLE AND CATHERINE REDGWELL, BIRNIE, BOYLE AND REDGWELL'S *INTERNATIONAL LAW AND THE ENVIRONMENT* (4th edn, Oxford University Press 2021) 116.

that actors whose activities affect the environment operate within environmental regulations and standards to protect ecological systems and prevent environmental harm, as evidenced by cloud seeding in the Indian jurisdiction under several water protection and environmental protection laws, regulations, and judicial decisions despite direct regulations pertain to environmental protection from cloud seeding.

The article also finds it practically imperative to satisfy the requirement of consent for cloud seeding, which has been an overcast area in gauging legality, to endeavour to uphold both principles of rightful conduct and rightful purpose in light of sovereignty residing in the people of India. Consent outlines the decision-maker of cloud-seeding, i.e., people, the government, private entities, or the judiciary. Dash argues that “governments use taxpayers’ money to execute large projects”²⁰⁴, whereas people have no decision-making power over cloud-seeding. In India, governments have pursued cloud seeding for over seven decades, and the general public’s consent has not been reported to have been considered. Even though the judiciary has suo motu powers, no judicial precedent has been observed on their exercise in the context of cloud seeding. In this backdrop, this article suggests referendums²⁰⁵ could be a way forward for determining public consent on cloud seeding.

Therefore, in the concluding remarks, it must be noted that the principles of rightful purpose and conduct apply only to government authorities and private entities and are outside the scope of the principles. Rightful purpose is a public-interest justification that emphasizes that cloud-seeding must serve essential State or community needs, such as cloud-seeding in 1992 in Maharashtra to supply drinking water to Mumbai, drought relief, and pollution mitigation. Consequently, any private or profit-driven motives that harm public welfare do not fall within the definition of the principle of rightful purpose. Furthermore, as discussed in the realm of indirect constitutional guaranteeing, the Constitutional provisions of Articles 21 and 48A support the lawful basis for securing access to water through cloud seeding, through a rights-based approach, and as a State obligation, respectively. In this context, it is clear that when private entities conduct cloud-seeding experiments for profit, they violate the standards of lawful conduct. However, when evaluating the principles of rightful purpose and conduct as benchmarks for the legality of cloud seeding in India, it is evident that the absence of a direct constitutional safeguard or a specific statutory reference to cloud seeding undermines the legality of such activities under both constitutional and administrative legal doctrines. In

²⁰⁴ Dash, *supra* note 54.

²⁰⁵ An instrument of direct democracy.

contrast, under environmental law, both the rightful purpose and the conduct are upheld, at least to some extent, through the rich jurisprudence on EIA procedures.

VI. CONCLUSION

In addressing the overarching question of this article, the legality of cloud seeding in India, this research emphasizes the importance of viewing ‘water’ as a fundamental ‘right,’ since it has been the vital elixir of human survival since ancient civilizations. Currently, through weather modification via cloud seeding, humans can induce precipitation, increasing water supplies and providing a practical solution amid growing water scarcity in the coming centuries. This groundwork helps highlight the right to water as humanity’s top challenge and suggests that cloud seeding could serve as an intertwined solution, like two sides of the same coin.

It is observed that cloud seeding is evident at both the union (national) and state levels, across both the scientific-experimental and operational-project-based dimensions. At the national scale, the government of India has attempted cloud seeding under the patronage of MoES and IMD, with support from IITM’s CAIPEEX. Several State-governments in India have also attempted cloud-seeding i.e. Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Rajasthan, Tamil Nadu under various projects, i.e. Varuna, Cauvery Basin Project, Varsha, Indira Meghamadhanamu, Varshadhare, Prakalpa Varsha and HydroTrace with diverse areal, ground based as well as drone technologies including mainly hygroscopic (warm cloud seeding) mechanism with often usage of the agents of silver iodide, dry ice and salt (NaCl) with objectives to overcome arid climate, severe droughts, failed monsoons, drinking water shortages, water scarcity for agriculture and to mitigate air pollution. In this setting, to find feasible answers to the quest of the legality of cloud seeding in the jurisdiction of India, in evaluation of the principles of rightful purpose and rightful conduct as benchmarks of lawfulness, it was evident that the absence of a direct constitutional safeguard or specific statutory reference on cloud seeding compromises the legality of such activities’ rightful purpose and rightful conduct under both constitutional and administrative legal doctrines. In contrast, under environmental law, both rightful purpose and rightful conduct are praised through the rich jurisprudence on EIA formalities decided by courts. Additionally, to implement cloud-seeding legally and effectively, this article supports the need for a long-awaited national policy and legislation on cloud-seeding in India, as essential steps to strengthen the empirical debate.

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