PRINCIPLES FOR RESPONSIBLE RESEARCH AND INNOVATION IN WEATHER CONTROL RESEARCH AND DEVELOPMENT IN MOONSHOT GOAL 8 (INTERIM DRAFT)

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PREAMBLE

The weather brings essential natural resources to living beings on Earth. However, extreme weather events such as typhoons and torrential rains sometimes cause catastrophic disasters that threaten the foundations of our social lives. Therefore, an option for harmonizing our social lives with the increasingly severe extreme weather associated with global warming is research and development to artificially mitigate the intensity of heavy weather events (weather control research). In Japan, starting in 2022, the Moonshot Research and Development Program established by the Cabinet Office launched Moonshot Goal 8 (MS8), which aims to garner "a society safe from the threat of extreme winds and rains by controlling and modifying the weather by 2050." MS8 is conducting research and development targeting the following areas:

- Making it possible to intervene to change the timing, range and intensity of typhoons and extreme rains (including those that occur in linear precipitation zones), significantly reducing disaster damage and bringing a wide range of benefits to society by 2050.
- Demonstration on a computer that it is possible to reduce disaster damage by controlling typhoons and extreme rains using realistic intervention operations, and conduct experiments to verify these operations by 2030.

Weather control and field experiments for this purpose not only contribute to disaster prevention and mitigation but also involve potential changes in water resource allocation and unforeseen damage. Consequently, associated political and ethical issues are anticipated. Furthermore, the very act of artificially intervening in the atmospheric systems brought about by nature could provoke various debates, including from religious and cultural perspectives. Therefore, in the research and development of weather control, it is essential to recognize ethical, legal, and

social implications (ELSI)* as non-technical aspects arising from the realization of weather control and field experiments, and to conduct this work with a responsible attitude toward society and the natural environment. The “Principles for Responsible Research and Innovation in Weather Control Research and Development in Moonshot Goal 8” (the Principles”) clarifies the tenets constituting “Responsible Research and Innovation” in weather control research and development within MS8 (“R&D”).

*ELSI is generally used as an acronym for ethical, legal, and social *issues*. In order to conduct R&D responsibly, the focus should not only be on the issues that must be overcome but also the potential *implications*—impacts and any changes—that may arise.

PRINCIPLE 1: PURSUIT OF SOCIAL BENEFITS

1. R&D must be conducted by clarifying its social benefits.

   (A) The social benefits of R&D include realizing a safe and secure society free from the threat of extreme wind and water disasters by controlling increasingly severe typhoons and torrential rain events by 2050.

   (B) Diverse potential applications of this technology other than (A) may be explored while also identifying their limitations.

2. R&D must be conducted with defined milestones aligned with the overall projects and by confirming the likelihood of achieving these milestones.

3. As R&D progresses, its position and role within disaster prevention and mitigation measures must be periodically reviewed, and the social benefits of R&D must be confirmed based on these reviews.

4. Entities seeking profit may participate in R&D, provided that their activities align with the pursued social benefits.

PRINCIPLE 2: CONSIDERATION OF ETHICS AND JUSTICE

1. R&D must be conducted with consideration for ethics and justice, and must respond appropriately to anticipated concerns.

2. From an ethical perspective, consideration must be given to concerns such as the following:

   (A) Humans' intentional intervention in nature may be perceived as an expression of human arrogance.

   (B) It may lead to selecting beneficiaries and those bearing risks.

   (C) It may create moral hazards, such as neglecting measures against wind and water disasters or against global warming—a factor intensifying typhoons and torrential rain.

3. Furthermore, it is necessary to fulfill the responsibility of maintaining the physical, mental, and social relationship between humans and the weather, and of passing it on to future generations, based on mutual trust and cooperation between citizens, businesses, regions, and nations.

4. From the perspective of justice, consideration must be given to concerns such as the following:

   (A) Distributive justice may be threatened when weather control has both positive and negative impacts distributed unequally.

   (B) Fair decision-making processes for research, development, and implementation—ensuring transparency and accountability, participation and inclusion of diverse potentially affected people, or dialogue with them—are essential for procedural justice.

   (C) Weather control may affect the interests of future generations over the long term, potentially raising issues of intergenerational justice.

5. Furthermore, attention must be paid to the dual-use nature of weather control technologies, which can be applied to both military and civilian purposes.

PRINCIPLE 3: RESEARCH AND DEVELOPMENT BASED ON SCIENTIFIC EVIDENCE

1. R&D must be grounded in robust scientific evidence on atmospheric processes, the water cycle, etc., and contribute to future scientific advances.

2. A monitoring system, including data acquisition, must be established to identify or distinguish the effects of the control measures.

3. The results of R&D, including field experiments, must be evaluated by the entire academic community, and not only through the peer-review process of publications.

4. The publication of results related to R&D must include not only successful cases but also failures, unresolved issues, and uncertainties.

5. By publicly releasing and sharing data obtained in R&D, the environment and opportunities must be ensured to facilitate verification outside R&D and to promote the advancement of scientific knowledge.

PRINCIPLE 4: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

1. For field experiments based on R&D, a reasonably feasible assessment must be conducted regarding impacts on the natural environment, including ecosystems and biological resources, as well as on atmospheric phenomena and the water cycle, regardless of whether such an assessment is legally mandated.

2. Furthermore, it is necessary to bear in mind that environmental impacts may extend beyond the present into the future.

3. For field experiments, to ensure safety regarding impacts on the natural environment and socio-economy, voluntary guidelines or other methods must prescribe matters related to implementation in addition to complying with relevant laws and regulations. Cooperation must be provided for necessary consultations on matters involving bilateral or multilateral international relationships.

4. If it is difficult to comply with relevant laws and regulations, ensure safety, or establish the necessary rules, field experiments must be suspended or modified, or necessary actions must be taken based on review or evaluation by researchers other than those conducting the experiments.

5. R&D must conduct studies from an academic perspective on impact assessment methodologies, environmental ethics, environmental justice, compensation, and dispute resolution.

PRINCIPLE 5: DIALOGUE WITH DIVERSE STAKEHOLDERS

1. R&D must establish opportunities to hear the opinions of entities with diverse backgrounds and viewpoints, regardless of whether they have a direct stake , and must be conducted based on the outcomes of these discussions.

2. R&D must strive to ensure that non-experts can understand it and participate in dialogue through appropriate information disclosure and plain explanations.

3. During the planning stage of field experiments, explanations and dialogue must be conducted with stakeholders potentially affected by the experiment. Timely information and reporting of results must be provided during and after the experiment's implementation.

4. The identification of stakeholders for field experiments must be conducted carefully, incorporating diverse opinions.

5. When conducting field experiments require the establishment of domestic and international rules, efforts must be made to actively participate in such rulemaking. Furthermore, cross-border mutual understanding and trust must be fostered through information exchange with researchers abroad and the implementation of joint research.

PRINCIPLE 6: TRANSPARENCY

1. Transparency must be ensured by disclosing relevant information and data regarding the outcomes of R&D, decision-making processes related to field experiments, implementation details, and evaluations.

2. A registry (open register) must be maintained for R&D.

3. In disclosing and sharing data, requirements related to *Open Science* must be adhered to, while also considering international trends such as the FAIR (Findable, Accessible, Interoperable, Reusable) principles.

PRINCIPLE 7: ADAPTABILITY

1. R&D maintains a flexible approach, recognizing that inherently important but unforeseeable issues may exist, and that new challenges and considerations may arise as R&D progresses, and continuously assessing ELSI.

2. R&D must strive to enhance the scientific understanding of weather control while also acknowledging the degree of uncertainty inherent in it (the difficulty of establishing causation between interventions and subsequent events), and must act in a manner commensurate with that degree of uncertainty.

3. When serious negative impacts or their possibility become apparent, necessary measures must be taken, including changes to the policy or content of R&D. When assessing negative impacts, consideration must be given not only to their extent and degree but also to the potential for long-term environmental effects.

4. Efforts must be made to ensure that the scale of interventions and their anticipated impact ranges are kept to a minimum. Furthermore, if these expand beyond the initially planned, necessary actions must be considered, including changes to the plan.

5. Field experiments must be conducted to anticipate the possibility of impacts or damage exceeding predictions. If the impacts or damage caused by the intervention cannot be predicted using reasonable methods, the experiment must be halted or modified to a less impactful alternative.

6. R&D must evaluate its outcomes and impacts in a timely manner, allowing for flexible changes to the research plan (including termination) and the reallocation of resources.

SUPPLEMENTARY PROVISIONS

The Principles must apply retroactively to May 2022, the start date of MS8 R&D. The Principles must be periodically reviewed and revised as appropriate based on progress in weather control research and other relevant developments.

MEMBERS OF THE MS8 JOINT ELSI UNIT

To ensure consistent treatment of ELSI that may be common across projects, MS8 has established the MS8 Joint ELSI Unit, comprising ELSI researchers from all projects, along with members providing guidance in program direction, meteorology, and an overarching perspective. The Principles was drafted by this unit.

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Abbreviations

- PD : Program Director
- SPD : Sub Program Director
- AD : Advisor
- PI : Performer