

PROBLEMS AND PROSPECTS OF RAINMAKING FROM CLOUDS — AN OVERVIEW

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During the last several years many countries have been making vigorous attempts to secure additional rainfall by artificial precipitation, that is by seeding the clouds with powerful chemical agents. These attempts, some successful and others not, would present prospects as well as problems to the mankind.

The state of present scientific knowledge is far from sufficient to draw conclusions and to forecast with exactitude the degree, nature and duration of the effects of the artificially induced change in the clouds on one territory may give rise elsewhere. Only a more detailed technological and scientific study on the trends of the cloud's course of movement would help to establish these effects.

RAINMAKING EFFORTS

Rainmaking from clouds is not a new art; but scientifically designed cloud seeding experiment is of recent origin.

Throughout the ages, a number of attempts have been made by man to increase the rainfall by a variety of interesting methods such as witchcraft, magic, religious rituals, church prayers and explosives. The Teutonic custom has been pouring water on a naked girl; in India it has been the snake

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dance. American Indians in Arizona practice the tribal Hopi dances, and in Africa rain queens perform mysterious rites to enhance the quantity of rainfall. The firing of guns and the ringing of church bells have long been practised in Switzerland, Italy and Austria. In the late 1800s in upstate New York, the local Presbyterian Minister, Duncan Mcleod, administered a huge collective church prayer which ended in a law suit by Phinneas Dodd against the Reverend Minister. These illustrations would indicate that, until recently, rainfall was considered as an Act of God, a natural phenomenon. The above ceremonials and rituals were intended to persuade the Gods in the Heaven to be sympathetic and drop their tears which would be transformed into rain when they reach the earth.

Modern scientific experiments to increase rainfall started only in the twentieth century. The experiments of Dutch scientist August W. Veraart, Swedish meteorologist Tor Bergeron and the German physicist Walter Findeisen in the thirties were partially successful. In 1930, Veraart dropped dry ice, among other things, into supercooled clouds and produced light amounts of rain on several occasions, but because of his sweeping claims all his attempts were discredited. Bergeron demonstrated that the presence of ice crystals in a supercooled cloud is necessary for the release of rain. Findeisen, in 1938, foresaw the possibility of producing rain from supercooled clouds by the introduction of artificial ice nuclei.

By way of their experiments, the scientists in Europe tried to establish that clouds would precipitate if they contained the height mixture of ice crystals and supercooled water drops. In United States a new wave of enthusiasm arose out of the World War II investigations of fog particles. In 1946, Irving Longinuir and Vicent Schaefer modified clouds by seeding them with dry ice pellets. In the following year Bernard Vonnegut demonstrated that a smoke of silver iodide crystals would produce the same results.

Pursuant to the above research results, a large number of Countries devoted considerable attention in experimenting with cloud seeding in the fifties and the number of participants have grown consistently in later years. Among others, Australia, Canadá, France, Germany, Israel, Japan, Soviet Union, Switzerland, United Kingdom and the United States of America have shown intense interest in the more advanced phases of basic research in cloud physics as well as large scale field experiments in cloud seeding. Research and development will continue to advance and this advance will move at a great speed.

ECONOMIC AND SOCIAL EFFECTS

During the dark ages, clouds were regarded as demons of the air. Storms, tempests, hurricanes and the accompanying floods caused by the cloud phenomenon were taken for granted as mischievous spirits, let loose by God to injure and destroy the man. These superstitious beliefs have already been taken over by modern scientific evidences. It has now been established that if the clouds can be forced to release their moisture before they naturally would or if the moisture can be prevented from falling, a characteristic change in the existing environment can be made. This change has an all-pervasive influence on the economic and social parameters of a society.

The modification of clouds and the weather pattern will concern not one particular individual or State because the effect of modification cannot be necessarily confined to the modifier's backyard. It is also apparently clear that the amount of moisture in the air is limited. Hence any successful attempt to induce rainfall artificially in a particular place will decrease the amount that would have fallen in some other areas.

The immediate effect of rainmaking is that it may considerably influence the industries, in particular agriculture,

which are in need of a regular supply of water. Damage done by major droughts in arid and semi-arid regions is so great and so widespread as to be almost incalculable. Modification of clouds may help alleviate rainfall deficiencies by increasing precipitation within drainage areas equipped with storage facilities which could be later distributed through irrigation system. Increase of water available for storage would also make possible enhanced use of hydroelectric power plants and the production of energy could be multiplied.

The experiments that have hitherto undertaken indicate that variations of modern cloud seeding techniques can be applied in eliminating or at least suppressing thunderstorms, hail, lightning, snowstorms, and hurricanes. They may also be used in combating fog, forest fires and floods.

It is predicted that by dropping of ice on clouds the development of thunderstorm may be modified and their severity reduced. The reduction in severity of the storms may reduce lightning damage and eliminate hail. As to snowstorms, it is observed that their direction may easily be changed thus causing the fall to take place away from urban and industrial areas. By modifying precipitation, nucleation techniques may dissipate incipient or possibly even developed hurricanes; or by disturbing their equilibria, change their tracks.

Cloud modification techniques might produce rainfall to assist in bringing forest fires under control. By directing or moderating the severity of storms which threaten river basins already approaching flood stage, it might be possible to control the floods which cause incalculable damage to man and property in different parts of the world.

In addition to the above possibilities, the application of precipitation techniques for military purposes is of great significance. What General Kenny, the then commander of the United States Strategic Air Force predicted in 1947 that "the nation which first learns to plot the paths of air masses

accurately and learns to control the time and place of precipitation will dominate the world" seems to be true today. Recent newspaper reports say that the United States forces have been seeding clouds over North Vietnam, Laos and South Vietnam to increase and control the rainfall for military purposes. Excess or inopportune rain produced by cloudseeding may create floods, destroy crops, increase automobile accidents due to slippery highways, and cause serious delays and interruptions in outdoor commercial activities.

LEGAL ASPECTS

The newly developed technological capability to regulate the fall of rain from clouds would present legal problems because it can benefit some countries, deprive others of benefit and cause damage to still others. As in many other fields the law lags far behind the scientific development. It may perhaps be argued that it is premature to discuss about the legal problems at the present stage of development. This is not true. One need not wait for the theft to be had committed before establishing rules to protect property. Thorny problems, such as the legal status of clouds, including their ownership and control, and problems of liability for damage would become new elements of international tensions.

Legal Status Clouds:

The determination of legal status of clouds which has not yet been defined by state practice or custom is necessary to identify the rights and obligations of States in respect to their claims to uses. In the absence of a properly defined legal status, the growth of practices through the accumulation of *fait accompli* might prove to be detrimental to the future efforts for the formation of a rational regime on clouds. It may also lead to unrestrained rivalry between neighbouring States in their appropriation.

Who Owns the Clouds:

From an international point of view the first question that arises is whether or not States have a right of ownership on the clouds, and if so on what basis it can be said to exist. In a strictly possessory sense, it may be said that the States cannot own the clouds as they cannot control them to such an extent considered necessary for possession of them. Traditionally States have regarded the mere physical presence of a tangible asset, such as a ship or aircraft within the territorial boundaries of a State as sufficient basis for authorizing that State to assert its control over that asset. It would appear that the factors which have stimulated such claims with respect to ships and aircraft will be applicable in case of clouds and that comparable claims will be made. But the clouds are of a vague and fugitive nature. Due to their peculiar characteristics which are in certain respects similar to those of running water, oil and gas, migratory birds and floating fish, the claim of sovereignty would raise problems.

States may invoke ownership of clouds by virtue of ownership of the underlying land. It has been a legal tradition to discuss the *ad coelum* doctrine whenever it is necessary to discuss rights on objects in the air. Under this doctrine, States would have an absolute ownership to the clouds and could use rights in such clouds to their own advantage. With the advent of aviation, this doctrine has been a subject of extensive legal analysis and it is no longer the law.

As a result of their physical qualities, clouds are rather distinct from any other tangible asset. Clouds are formed by the cooling of water vapour changing in the process from an invisible to visible state. The cooling may be effected by expansion due to uplift and consequent diminished pressure, or to radiation and direct loss of heat or to contact with a cooler air mass. The dimensions, shape, structure and texture

of clouds are largely influenced by the kind of air movements. Clouds which are today on the territory of one State and therefore a part of its State territory may move into the territory of another State and become part of that State's territory. It may perhaps be said of moving clouds what the United States Supreme Court said of migratory birds in the famous **Missouri v. Holland** case:

To put the claim of the State upon title is to lean upon a slender reed. Wild birds are not in the possession of anyone; and possession is the beginning of ownership. The whole foundation of the State's rights is the presence within their jurisdiction of birds that yesterday had not arrived, tomorrow may be in another State and in a week a thousand miles away... The subject matter is only transitorily within the State and has no permanent habitat therein.

The analogy of clouds to migratory birds is defective in the sense that clouds do not follow any predictable course. For the same reason analogy to water, oil and gas does not hold good. Water courses follow defined channels; they flow with sufficient constancy as to enable the taking of a measurement of the degree of interference with their natural state. Even underground water provides a continuously available supply of water which is reduced in a measurable degree by removal of certain amount. Oil and gas, like water, are also subject to definite location and ultimate possession. Furthermore, clouds do not continue to travel in a visible form indefinitely. They constantly disappear to be displaced by others. They are liable to contract and expand and they move from one place to another with the slightest change in the direction of wind. In brief, clouds may dissipate, change shape, location, content; they may even evaporate entirely; they may divide into two or more clouds or may merge with other clouds. In view of these peculiar characteristics it might be said that clouds like air and light are not the subject of exclusive possession of subjacent States; they are *sui generis*.

Liability for Damages:

Apart from the direct injury caused by the lowering or raising the level of rainfall, the use of toxic material such as silver iodide for seeding the clouds may complicate the problem of liability for damage. Further, due to diverse social and economic systems, the exploration and modification of clouds will be carried out by different types of entities. The type of entities may include public governmental agencies, private companies, mixed public and private corporations, and State-owned national companies. The socialist countries will be represented either by a governmental agency or by a State-owned and State-directed national companies. The countries with a free enterprise system will be represented with by governmental agencies, corporations with a partly private and partly state owned capital and purely private entities.

A number of other problems may arise with respect to defining and delimiting liability of the entity undertaking the activity causing the damage or injury on foreign territories and peoples. First of all, the question may arise of the type of interest protected, that is the kind of injury for which recovery may be had. Second, there is the question of the type of conduct giving rise to liability: should liability be irrespective of the fault or should it be based upon fault? Third, should liability be unlimited? Finally what machinery should be provided for determining liability and ensuring the payment of compensation?

It is too early to make any specific suggestion as to the law which should govern the liability of States who undertake waterproducing activities in the atmosphere. The 1952 Rome Convention on the Liability for Surface Damage caused by Aircraft, the 1962 Brussels Convention on the Liability of Operators of Nuclear Ships, the 1962 OECD Convention on Third Party Liability in the Field of Nuclear Energy and the 1963 Vienna Convention on Civil Liability for Nuclear Damage may serve as guidelines in formulating rules.

INTERNATIONAL COOPERATION

Since clouds know no political boundaries, any small cloud seeding experiment may have impact on neighbouring territories. Along with advance of research and technology it is possible that a country might develop the capability to inflict damage on the economy and civil population of another country.

The technological and other material resources required for the conduct of advanced scientific research in cloud seeding are far beyond the capabilities of most countries today. This present lack of capabilities might not prejudice their future rights of access and might not debar them from enjoying the benefits at a later date.

The study and exploration of clouds involve the interests of many countries. Activities by countries in this regard should not be inimical or detrimental to the adjacent countries. A foremost objective should be the encouragement and ensuring of international cooperation in respect to the utilization of clouds. The experience of mankind with the outer space, seabed, ocean-floor, and rivers have demonstrated that the basic policy of inclusive competence must embrace certain interrelated and mutually supporting principles of jurisdiction.

The programme of advanced research required to develop the technological and scientific capability suggests a strong emphasis of international cooperation. The experiments that are being carried out in several countries also underscore the need for promoting international exchange of data and research finding for maximizing their usefulness. Some form of international collaboration will also be essential in the planning and execution of projects that may have effect not only upon the target areas but on areas in other countries.

The technical capability of modifying the atmospheric water resources is still in its infancy. Before going further,

it seems desirable to explore the possibility of establishing international mechanisms appropriate to examine the need for cooperation in, and regulation of, the exploration and use of clouds and to examine the scientific, technical, economic and legal problems involved, under the auspices of the United Nations or any of its specialized agencies, for instance world Meteorological Organization, Food and Agriculture Organization or the United Nations Scientific and Cultural Organization and inter-governmental machinery could possibly be set up. The International Council of Scientific Union and its associated Unions could also be a suitable non-governmental framework for consultation and exchange of scientific data and information. A general declaration by the United Nations General Assembly as in the case of outer space, for the peaceful uses of clouds would appear advisable concerning (1) The use of clouds for the benefit of mankind; (2) Freedom to conduct experiments and to control and modify the clouds by all States in accordance with international law; (3) Observance of corresponding interests of other States in clouds, and conduct of appropriate international consultations if an experiment planned by a State would cause potentially harmful interference with activities of other States; and (4) The international responsibility of States for their experiments.

SOME OBSERVATIONS

Rational utilization of clouds would require the concerted action of several countries on the basis of certain minimum agreed principles defining their rights and obligations. From the scope and complexity of the issues, it is evident that the subject does not lend itself to quick formulation of a comprehensive set of rules of a universal character. Nevertheless, there is a pressing need to make a serious attempt towards the formulation of general guiding principles of law.

The principle of 'reasonable and equitable utilization' often advocated in international water resources development may be a feasible concept to be followed in the case of clouds. The classical concept of exclusive territorial control may have to be modified and subordinated to that of inclusive and common interest in conformity with the general trends in the progressive development of international law and relations. Underlying this concept is the interest of participant States that the benefits of exploitation be maximized. It offers the hope of a more realistic and rational use of the resources.

The concept of 'reasonable and equitable utilization' does not mean to suggest that each participant State shall receive an identical share in the use of clouds. It may depend on various factors such as geography, hydrology, climate, past utilization of waters, social and economic needs, population, availability of other resources and the like which are to be considered in determining what is a reasonable and equitable share. The essence of the concept is sharing the beneficial uses of the clouds based on the notion of good faith, good neighbourly relations, and no abuse of right.