THE NATURE OF RURAL PUBLIC OPINION TO RAINMAKING IN WESTERN AUSTRALIA

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Abstract. The apparent success of cloud seeding attempts by local farmers in the Northern Wheatbelt of Western Australia in 1977 and 1978 led to the funding by local farmers and State Government of a three-year cloud study to ascertain the viability of a long-term cloud seeding program. To assess local social attitudes to the technology, a survey was carried out in early 1981 in the cloud study area and in two regions downwind. The results shed light on the rural public's perception of the technology; their belief in the efficacy of cloud seeding; their attitudes to liability and authority; their fears of side effects; and their views of economic benefits and losses.

1. INTRODUCTION

Much of the Australian continent is precipitation deficient and much of its farming a marginal activity, dependent each year on the arrival of suitable rains at the right time. Because of rainfall variability there is drought somewhere in Australia each year.

Parts of the Northern Wheatbelt of Western Australia were drought-affected between 1976 and 1981. The areas with severe and serious rainfall deficiencies for three months or more for the 1974-1981 period are indicated in Figure 1. In 1977-1978 2,600 farmers were hit by drought and in 1979-1980 1,380 farms were declared drought-affected (The West Australian, 1979a; 1980).

The effect on wheat production was marked. In 1975-1976, before the drought, the average wheat crop per farm in Mullewa, Morawa and Perenjori shires (Figure 2) had been 981, 840 and 938 tonnes respectively, whereas in 1979 the production for the same three shires was 775, 56 and 210 tonnes respectively (The West Australian, 1979b). Further estimates suggest that wheat farmers of the three shires of Mt. Marshall, Perenjori and Dalwallinu have lost well over $100 million in crop production alone between 1976 and 1980 (Zekulich, 1980).

2. CLOUD SEEDING ATTEMPTS

In 1977 a group of about 500 farmers in the Morawa region, calling themselves the "Northern Rain Seekers' Association", contributed $27,000 for a cloud seeding operation which lasted from late July to mid October. The group was aided in its mission by the Western Australia Department of Agriculture, and the operation was supervised by the senior Commonwealth Scientific and Industrial Research Organization (CSIRO) cloud seeding officer. Interest in the project was stimulated by his comments:

> There were good reasons why it would pay farmers, and the Government, to mount a fulltime cloud seeding programme... If farmers in a wheat growing area collected $60,000 for three months of cloud seeding it would have to pay off only one year in 10 for them to be in front. (McIntosh, 1977a)

An evaluation of the 1977 project suggested, however, that only rarely were the clouds cool enough to meet the seeding criteria for silver iodide, and then they were already raining (Halse, 1978). No scientific proof of effectiveness was thus possible, although a few unusual rainfall occurrences were noted, e.g. 27 mm at Morawa West on the first day of cloud seeding (McIntosh, 1977b). The real outcome was a growing inclination towards cloud seeding by the farmers who felt the operation had been worthwhile, despite the widespread crop failure in that year (Halse, 1978; The West Australian, 1978a).

In the same year three other weather modification groups were formed: the Elsewhere Rain Inducement Committee based at Northampton; the Dalwallinu and Districts Rain Inducement Committee, and the North East Weather Research Council of Mt. Marshall. Subsequently most merged with the Morawa group to form an umbrella organization - the West Australian Weather Research Association, representing about 1,000 to 1,500 farmers (The West Australian, 1978b).

Further cloud seeding attempts were carried out by the Northern Rain Seekers group from May until September of 1978, at a cost of $17,260 (Fallon, 1981). Due to changing weather patterns, once again no conclusion could be drawn about the project's effectiveness. The continuing problem lay in finding clouds suitable for seeding during dry periods.

The farmers, however, remained enthusiastic. "Cloud seeding has become a concrete operation", the Secretary of Northern Rain Seekers' Association and Chairman of the West Australian Weather Research Association was quoted as saying, pointing to the fact that two seeded areas had both received more rainfall on one occasion than had an unseeded area in the vicinity (Weekend News, 1978).

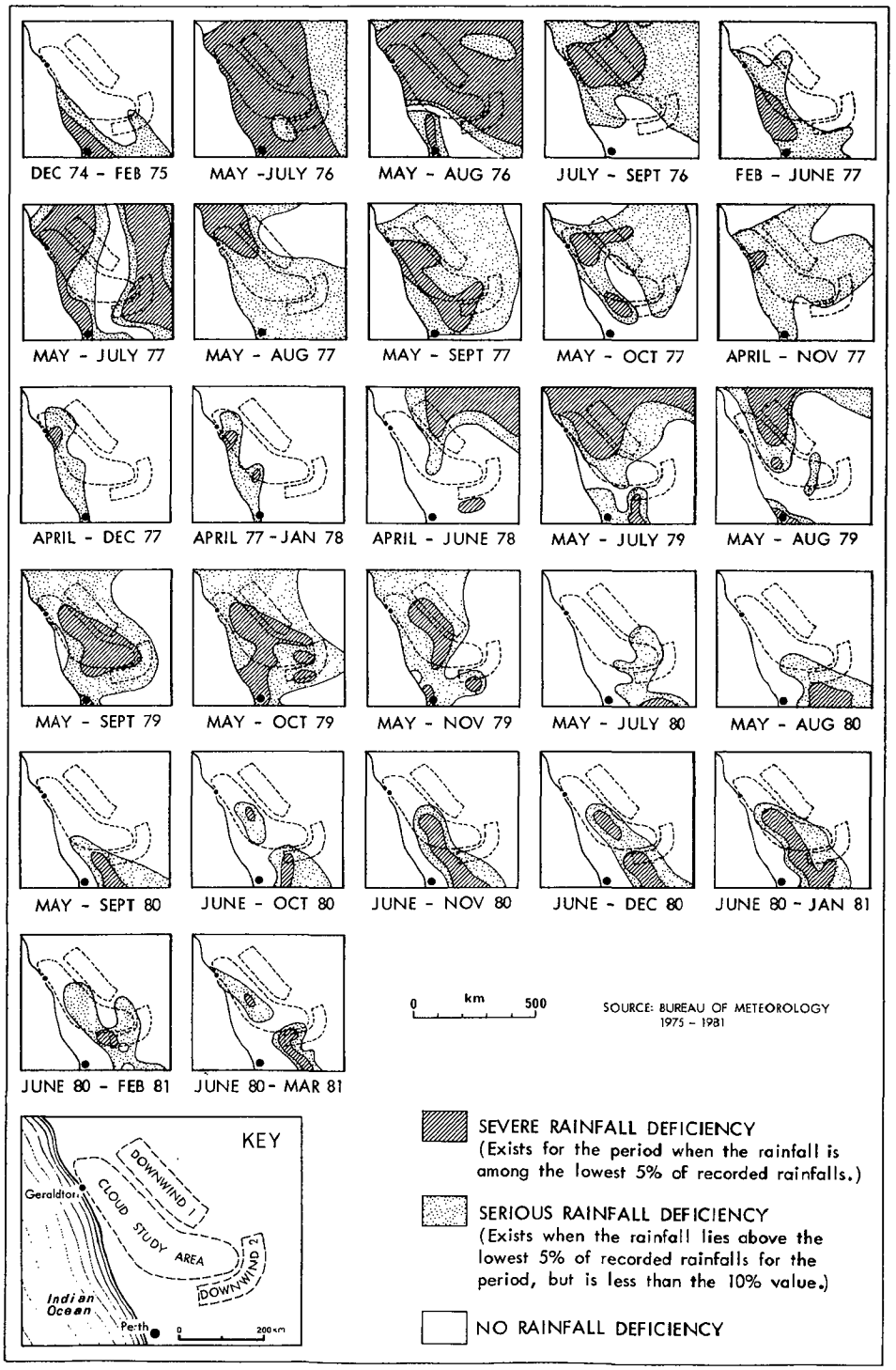

Fig. 1 Rainfall Deficiencies in the Northern Wheatbelt of Western Australia, Dec. 1974 to April 1981.

Discussions between the Western Australia Department of Agriculture and CSIRO led to the recommendation that two or three years of cloud observations in the Northern Wheatbelt were needed to ascertain whether a two to three year experiment with silver iodide seeding was warranted (The West Australian, 1978c; 1978d). Failing to receive backing from the Federal Government, the Western Australia State Government turned to the farmers themselves for additional funds (The West Australian, 1979c). Weather modification groups were requested to raise the necessary figure of $50,000 a year for three years to be subsidized on a two for one basis by the State Government (Hasleby, 1979).

The West Australian Weather Research Association collected or received pledges for the amount requested, with the Northern Rain Seekers' Association agreeing to make available to the Weather Research Association all the monies it collected from 1980 to 1982 inclusive for the cloud study (The West Australian, 1979d). On February 1980 the State Government gave the go-ahead to the Northern Wheatbelt Cloud Study which would research winter and spring cloud characteristics for three years. In the first year the Northern Rain Seekers contributed $23,800 (Fallon 1981) with each member of that group paying a levy of two cents per hectare with a minimum contribution of $50. Local businesses also made donations with one company contributing $800 (Fallon, 1981).

The Northern Wheatbelt Cloud Study, under the leadership of Dr. Bailey of the West Australian Institute of Technology, covered part or all of 12 shires (Figure 2). To oversee the cloud study the Western Australia Government set up both a management and a technical committee whose membership consisted of State, Federal and local farming interests (Western Farmer and Grazier, 1980).

The Cloud Study focussed on two major issues during the first year of operations:

a) the collection of cloud characteristics; and

b) the simulation of a cloud seeding experiment by CSIRO using data from the Northern Wheatbelt Cloud Study area.

Tentative conclusions from the cloud data suggested that "there are significant indications that a suitable number of occasions has occurred with a potential for successful seeding to give hope for a viable seeding operation" (Northern Wheatbelt Cloud Study, 1980). However it also appeared, from cloud top temperature measurements, that if a rainmaking project were to be carried out, dry ice would have greater potential as a seeding agent than silver iodide. Since some farmers in the area consider that the 1980 season had less cloud than normal, the above conclusions will have to be substantiated.

Since research was being carried out on cloud characteristics to assist in determining if a weather modification program was feasible, it was deemed an appropriate time by the author to gather public opinion data on rainmaking. The premise was that such information could be helpful in identifying concerns prior to the program's commencement.

3. THE NORTHERN WHEATBELT STUDY

The Northern Wheatbelt Cloud Study area was used as the target zone while two downwind areas were selected from zones to the east of that region. Parts of the cloud study area are known to have been previously seeded (McBoyle, 1980) but the downwind zones, as far as is known, have never been seeded. Downwind II zone is mainly a wheat producing region similar to the cloud study area while the downwind I zone is a drier, less densely populated region concentrating more on pastoral pursuits (Figure 2).

The objectives of the study were to ascertain:

a) the degree of awareness and knowledge of cloud seeding activities;
b) the degree of public approval for the use of cloud seeding technology;
c) the extent of public belief in the effectiveness of cloud seeding techniques;
d) whether any fear exists of side effects from cloud seeding activities;
e) public expectations of potential economic benefits or losses;
f) the public's knowledge of which groups support or oppose cloud seeding projects;
g) the public's awareness of legislation controlling cloud seeding operations; and
i) the public's view on compensation as it relates to cloud seeding activities.

A stratified random sample of 600 was taken from the areas' electoral rolls; 300 from the cloud study area and 125 and 175 from the downwind I and II zones respectively. The questionnaires were mailed in late February 1981 and an overall return of 40% (240) was obtained. The cloud study area had a return of 42.3% (127) and the downwind I and II zones had returns of 33.6% (42) and 40.7% (71) respectively.

3.1 Survey Results

Overall it may be said that the typical respondent in all areas was male, under 50 years of age with high school education, involved with production from the land and had lived in the area for at least 20 years.

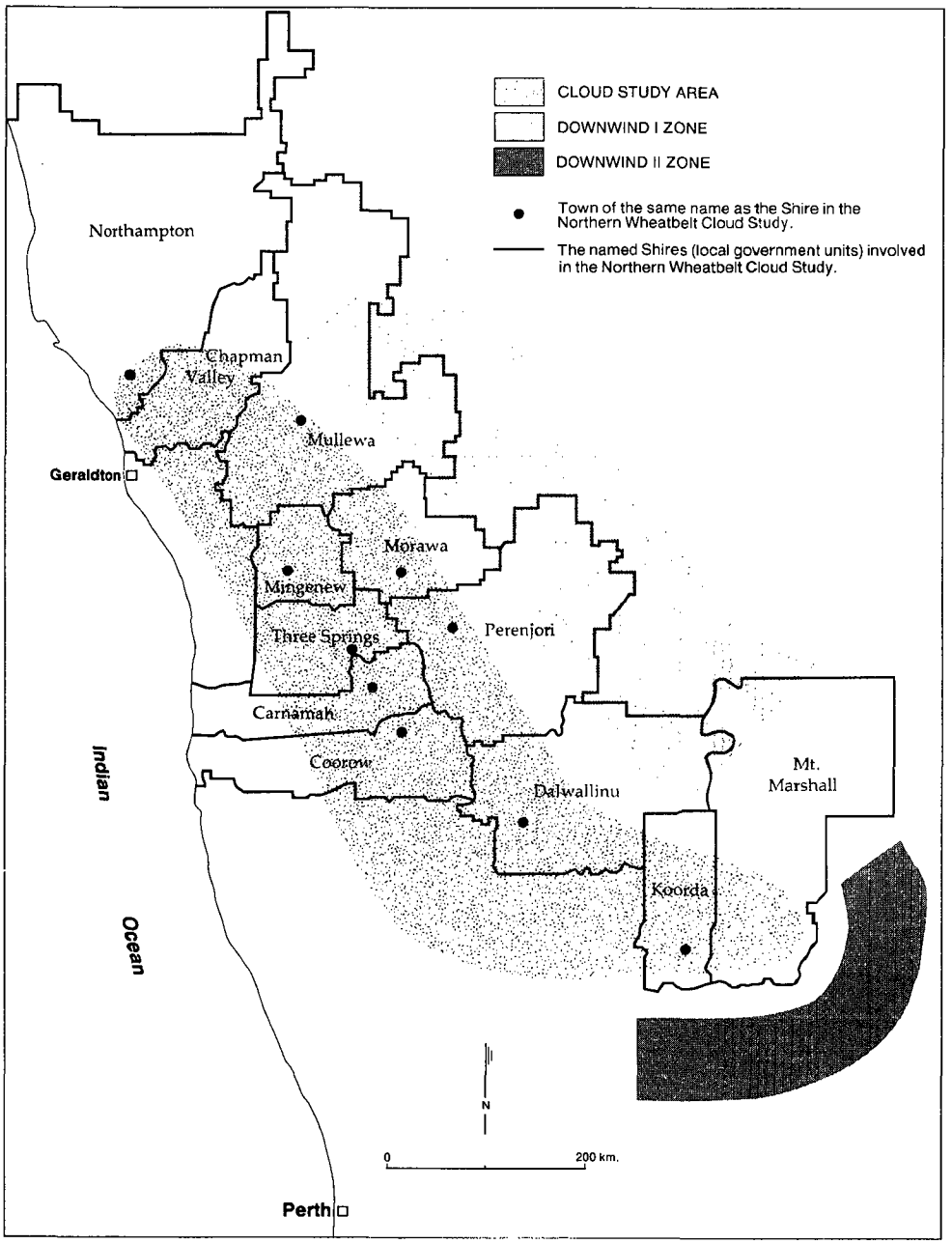

Fig. 2 Cloud Study Area and Downwind Zones I and II.

3.2 Awareness

Nearly everyone (more than 95% in every region) was aware of cloud seeding projects to increase rain with most of their information being obtained from media sources (Table 1). These percentages, although high, were not as high as those found by McBoyle (1980) in the only other attitudinal study done on rainmaking in Australia. However both studies indicate that the media appear to be the main information source on rainmaking in Australia whereas in North American studies (Haas, 1974) personal contact was rated of greater significance.

Table 2 shows that the majority of respondents (57.5%) in the cloud study area were aware that cloud seeding had occurred in their area. The percentage was lower in the other two zones. Although there have been no projects in the downwind I zone, 42.9% of respondents from that area were convinced that projects had been carried out in that zone, thereby reflecting a perception, right or wrong, of having been affected by downwind effects from the projects operating to the west of them. On the other hand, the downwind II respondents were certain (84.7%), and from the published material, correctly so, that no projects had been carried out in their area.

Although most people had heard of cloud seeding projects to increase rain it appears that the information sources were more complex in areas that have been affected or perceived themselves to have been affected by cloud seeding projects than in areas that have had no exposure to such programs (Table 2).

3.3 Belief in Effectiveness

As was the case with the information sources, there appears to be a gradation of belief in the technology's effectiveness from the cloud study area (63%) through the downwind I zone (59.5%) to least belief (48.6%) and highest uncertainty (38.9%) in the downwind II area (Table 3).

Since a belief in the effectiveness of the technique is reported to promote readier acceptance of the practice (Farhar, 1976) one would expect from the above figures that the respondents in the cloud study area would be the most open to a weather modification program with the downwind I zone respondents being the least receptive.

3.4 Side Effects

Lack of agreement about possible side effects was expressed in the figures of Table 4. However of those who were apprehensive about side effects, most cited potential problems related to an "imbalance" of rainfall (Table 5). Such a concern may relate to fears of lack of control of the technology rather than to its effectiveness. This could be viewed as similar to the "concern over risk" indicated by Farhar (1978). The idea that additional rain is gained only at the expense of rain loss in another area ("Robbing Peter to Pay Paul") was viewed as a potential problem of greater concern in the wheat growing areas than in the drier pastoral zone (28% and 13% respectively).

Questioned about possible side effects beyond the seeded area, overall uncertainty was again expressed, with the fear of precipitation loss from the "Robbing Peter to Pay Paul" concept being the dominant issue in all zones.

3.5 Information

Public meetings were considered the most suitable single means in all areas of prior notification of cloud seeding projects (Table 6). This was followed by advance notice in local newspapers in both the cloud study area and the downwind I zone (18.1% and 19.0% respectively) while the respondents of the downwind II area were equally content with advance notice in newspapers or an environmental impact statement (19.4% each). In all areas, however, more than one means of notification was favoured by 32% or more of respondents with the use of all three methods gaining the most support although being more dominant in the downwind zones.

The majority of respondents in all areas believed that there were organized groups in the State supporting cloud seeding. This belief was strongest in the cloud study area (78.7%) and weakest in the downwind II zone (69.4%). However, when it came to naming the group(s), the highest percentage of correct answers (64.6%) came, not unexpectedly, from the respondents living in the cloud study area (Table 7). However, it was surprising that only 2% of these respondents mentioned the Northern Wheatbelt Cloud Study, which had completed its first year of operations in 1980.

3.6 Economic Issues

The respondents in the two wheat-growing areas - the cloud study area and the downwind II zone - perceived the economic issue similarly; 61% considered that they would receive economic benefits from cloud seeding; 13% were unsure; and 25% were definite that there would be no economic benefits to them personally. In the drier downwind I zone, where grazing is more important, one in three saw no economic benefit while 54.8%, a smaller percentage than in the other two areas, considered that there would be economic benefits from the technology.

TABLE 1

Question: If you have heard of cloud seeding projects from what source did you obtain your information?

	CSA (Cloud Study Area)	DI (Downwind I zone)	DII (Downwind II zone)
From Friends	8.2 (%)	9.8 (%)	2.9 (%)
Public Meetings	2.5	7.3	0.0
Media (newspapers, radio, T.V.)	47.5	53.7	75.4
Government	1.6	0.0	1.4
Cloud Seeding Projects	2.5	4.9	2.9
More than one of the Above:			
Friends and Media	13.1	9.8	8.7
Media and Public Meetings	7.4 } 36.8	2.4 } 21.9	1.4 } 14.3
Other Combinations	16.3	9.7	4.2
Other	0.8	2.4	2.9
Total	99.9	100.0	99.8

TABLE 2

Question: To your knowledge, has there been any cloud seeding projects to increase rain in your area?

	CSA	DI	DII
Yes	57.5 (%)	42.9 (%)	12.5 (%)
No	37.0	52.4	84.7
Do not know	4.7	4.8	2.8
Missing	0.8	0.0	0.0
Total	100.0	100.1	100.0

TABLE 3

Question: Do you think that cloud seeding can actually increase rain?

	CSA	DI	DII
Yes	63.0 (%)	59.5 (%)	48.6 (%)
No	7.1	11.9	12.5
Do not know	28.3	28.6	38.9
Missing	1.6	0.0	0.0
Total	100.0	100.0	100.0

TABLE 4

Question: Do you think there could be undesirable side effects caused by cloud seeding activities?

	CSA	DI	DII
Yes	40.2 (%)	38.1 (%)	38.9 (%)
No	28.3	35.7	26.4
Do not know	30.7	26.2	34.7
Missing	0.8	0.0	0.0
Total	100.0	100.0	100.0

TABLE 5

Question: If yes (to question in Table 4), what kind of effects would you expect? (answers grouped).

	CSA (Cloud Study Area)		DI (Downwind I zone)		DII (Downwind II zone)	
Upset the Balance of Nature	17.6 (%)		31.3 (%)		25.0 (%)	
Excess Rain and Flooding	35.3	45.1	25.0	43.8	32.1	35.7
Rain at wrong place/time	9.8		18.8		3.6	
Robbing Peter to Pay Paul*	27.5		12.5		28.6	
Legal/Social Problems	7.8		6.3		0.0	
Chemical Pollution	0.0		0.0		7.1	
Other	2.0		6.3		0.0	
No Answer	0.0		0.0		3.6	
Total	100.0		100.2		100.0	

*the idea that additional rain is gained only at the expense of rain loss in another area.

TABLE 6

Question: Which, if any, of the following do you think should be done before starting a cloud seeding project to increase rain?

	CSA		DI		DII	
Advance notice in local newspapers	18.1 (%)		19.0 (%)		19.4 (%)	
Public meetings	29.9		26.2		29.2	
Environmental impact assessment	12.6		16.7		19.4	
More than one of the above:						
Advance notice and public meeting	12.6	33.1	7.1	38.0	6.9	32.0
Advance notice, public meeting and environmental impact assessment	13.4		21.4		18.1	
Other Combinations	7.1		9.5		7.0	
None of these	6.3		0.0		0.0	
Total	100.0		99.9		100.0	

TABLE 7

Question: If you believe that there are organized groups in the State supporting cloud seeding, please name the organization(s).

	CSA		DI		DII	
Correctly Named Organizations:						
Northern Rain Seekers	45.4 (%)		21.9 (%)		14.0 (%)	
The Elsewhere Rain Inducement Committee	4.0		6.3		0.0	
The Dalwallinu and Districts Rain Inducement Committee	1.0		0.0		2.0	
The North East Weather Research Council of Mt. Marshall	4.0	64.6	0.0	31.3	2.0	18.0
The West Australian Weather Research Association	2.0		0.0		0.0	
More than one of the above	8.1		3.1		0.0	
Northern Wheatbelt Cloud Study	1.0		0.0		0.0	
Northern Wheatbelt Cloud Study and The West Australian Weather Research Association	1.0		3.1		0.0	
Farmers' Groups	5.1		21.9		18.0	
No Name	23.2		34.4		54.0	
Others	5.0		9.3		10.0	
Total	99.9		100.0		100.0	

The main form of economic benefit perceived in all regions was increased agricultural production with economic spin-off being also valued in the two wheat growing areas.

Since 55% to 61% of all respondents perceived some personal economic benefit from a cloud seeding project it was interesting to note that at least one in three respondents in all areas considered that farmers alone (the group most respondents belong to) should foot the bill for such projects (Table 8). In the downwind I and II zones, 28.6% and 26.4% respectively considered that a joint payment venture between farmers and either or both State and Federal Government was also a suitable method while similar percentages of respondents in the same areas considered that government alone, either Federal, State or more frequently both, should pay the cost.

However, the reaction was different in the cloud study area. Here the respondents considered that payment should first come from a co-operative venture of farmers with the aid of Government(s) (37.8%), followed by farmers alone (34.6%) and then by either or both levels of Government on their own (22.1%) (Table 8). It was probable that the joint financial payment method was most favoured by these respondents since the Northern Wheatbelt Cloud Study, to which some of them had been contributing, was a co-operative financial venture between farmers and State Government with Federal technical assistance available when needed.

3.7 Liability

The questions in Tables 9 to 11 were designed to ascertain whether the respondents viewed commercial operations differently from scientific experimentation with regard to liability for possible damages, and to determine whom they felt ought to be held responsible for unexpected damages.

Most respondents in all areas felt that commercial operators should be liable for damages from their operations (Table 9). However, when the cloud seeding was intended for experimental purposes there was less agreement as to liability (Table 10). In this situation the percentage of those in favour of holding the operators responsible for liability dropped at least 25% in all zones. On the other hand, the percentage of those who felt that the operator should be free from liability for experimental purposes rose at least 21% in all areas.

These results tend to confirm the viewpoint determined from N. American studies (Haas, 1974; Farhar, 1975b) and the other Australian study (McBoyle, 1980), that experimental use of cloud seeding is viewed more favourably than operational use. However, with so many respondents against freeing the operator from liability for possible damage no matter the purpose of the project, it appears that some form of proof of financial responsibility needs to be included in the terms of reference of any potential weather modification progam. The use of such a safeguard has been discussed for U.S. states in Carswell and McBoyle (1983).

Regarding compensation, the respondents in the cloud study area make the same ordering of groups which should pay as respondents in the downwind II zone, but were less definite in their viewpoints. The respondents in these areas considered that the responsibility for payment should fall mainly on the shoulders of the project funders, followed by Government, either Federal, State or both (Table 11). Only a very small percentage of respondents considered that the State Government alone should bear the burden. However, one respondent in 10 in these areas considered that no one was responsible for paying compensation for the unexpected damages. On the other hand nearly one in five respondents (23.8%) in the downwind I zone considered that no one was responsible for compensation although the project funders were still viewed as the primary compensation source (40.5%) while 19.1% laid the burden on the Government. In the downwind I zone the higher percentage of respondents who considered that no one should pay compensation relates directly to the higher percentage favouring freedom from liability for operators for both commercial and experimental purposes in this area (Tables 9 and 10).

3.8 Authority

In all three areas there was uncertainty as to who holds the authority to cloud seed (Table 12). Local government was not presented in the questionnaire as one of the named categories because of two reasons. Firstly, Sato (1970) had questioned the suitability of local government as an authority unit and secondly no shire (the name of the local government unit) had ever been directly involved in the funding of a weather modification program in Australia while all the other five named categories had.

The uncertainty as to who held authority was not unexpected since there are no Australian or Western Australian statutes related to cloud seeding, although 64% of the respondents wished to see such a law. With no regulations what body did they think held the authority? What body did they think should hold the authority? and were there many differences between the answers to these two questions?

TABLE 8

Question: Who should pay for a cloud seeding project for agricultural purposes in a specific area?

	CSA (Cloud Study Area)	DI (Downwind I zone)	DII (Downwind II zone)
Federal and/or State Government	22.1 (%)	28.6 (%)	26.4 (%)
Farmers alone	34.6	38.1	34.7
Farmers with State or Federal Government	14.2	11.9	4.2
Farmers with State and Federal Government	23.6 } 37.8	16.7 } 28.6	22.2 } 26.4
Others	3.9	0.0	4.2
Do not know	1.6	0.0	6.9
Missing	0.0	4.8	1.4
Total	100.0	100.1	100.0

TABLE 9

Question: Do you think that cloud seeding operators, for commercial[1] purposes, should be free from any liability for possible damages as a result of their activities?

	CSA	DI	DII
Yes	17.3 (%)	28.6 (%)	18.1 (%)
No	70.9	69.0	75.0
Do not know	11.0	2.4	6.9
Missing	0.8	0.0	0.0
Total	100.0	100.0	100.0

[1]To increase rain on behalf of a client(s).

TABLE 10

Question: Do you think that cloud seeding operators, for experimental[1] purposes, should be free from any liability for possible damages as a result of their activities?

	CSA	DI	DII
Yes	45.7 (%)	50.0 (%)	44.4 (%)
No	45.7	42.9	50.0
Do not know	6.3	7.1	5.6
Missing	2.4	0.0	0.0
Total	100.1	100.0	100.0

[1]To further scientific knowledge of cloud seeding processes.

TABLE 11

Question: If there are unexpected damages as a result of cloud seeding who should pay compensation?

	CSA (Cloud Study Area)		DI (Downwind I zone)		DII (Downwind II zone)	
Federal Government	6.3	(%)	4.8	(%)	2.8	(%)
State Government	0.8	23.6	2.4	19.1	0.0	18.1
Both State and Federal Governments	16.5		11.9		15.3	
Those funding the project	38.6		40.5		52.8	
More than one of the above	8.7		11.9		11.1	
No one	11.8		23.8		11.1	
Insurance Companies	6.3		0.0		5.6	
Other	4.7		0.0		0.0	
Missing	6.3		4.8		1.4	
Total	100.0		100.1		100.1	

TABLE 12

Question: Who do you think holds the authority to cloud seed an area?

	CSA		DI		DII	
Federal Government	0.0	(%)	0.0	(%)	1.4	(%)
State Government	10.2		19.0		18.1	
C.S.I.R.O.	13.4		19.0		11.1	
Funding Bodies	12.6		9.5		6.9	
Residents	17.3		21.4		11.1	
More than one of the above	30.0		11.9		30.7	
Do not know	15.7		19.0		18.1	
Missing	0.8		0.0		2.8	
Total	100.0		99.8		100.2	

TABLE 13

Question: Who do you think should hold the authority to cloud seed an area?

	CSA		DI		DII	
Federal Government	0.8	(%)	0.0	(%)	1.4	(%)
State Government	11.0		14.3		19.4	
C.S.I.R.O.	18.1		28.6		15.3	
Funding Bodies	3.9		4.8		2.8	
Residents	22.8		26.2		16.7	
More than one of the above	39.3		26.2		34.8	
Do not know	3.9		0.0		6.9	
Missing	0.0		0.0		2.8	
Total	99.8		100.1		100.1	

In the wheatbelt areas (the cloud study area and the downwind II zone) 30% of respondents considered that the authority to cloud seed an area did not lie with any single body but with some combination of the many interests involved, whereas single agencies were more favoured in the downwind I zone (Table 12). Of the single agencies, the "Residents" category received the largest number of replies in the cloud study and downwind I areas (17.3% and 21.4% respectively) while the downwind II zone respondents favoured the State Government (18.1%). In all three areas the Federal Government was considered by few respondents as having the authority to cloud seed an area although one of its agents, CSIRO, was considered the authority by 19% in the downwind I zone, 13.4% in the cloud study area and 11.1% in the downwind II area.

When the respondents were asked to name the agency which should hold the authority to cloud seed, their opinions were varied. The main contenders were the "Residents", CSIRO, State Government and a combination of authorities (Table 13). Interestingly enough the ranking of these agencies varied in each of the three areas.

The downwind II zone showed little change in proportion of respondents between Tables 12 and 13 while the other two areas indicated increases in the CSIRO, the "Residents" and the combination categories with the greater movement between categories occurring in the downwind I zone.

4. SUMMARY

Respondents living in the cloud study area previously exposed to cloud seeding appeared to have a greater belief in the effectiveness of the process, placed a greater emphasis on experimental activities and received their information about the technology from a greater variety of sources than those respondents in non affected areas.

Although uncertainty was evident in all three areas regarding the possibility of undesirable side effects from cloud seeding operations, those who were certain that there would be problems considered the main issue to be the lack of control of the rain induced. A secondary fear, more prevalent in the downwind zone than in the cloud study area, was the danger of upsetting the balance of nature as a result of the operations. Regarding the possibility of undesirable side effects beyond the area seeded, the major fear in all areas was the potential problem of "Robbing Peter to Pay Paul"; a fear which was stronger in the wheatlands than in the drier zone of downwind I.

In every area, if enough lead time was available, all three methods should be used to give prior notification of a cloud seeding project but if time was limited public meetings would be the next most suitable avenue to take.

Since most of the organized groups supporting cloud seeding were located in the cloud study area it was not surprising that three out of every five respondents from that area could correctly name such a group. Only 2% named the Northern Wheatbelt Cloud Study despite its public relations efforts at the agricultural shows in 1980 (Northern Wheatbelt Cloud Study, 1980). On the other hand, most respondents in the downwind zones could not correctly name a cloud seeding organization although most of the respondents knew of their existence.

Although respondents were divided as to whether cloud seeding operators carrying out experimental projects should be held liable for possible damages from their operations, they were much more convinced that commercial operations should be held liable. In all three areas many considered that the funders of projects should be held responsible for the compensation from the unexpected damages.

Most respondents in all areas considered that a law to control cloud seeding was needed. The group favoured most by wheatbelt respondents to be given the authority to cloud seed an area was the same one which they already believed held that authority, namely, a committee composed of many interest groups. On the other hand, the downwind I zone respondents put greater faith in CSIRO as the group to be given the authority to cloud seed an area although at the present time they believed the authority lay in the hands of the residents.

5. CONCLUSION

The findings from this survey reiterate many of those found in similar studies overseas (Haas, 1973; 1974; Haas and Krane, 1973; Farhar, 1974; 1976; 1978; Farhar and Mewes, 1976; McBoyle, 1978) and from the other Australian survey on weather modification (McBoyle, 1980). However, a crucial finding that needs reinforcing is that it would appear that where there is a stronger belief in the efficacy of cloud seeding to increase rain there will also be a greater variety of responses to questions; a greater fear of side effects within and beyond the target area mainly related to lack of control of the rain induced, and a greater belief in joint efforts whether it be payment for projects, compensation for unexpected damages or the tenure of authority for seeding, than in areas with less belief in its effectiveness.

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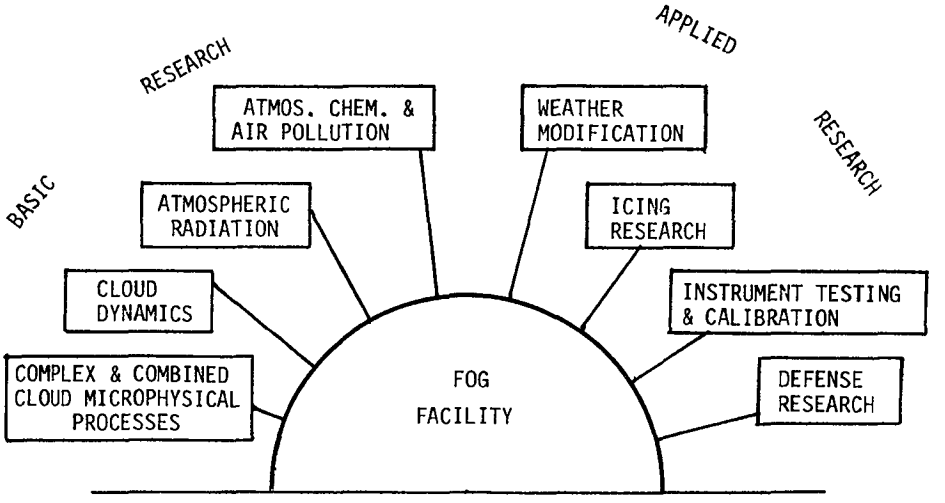
CLOUD SEEDING RESEARCH IN A FOG FACILITY



A large hemispherical balloon with a diameter on the order of 100 m (or alternatively a large air tank) containing an artificially generated fog in a Rocky Mountain high valley site making use of the cold, clean air which flows and accumulates there due to the daily radiation cooling, may prove to be useful for a variety of research studies involving clouds and fogs under supercooled and non-supercooled conditions. The facility may accommodate a horizontal high speed wind tunnel and a vertical one using the fog. An effort is currently underway to integrate interest of all federal agencies involved, and possibly of some private foundations, towards establishing a nationally or even internationally shared fog facility. Suggestions are made below for its use by the scientific and technological communities.

This facility is suitable to simulate phenomena of clouds and fogs on scales larger than the laboratory scale but smaller than in the free atmosphere. It is anticipated that the facility will find its utilization in the following major areas.

1. COMPLEX AND COMBINED MICROPHYSICAL PROCESSES:

   Ice phase and non-ice phase processes, coalescence of cloud and fog droplets, coalescence and disintegration of rain drops, diffusional growth of ice crystals, competitive growth, graupel and hail growth, heating and cooling due to phase changes, microphysics-induced dynamics, secondary ice crystal production, ice melting and evaporation, basic data generation for cloud modeling, charge generation and cloud electrification and ice aggregation.

2. INSTRUMENT TESTING AND CALIBRATION:

   Direct sensors; temperature, humidity, liquid water content, drop size distribution, ice crystal size distribution, in supercooled and non-supercooled clouds and fogs and in ice crystals of various forms, under moving or still conditions.

   Remote sensors; radar, lidar, sodar and microwaves, including ultra-high energy beams against liquid clouds, ice clouds and precipitation of various sorts.

3. ICING RESEARCH:

   Aircraft; wing performance, mechnism and instrument malfunction due to icing, helicopter rotor performance under icing condition, deicing testing.

   Automobile; wind shield glaciation due to freezing rain and melted snow and deicing device testing, highway fog and the shielding plantation.

   Ice crystal generation by sensing aircraft.

4. FORMATION AND DISSIPATION OF CLOUDS AND FOGS:

   Intermediate scale experiment of entrainment, cloud and fog formation by mixing and adiaba-

tic expansion, effect of condensation nuclei including acid rain formation process.

5. RADIATION BALANCE:

   Simulation experiments, scattering, transmission, and reflection of electromagnetic waves in non-ice and ice phase clouds and precipitation, cirrus crystal behaviors, frost damage research involving fog and smoke method for protection.

6. CLOUD SEEDING RESEARCH:

   Special ice nuclei generator testing, homogeneous ice nucleants in particular, ice nuclei performance, nucleation mechanisms, initial behaviors of ice nuclei and ice crystals including their fall and diffusion, moisture depletion by growing ice crystals at the plume center, warm fog modification method testing.

7. AIR POLLUTION AND ATMOSPHERIC CHEMISTRY:

   Scavenging of aerosol particles by cloud droplets, ice crystals, and precipitation elements including thermo- and diffusiophoretic effect, chemical reactions and gas to particle conversion in cloud air space and droplets and resultant change of particulate characteristics after evaporation, condensation nuclei generation, residual nuclei, acid rain processes.

8. DEFENSE RESEARCH:

9. LOW TEMPERATURE TESTING OF EQUIPMENT:

   Preparation for polar and high altitude research.

10. OTHER APPLICATIONS:

    Base for other field studies, interaction between natural precipitation and artificial fog, natural fog and ice crystal studies.

Considering recent development in areas such as remote sensing, cloud modeling and airborne probing of clouds in addition to the steady progress made in laboratories, and looking into the direction of atmospheric research in the immediate and distant future, the fog and cloud facility is expected to find numerous and sometimes unique uses, some of which are not even forseen at present.

Those who have interest or suggestions on the facility, write or call Nori Fukuta

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