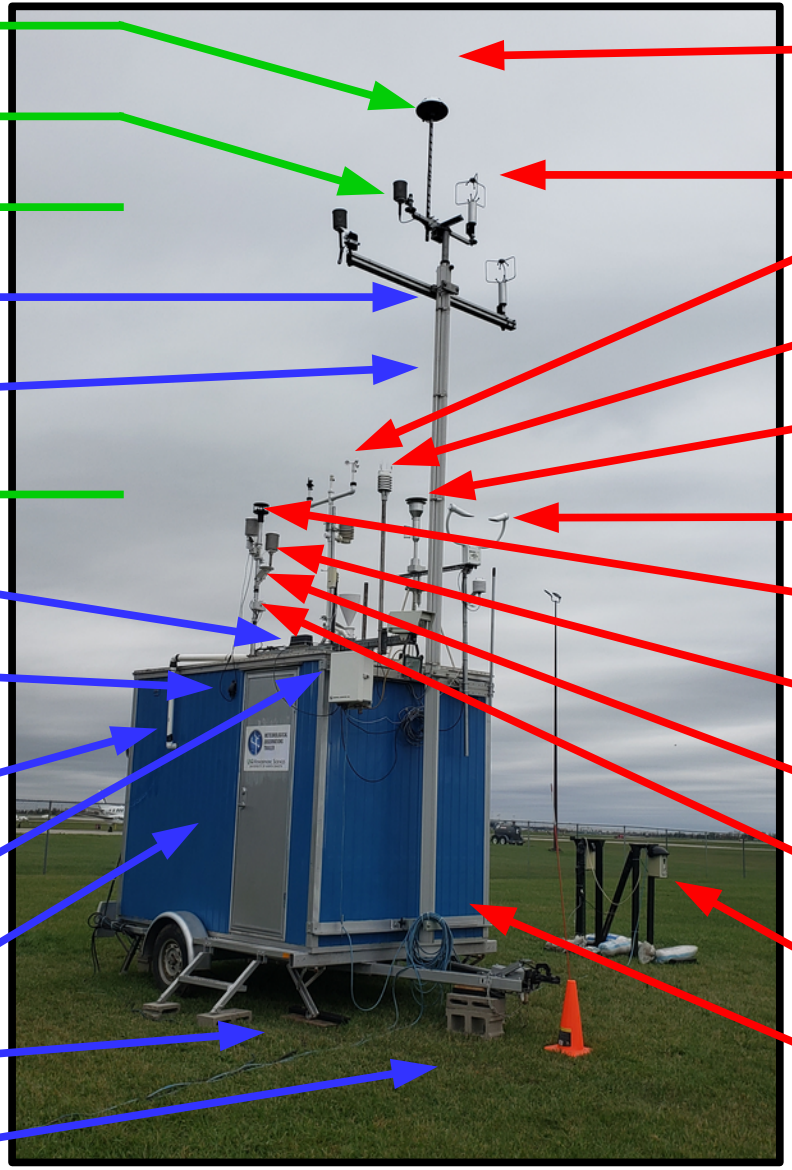
Economic Impacts of Weather Modification

Potential Gain

- **Rain Increase:**
  - Better crop yields.
- **Snow Increase:**
  - Water for farming, power, and municipals.
- **Hail Reduction:**
  - Better yields and less property damage.
- **Fog Modification:**
  - Fewer delays and cancellations.


4 ft Pole
Extendable to 12 M
6 M Height
Tiltable Tower
Tower Wire Guides
4 M Height
Cell Data Antenna
2 Port Side Access
Wire Access Tube
Power Distribution
Lockable Door
Lifting Jack
Support Blocks
All Sky Camera
3 Axis Sonic Anemometer
3D-PAWS
Weather Transmitter
Aerosol Inlet
Present Weather Sensor
2 Axis Sonic Anemometer
iMet-XQ2 UAV Sensor
MiniOFS Visibility Sensor
Pressure Transducer
Deeplens Camera
MetTrailer

Economic Model

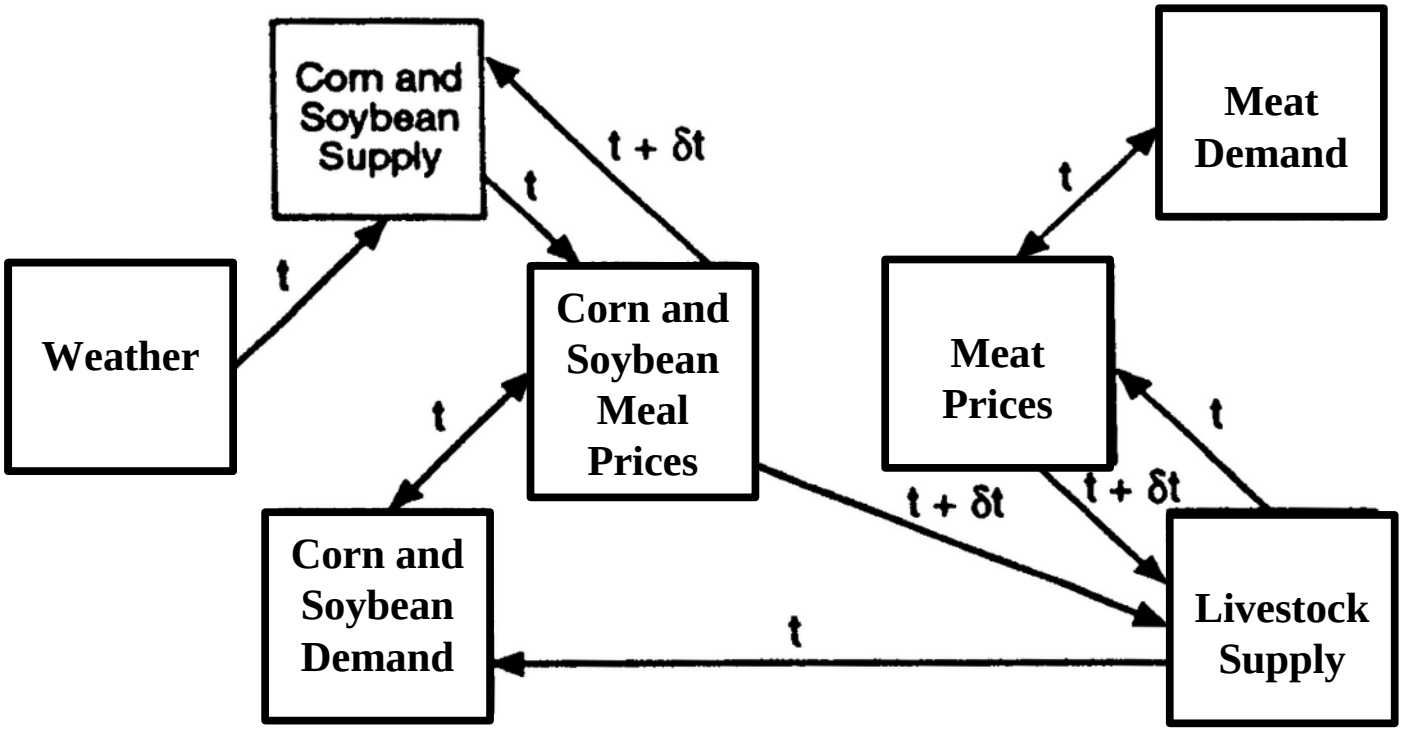


Figure 2.1 – Flow chart of an Economic Model for determining the economic effects of precipitation enhancement in the corn belt (Garcia et al. 1990).

Economic Gain:
Rainfall increases Grow Yields

Table 3. Average Yield Increase Per Harvested Acre Due to Growing Season Rainfall in Four Regions of North Dakota

	Western	West Central	East Central	Red River Valley
June-July increased rainfall (inches)	0.83	0.82	0.81	0.80
June-Aug. increased rainfall (inches)	1.15	1.17	1.16	1.13
Wheat (bu/acre) [a]	2.25	2.2	1.7	1.4
Barley (bu/acre) [a]	2.08	2.3	2.4	2.0
Oats (bu/acre) [a]	2.91	4.1	3.2	2.4
Flax (bu/acre) [a]	0.5	1.6	1.3	1.0
Corn Grain (bu/acre) [b]	3.17	4.1	3.5	2.8
Sunflower (lbs/acre) [b]	156	158	139	136
Soybeans (bu/acre) [b]	c	c	c	1.7
Dry Edible Beans (hdwt/acre)	c	c	c	c

Source: Schaffner et al. (1983)

[a] June-July added rainfall was used in calculating yield increase.

[b] June-August added rainfall was used in calculating yield increase.

c Not available

Rainfall Increase Benefits
North Dakota Program

- Study by Bangsund and Hodur (2019) (NDSU Dept. of Agribusiness and Applied Economics).
- Assume 5 % or 10 % increase in precipitation during the growing season.
- Apply seeding to current project areas and also statewide.

North Dakota Economic Impacts

AVERAGE NDCMP IMPACTS (per planted acre)

	VALUE OF HAIL SUPPRESSION	VALUE OF RAIN ENHANCEMENT	COMBINED DIRECT IMPACT	GROSS BUSINESS VOLUME
5% Scenario	$ 1.57	$ 3.58	$ 5.16	$ 15.87
10% Scenario	$ 1.57	$ 6.84	$ 8.41	$ 25.89

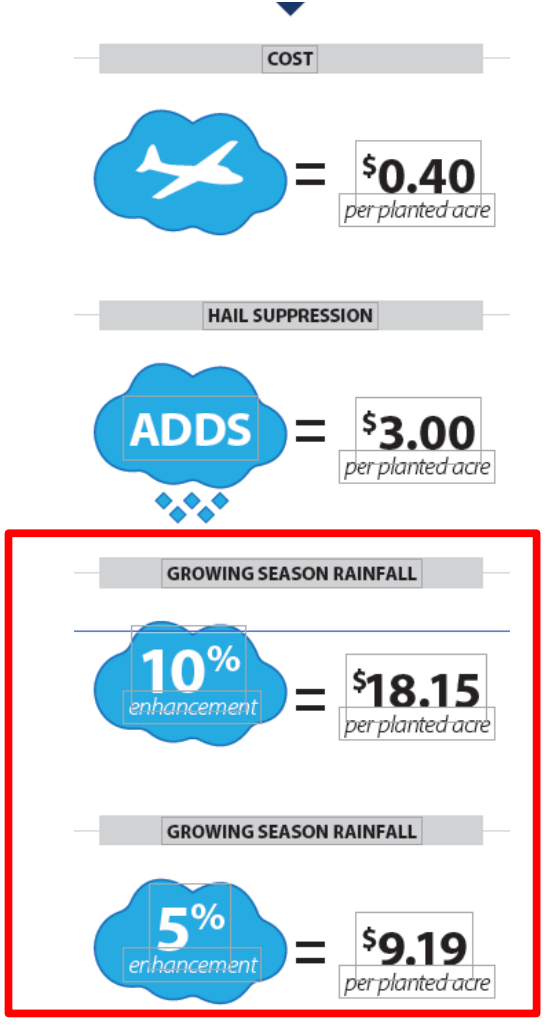
POTENTIAL STATEWIDE IMPACTS

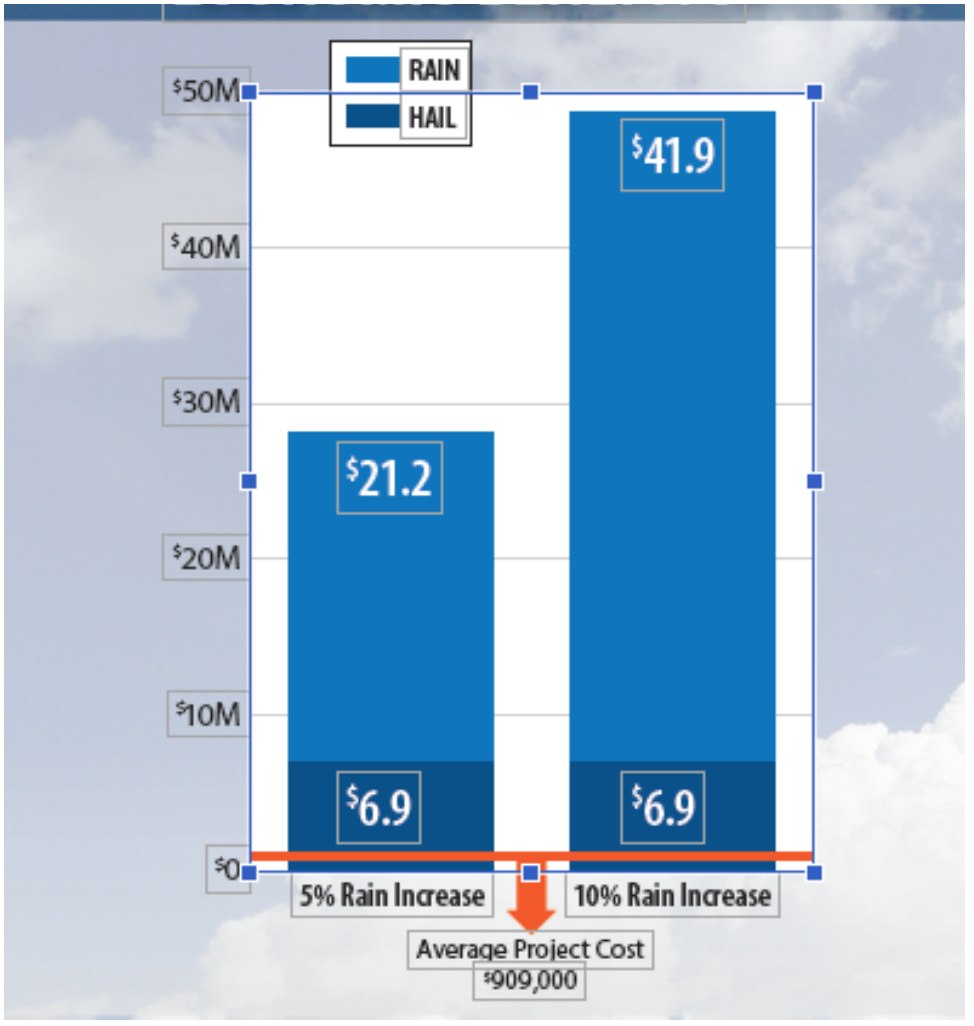
	PLANTED ACRES	VALUE OF HAIL SUPPRESSION	VALUE OF RAIN ENHANCEMENT	COMBINED DIRECT IMPACT	GROSS BUSINESS VOLUME
5% Scenario	19.6 M	$ 53.3 M	$ 42.1 M	$ 95.4 M	$ 293.8 M
10% Scenario	19.6 M	$ 53.3 M	$ 81.3 M	$ 134.5 M	$ 414.2 M

Current Program Economic Benefits

~$3 per acre
Hail Suppression

~$9-$18 per acre
Rain Enhancement





5 percent Rain Increase Scenario

Average Annual Economic Effects (per Planted Acre)

(All Acres)

Value of Hail Suppression	Value of Enhanced Rainfall	Direct Impacts Combined Effects	Gross Business Volume	Gross Business Volume	
$1.34	$3.12	$4.46	$13.72	$22,408,706	Western
$2.11	$4.56	$6.66	$20.51	$14,449,294	West-central
$1.57	$3.55	$5.12	$15.77	$36,858,000	Total

10 Percent Rain Increase Scenario

Average Annual Economic Effects (per Planted Acre)

(All Acres)

Value of Hail Suppression	Value of Enhanced Rainfall	Direct Impacts Combined Effects	Gross Business Volume	Gross Business Volume	
$1.34	$5.95	$7.29	$22.44	$36,641,706	Western
$2.11	$8.70	$10.81	$33.27	$23,430,294	West-central
$1.57	$6.78	$8.35	$25.70	$60,072,000	Total

Potential Statewide Impacts (in millions of dollars)

	Planted Acres	Value of Hail Suppression	Value of Rain Enhancement	Combined Direct Impact	Gross Business Volume
5% Scenario	19.6	53.3	42.1	95.4	293.8
10% Scenario	19.6	53.3	81.3	134.5	414.2

Hail Suppression Benefits

- Another recent analysis by Smith, et al. 1992, showed a 45 % reduction in hail insurance loss ratios.
- Based on insurance data
- Used target-control comparison, including historical record to 1924
- Seeded period was 1976-88
- Direct benefit $34.4 million (agriculture only!)

Costs and Benefits

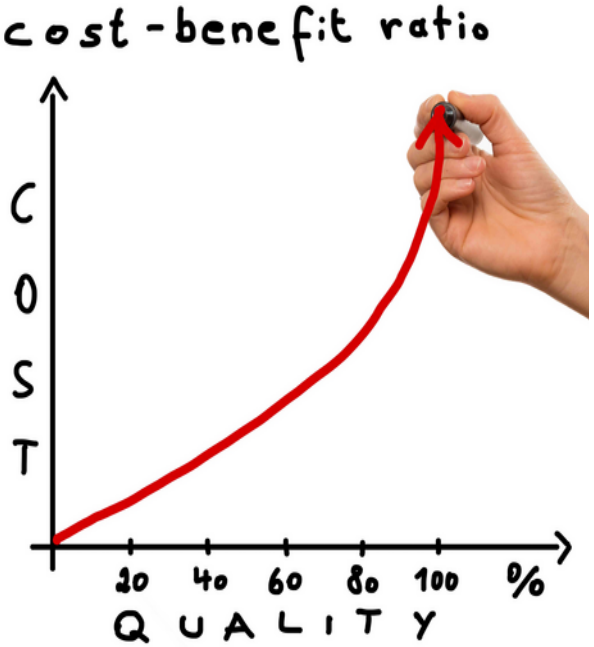
- Costs depends upon the size of the program.
  - Larger programs tend to be more efficient
  - North Dakota costs now about $0.40/acre.
  - This is for both rain increase and hail suppression.
- Benefit-to-Cost Ratios:
  - **30:1 Assuming a 5 percent rain increase**
  - **53:1 Assuming a 10 percent rain increase**

Total Benefits (Statewide North Dakota)

- Multiplier effect of about 3 for added benefit to whole community.
- Total annual impact $414 million.
- Total annual cost of statewide program would be about $5 million.
- Benefit to cost ratio of over 80:1.
- Estimated increase in tax revenue would exceed the cost of program.

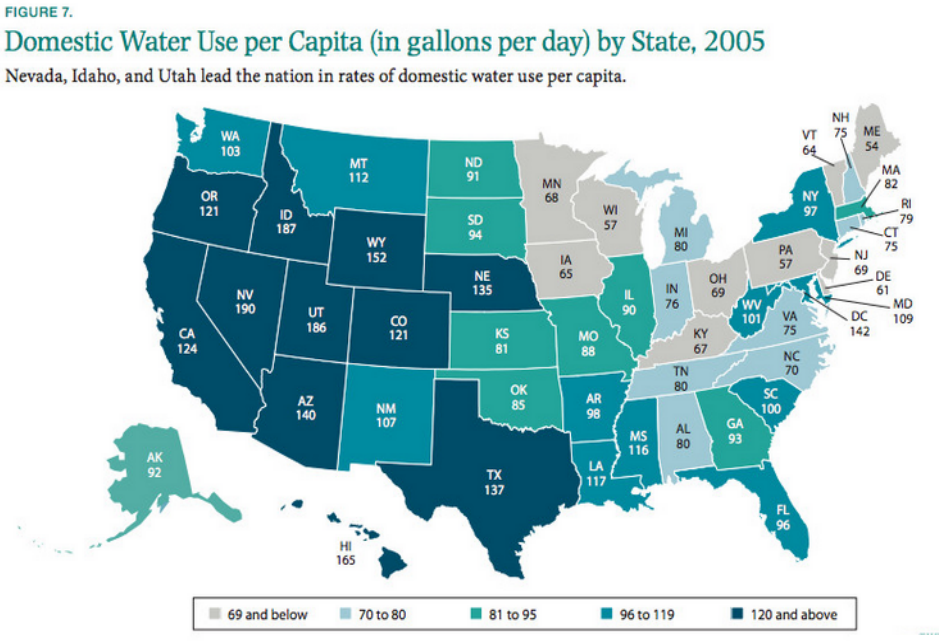
Reasons for Projects

- Reasons for Weather Modification Projects:
  - Potentially large benefit/cost ratio.
  - Increased water resources.
  - Low project cost.
- Reasons against Weather Modification Projects:
  - 5-10 % increase is marginal.
  - May not always want or need the water.
  - Will have losers as well as winners.



Overall Benefits of Projects

- Potential 5 - 10 % increase.
- Analyses by power companies looking at increased power generation estimate benefit-cost ratios of 3:1 to 10:1.
- Cost of water in western states for agriculture and municipal use is $100s per acre foot while seeding costs are $10s per acre foot.



Source: Kenny et al. 2009.
Note: 2005 is the latest year for which data are available. The five categories were constructed to contain roughly the same number of states.
Domestic water includes self-supplied withdrawals as well as public-supply water deliveries.

Adverse Effects

- Some people will benefit more than others and some may find weather modification undesirable.
- Some examples are snow removal, loggers, and recreational industries.
- It would seem reasonable that there should be some sort of adjustment or compensation made to those affected adversely.

Price Effects

- High demand/low supply = high price.
- Low demand/**high supply** = low price.
- High price can reduce demand.
- **High supply** reduces price.

Would insurance companies directly benefit from reducing damage from hail?