ॐ

Dec. 27, 2025 -

Drought - huge problem in Alberta and many regions around the world - focus on Alberta but include a not at end for global.

* Drought: Shortage of precipitation over an extended period (season or more) - results in insufficient water availability negatively impacting plants, animals, and people.

Climate change is making droughts more frequent, severe, and longer - as climate change is continue/worsen so is this trend

Happens because:

- Climate Change → Rising Global temp → altered precipitation pattern
- Climate Change → Rising global temp → increased evaporation rate + water consumption in plants → dry conditions in ecosystem + strained water supplies.

Statistics - how big of a problem is drought?

* Globally:
- # of recorded droughts increased by 29% over past 20 years.
- In 2023, nearly half (48%) of global land area experienced at least one month of extreme drought.
- By the end of centuary, 40% of global area is expected to experience year-round drought.
- Economic costs of drought are estimated at approx. $307 billion annually, and are expected to increase by 35% by 2035. - mostly in agriculture industry

* In Canada:
- As of Nov. 30, 2025, 84% Canadian land was abnormally dry or experiencing drought.
- Drought is most significant climate-related risk to agriculture sector
80% effected

* In Alberta   Dec. 27, 2025

- As of December 2025, 74% of Alberta's land is experiencing drought and 14% is classified as abnormally dry.

December 28, 2025

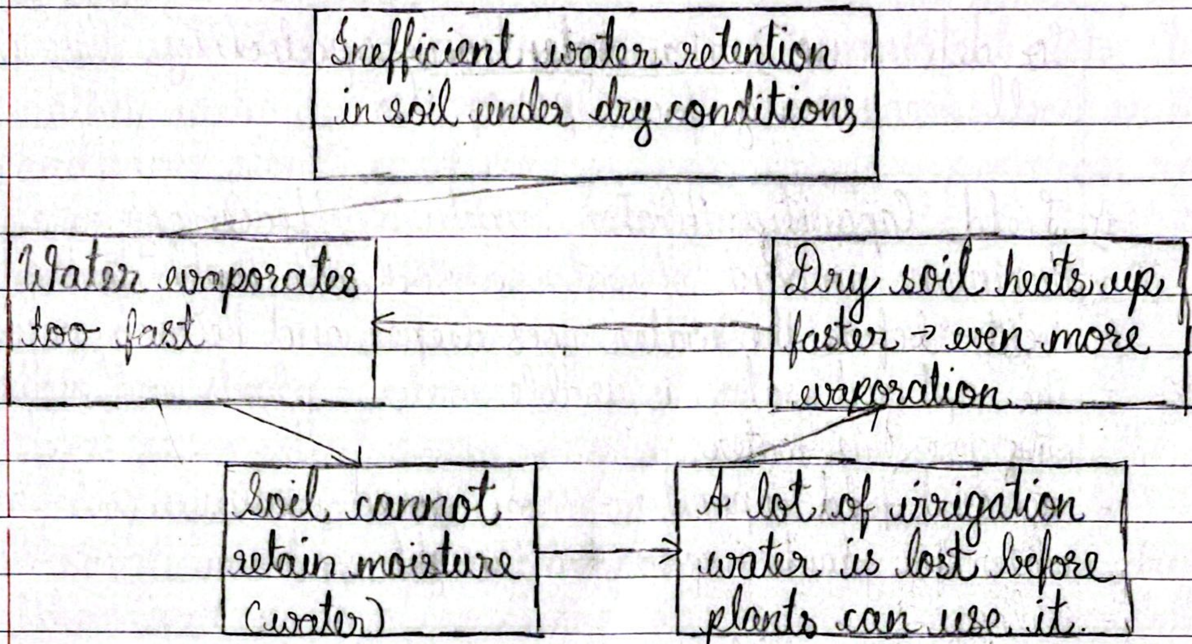
* Impacts of Drought in Alberta - More details on Google Doc

Soil erosion   Vegetation death / Crop failure
Economic loss
Risk of flooding — Drought — Reduced Crop Yields
Increased risk of   Habitat loss for fish / wildlife
Wildfires   Livestock loss - insufficient forage

* Current solutions to drought including the Alberta Drought Response Plan focus on conserving water from all non-essential uses, and directing it all to the agriculture sector.
- But this is only half the solution and not very effective at managing drought, because during drought / dry conditions the water retention in soil becomes poor, so all the conserved water is going to be useless, since it will get evaporated before soil can retain it and get it to plants, due to dry conditions / soil

* Water Retention: Soil's ability to hold onto water (like a sponge) after rain or irrigation, keeping it available for plants, rather than letting it evaporate.
- Thus increasing water retention in soil is the bigger part of solution to drought management.

December 29, 2025



* Research Questions:
- Do soil amendments affect soil's water retention?
- How much impact do low-cost soil amendments have on soil's water retention capacity?
- More specifically, which type of low-cost soil amendment increases a soil sample's water retention capacity the most?

get more specific

* Soil amendment: Products added to the topsoil to improve conditions/structure and plant growth - 2 main types
- Inorganic: Made from non-living sources (mined or manufactured
  eg. gypsum, clay, vermiculite, bauxite
- Organic: Originate from something that was living
  eg. Compost, Manure, Biochar, Wood chips.

Hilroy

December 30, 2025

isn't a single value - dependent on a set of factors.

To determine water retention capability, this experiment will measuring four parameters.

1) Field Capacity: Water capture efficiency
- Maximum amount of water a soil can capture after an irrigation event - before the water goes deeper and becomes groundwater
- The captured water is usable water - plants and evaporation only use this water.
- Increased field capacity = more stored water in soil = more usable water for plants = good for drought.

2) Gravimetric Soil Moisture Content:
- Quantifies the amount of water present in soil relative to mass of dry soil particles. - How much water is present in the soil at a given time
- Important to know because tells us the amount of days the soil can stretch the usable water during drought conditions.
- Most number of days = most efficient = most water retention

3) Evaporation Rate:
- How much water is leaving the soil at a specific time (day/hour) - the lower = the better
- Captures a daily snapshot of water loss - useful when comparing shorterm differences and immediate reactions between different treatments.
- Only reliable for daily/short-term comparison - can't be used to predict long-term pattern because of exponential decay.
- Water loss = Initial mass - Final mass } Daily 24 hour period - Standard practice
- Evaporation rate: Water lost / time } but it like thing

★ Exponential decay: A phenomenon that states that the shape of the drying (water evaporation) is curved not linear, so water evaporation doesn't happen at a constant rate, but rather water is lost quickly at first when the soil is wet and more slowly as it dries - thats why evaporation rate is only relevent for short term impacts/comparisons and not long-term patterns.

4) Moisture decay:

- Takes exponential decay into account and gives us the speed of evaporation (how fast the water is being evaporated).
- A single number that summarizes the soils overall drying behavior (evaporation decay - fast initial loss to slower later loss)
- Gives complete picture of how different soil amendments affect long term water retention behavior in soil - critical to know for long term implications in drought.
- The smaller the value = the lower the speed = the better for drought

January 1, 2026 - Calculations

1) Gravimetric Soil Moisture Content:

synonyms { Mass of water = Wet soil mass (everyday) - Dry equilibrium mass

Gravimetric water content (GWC) = $\frac{\text{Mass of water}}{\text{Dry equilibrium mass}} \times 100$ } Mass of water as a percent of the dry soils weight

- Dry equilibrium mass: also known as dry soil mass is the final mass after which the mass of whole same stops changing.
- GWC is calculated daily, until the mass of sample stops changing (reached dry equilibrium mass.

2} Field Capacity (FC):

Point ~~loss~~ have weasering cup. - Typically sensors are used but:

FC = Water added at 100ml intervals before leakage. } just day 1.
both measured in mass – tell how much water in soil

3} Moisture decay:

Step 1 = Take the GWC values
Step 2 = Since its a curve (exponential decay), apply natural log (ln) to straighten curve into line.
* Natural log transforms curves into simpler lines, without modifying the data, so underlying patterns become more visible and easy to understand.
Step 3: Graph – Time (days) on x-axis and ln (moisture) on y-axis – Slope of this line is moisture decay (k) – ~~k~~ =
Step 4: Find slope – $b = \left(\frac{y_2 - y_1}{x_2 - x_1}\right) = K = \left(\frac{\ln(\text{moisture})_2 - \ln(\text{moisture})_1}{\text{time}_2 - \text{time}_1}\right)$
Step 5: State as K/day^{-1}

January 6, 2026

Quality of soil is determined through several parameters:
- Aeration
- Drainage
- Structure / Texture
- Water retention

January 11, 2026

* Key Quality Parameters: Soil

1) Aeration: Refers to air content within soil, the balance between oxygen and CO_2 - healthy soil requires sufficient oxygen for roots to respire and for beneficial microorganisms to thrive - this prevents anaerobic conditions (harmful to most plants)

2) Drainage: Process by which water moves through and out of soil - proper drainage prevents waterlogging (impairs aeration) and ensures that soil retains enough moisture.

3) Structure: How individual soil particles bind together to form larger aggregates / peds. Good structure = stable matrix that allows for water movement / aeration / root penetration, bad structure = compaction / reduced productivity

4) <u>Water Retention</u>: Capacity of soil to hold water and make it available to plants.

* Since the project is about making plants more resistant to drought conditions, so for the scope of this project I will be focusing just on water retention property.

January 12, 2026

* How organic and inorganic soil amendments impact soil's water retention - How are there mechanisms different

Amendment Type	Impact on water retention	Primary Mechanism	Examples
Organic	Should increase overall water-holding capacity and plant available water	- Acts as a sponge: Organic matter bind soil particles into stable aggregates, creating a diverse range of macro/micropores that absorb and hold water. - The organic material itself is very porous, this can hold a lot of water, slowly releasing it	- Compost, manure, peat moss, biochar, crop residue, and etc.
Inorganic	Should increase water retention - the effect is often more immediate but less long-lasting than organic.	- Creates physical pore spaces: Inorganic material are lightweight and porous, creating air pockets, holding moisture within their internal structure.	- Perlite, vermiculite, gypsum, bentonite, superabsorbent polymer (SAP), etc.

* Since all examples of inorganic and organic soil amendment share same/similar primary mechanism, only one example from each category was chosen to experiment

with. Organic = Manure Inorganic = Vermiculite

- The selection was based on materials availability and cost - because this experiment was started off season (in january), many of the example soil-amendments were unavailable in-store, and expensive online - so thats why selection was based on availability and cost.
- Limitation: Since selection was based on cost and availability, and for budgeting reasons only one example from each category was tested - there is a chance that some other example of soil amendment from either category with more water retention ability may have been overlooked.

January 18, 2026:

- Materials Needed:
- Potting soil
- Vermiculite (garden grade)
- Manure
- Weighing scale / measuring cup
- Identical containers / cups / pots
- Measuring cup
- Labels + marker
- Notebook / template to record data
- Procedure:

Step 1 Preparation:
- Measure 50g of potting soil into one cup - control group
- Make treatment groups - mix 20% soil amendment to 80% soil (this is the general recommended standard) - so 40g soil + 10g soil amendment - mass should stay 50g, same for 3.

- Use identical containers with drainage holes and label them.

Step 2 Establishing Field Capacity:
- Slowly add water to each container in measured amounts (10ml at a time), until it starts to leak from the holes.
- Measure the total water added: The total volume of water added before leakage is the amount of water soil can store, thus the field capacity.

Step 3 Initial Mass Measurement:
- Weigh each cup after establishing field capacity - record this mass as Day 0 mass.

Step 4 Simulated Drought Phase:
- Place all containers in the same indoor location
- Maintain the same room temperature (20 - 23°C)
- Do not add any additional water.
* No water simulates drought conditions.
* Indoor placement reduces environmental variability.

Step 5 Daily Mass Measurements:
- Weigh each container once per day at the same time.
* Because there are no plants or other form of drainage, all mass lost is assumed to be of water, due to evaporation. This follows the principle of conservation of mass.

Step 6 Determining Dry equilibrium Mass:
- Record mass everyday until measurments stabilize for two consecutive days.
- This final stable mass is recorded as dry equilibrium mass.

Step 7 Data Processing (Determining 4 Parameters):
- Field Capacity
- Evaporation Rate (Average)
- Gravimetric Soil Moisture Content
- Moisture Decay

} According to steps on Dec 31 and Jan 1

January 26, 2026

What data will I need from experiment.
- Amount of water added before leakage.
- Mass of sample (everyday)
- Dry equilibrium mass.
- Quatitative obervation
- Date/Time

1ml = 1g.

Soil Type: Plain Potting Soil

Initial Water Added (mL): 190 ml (approx.) 200g - Soil

Dry Equilibrium / Final Stable Mass (g):

Day	Date	Time	Mass of Sample (g)	Daily Mass Change (g)	Qualitative Observation
0	Jan 27, 2026	11:50 pm	287g		Appears to be really soggy - lot of water on top too - shows poor absorption and [illegible]
1	Jan 28, 2026	11:50 pm	250g	-37g	Very crumbly soil dry - Not great moisture hold
2	Jan 29, 2026	11:50pm	237.5	-12.5g	Forming solids - a little hard to crumble - Showing increasing dryness.
3	Jan 30, 2026	11:50	205g	-32.5g	Has become very clumpy - still has some moisture but dry patches are visible - Feels light
4	Jan. 31, 2026	11:50	187.5g		- Feels light, there's clumps forming - sign of slight dryness
5	Feb. 1, 2026	11:50	187.5g		- cup feels light - clumps more frequent and bigger
6	Feb 2, 2026		183.5g		- Soil was all dark brown/black - but now there's a very slight light brown shade
7	Feb. 3, 2026		176g		- Soil feels more dry to tough - bigger clumps forming - edges turning light brown
8	Feb 4, 2026		176g		- Soil is almost dehydrated, large clumps, color increasingly turning lighter brown.
9	Feb. 5, 2026		176g		- dry, dehydrated color lighter, feels very light.
10	Feb 6, 2026		176g		- Feels light, huge clumps, lighter color
11	Feb 7, 2026		176 g		- Same pattern repeating

Soil Type: Potting Soil (80%) + Cattle Manure (20%)

Initial Water Added (mL): 125ml

Dry Equilibrium / Final Stable Mass (g):

Day	Date	Time	Mass of Sample (g)	Daily Mass Change (g)	Qualitative Observation
0	Jan 27, 2026	11:55 pm	280g		Appear to be a little soggy - not as much as plain-water has penetrated deep - but soil is bulky - forming chunks. Decent absorption.
1	Jan. 28, 2026	11:52 pm	270g	-10g	Good moisture hold - feels damp
2	Jan 29, 2026	11:52 pm	250g	-20g.	The soil is "sinking" texture feels very dense, moist, and wet.
3	Jan 30, 2026	11:52	230g	-20g	No visible clumps - no visible sign of dryness - feels wet and moist - its sinked though
4	Jan 31, 2026		227g		- Soil feels damp and moist no visible clumps - but volume decrease soil "sunk"
5	Feb. 1, 2026		220g		- Cups is heavy - soil is feeling a little dryer very slight clumps forming
6	Feb. 2, 2026		212.5g		- Volume sunk even more very tiny clumps forming color still dark brown - slight brown from side
7	Feb. 3, 2026		208 g		- Feels dry to touch small clumps formed - edges light brown
8	Feb. 4, 2026		207g		- More dry to touch medium-sized clumps increasingly lighter
9	Feb. 5, 2026		203g		- Feels moderately light - edges lighter feels dryer.
10	Feb. 6, 2026		200g		- Feels lighter, lighter color, bigger clumps dehydrated.
11	Feb. 7, 2026		200g		- Feels more lighter + dryer lighter color more visible
12	Feb. 8, 2026		200g		
13	Feb 9, 2026		200g.		

Hilroy

Soil Type: Potting Soil (80%) + Vermiculite (20%)

Initial Water Added (ml): 200ml 160g + 40g

Dry Equilibrium / Final Stable Mass (g):

Day	Date	Time	Mass of Sample (g)	Daily Mass Change (g)	Qualitative Observation
0	Jan. 27	11:53 pm	325g		Vermiculite seeds appear bigger/expanded - soil is not bulky nor water is gathering - the soil appears light and "dry" - penetration deep too - Good absorption
1	Jan 28, 2026	11:52 PM	300g	-25g	Good moisture hold - feels very damp and wet.
2	Jan 29, 2026	11:54 pm	270g	-30g	No clumps forming - no dryness, surface feels wet and moist
3	Jan 30, 2026	11:54 pm	250g	-20g	No visible clumps - no sign of dryness - soil feels wet and moist to touch.
4	Jan. 31, 2026	11:54	250g		
5			[illegible]		
6			237.5		
4	Jan. 31, 2026		250g		Soil is damp + wet, bead appear bigger
5	Feb. 1, 2026		245g		- Soil is moist - container is heavy - beads appear bigger
6	Feb. 2, 2026		237.5g		- Nothing really changed from yesterday; just beads appear bigger
7	Feb. 3, 2026		230g		- The bead becoming prominent - soil still feels damp but soil turning slight light brown
8	Feb. 4, 2026		226g		- Very tiny clumps starting - color becoming slightly lighter
9	Feb. 5, 2026		225g		- More bigger clumps - edges more lighter
10	Feb. 6, 2026		223g		- Still tiny clumps but splotches of light brown, feels heavy and damp
11	Feb. 7, 2026		220g		- Edges lighter, still feels damp and heavy
12	Feb. 8, 2026		218g		Same pattern
13	Feb. 9, 2026		216.5g		Fell light - top dry
14	Feb. 10, 2026		215g		Feels light - top dry color light