SECJ3553 - SEC 16
Artificial Intelligence
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Progress-2
Agriculture - AgriNINE.11

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For this CLO, we selected three KRs

KR1 *KR2* *KR3*

Which represent the essential decision-making processes of AgriNINE-11 (soil condition, crop selection, and irrigation control).

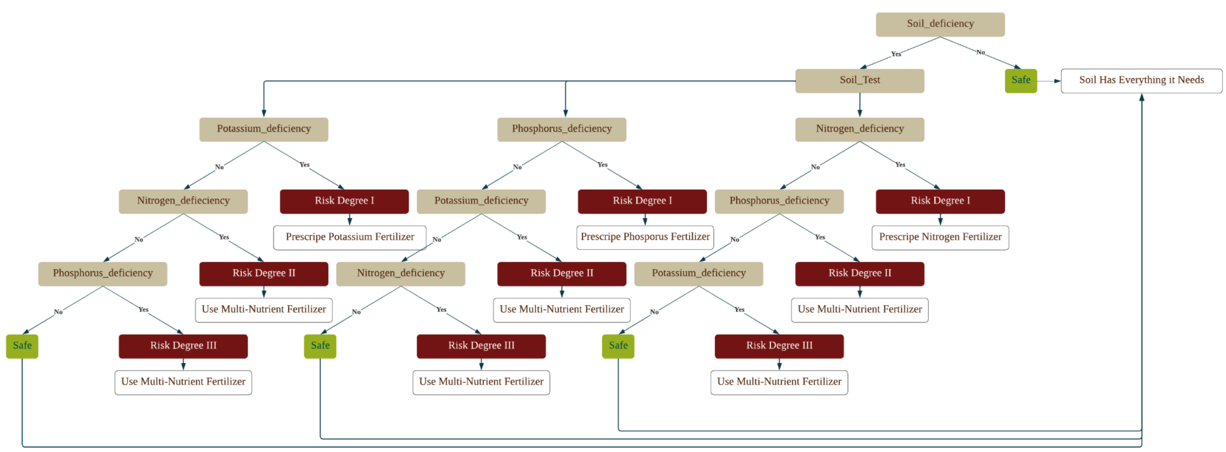
These three KRs form a logically connected chain and allow us to present a clear, complete, and meaningful state-space analysis.

1. Define the State Using States and Actions

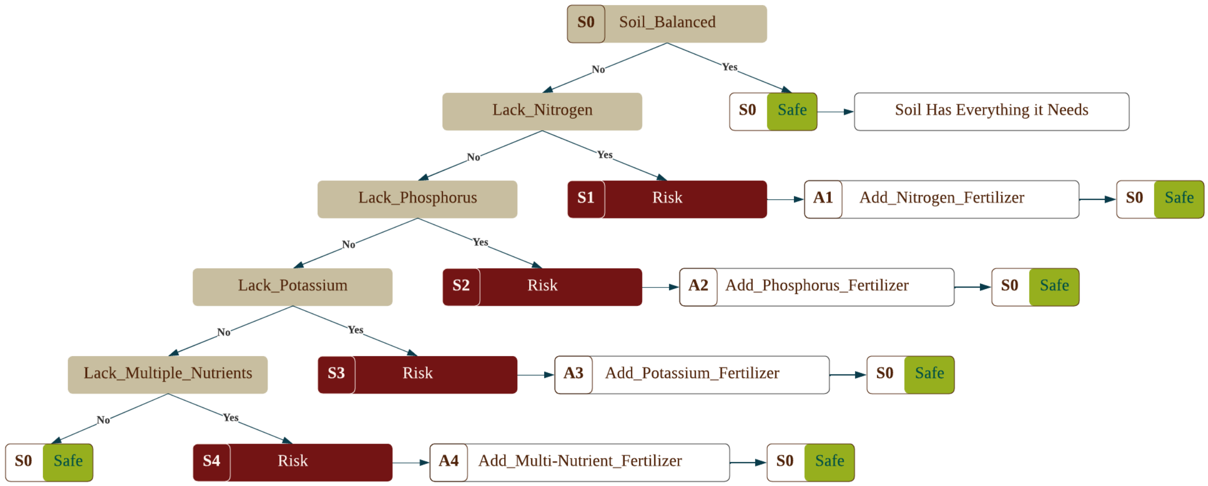
KR1 (Soil-Nutrient Suitability)

It is the attempt of this part of the system to comprehend one thing, not too complicated:

- ★ Is there not something wrong with the soil or something wanting to the crop?
  $\neg \exists x \, (\, Wrong(x, Soil) \lor Lacking(x, Crop) \,)$
- ★ In order to respond to that, we consider every soil condition a state and every potential suggestion of the system an action.
- ★ This simplifies this problem since each state displays where the soil currently is, and each action displays what the AI currently chooses to take.



Model 1.0. Conceptual State-Space Model Showing Soil Conditions



Model 1.1. State-Space Model Showing Soil Conditions

1.1 States

State S0 - Soil Has Everything it Needs

This is the ideal state.
All the nutrients needed by the crop are already in the soil, thus the farmer will not need to add anything to it.
The system is merely cognisant of the fact that things are already balanced and healthy.
It's a "no problem here" state.

State S1 - Soil lacks Nitrogen (N).

In this case, the soil is generally fine, but the lack of nitrogen is found.
Nitrogen plays a role in the growth of the leaf and therefore, the system takes note of the fact that the plant may not contend unless some action is taken.
This state means:
The soil is not able to give nitrogen to the crop but it requires it.

State S2 - Soil Lacks Phosphorus (P)

The soil of this state does not contain phosphorus.
Phosphorus is used to enlarge roots hence the system perceives this as a possible weakness to the crop.
This state basically says:
Roots will not grow well without the application of phosphorus.

State S3 - Soil Is deficient in potassium (K).

This condition indicates that there is a low content of potassium.
Potassium also helps the plant to be healthy and combat stress.
This system will realize that this is a significant nutrient that the soil is deficient in and that this could have an impact on the general health of the plants.

State S4 - Soil lacks many Nutrients (N + P + K).

This is the gravest of conditions.
There is a lack of more than one nutrient and this implies that the soil is not prepared to produce healthy crops.
The system understands that there will be a larger correction required by the farmer in this case.
It's basically saying:
The earth requires multiple nutrients and not merely one. We must fix this properly."

1.2 Actions

Action A1 - Prescription of Fertilizer containing Nitrogen.

This action occurs when the soil is in S1.
The system suggests the use of nitrogen containing fertilizer, since nitrogen is absent.
It is a simple straight forward answer: "Add N so that the problem is fixed.

Action A2 - Recommend Fertilizer That contains Phosphorus.

This will be initiated in case the soil is left in S2.
There is no phosphorus hence the system recommends a P containing fertilizer.
This is to enable the plant to grow well and with a good root.

Action A3 - Recommend Fertilizer containing Potassium.

This move occurs when the soil is in S3.
The level of potassium is low hence a system suggests a fertilizer containing K.
This assists the plant to remain healthy and more stress resistant.

Action A4 - Recommend Multi-Nutrient Fertilizer.

This action occurs in the case of soil in S4 (lacking a number of nutrients).

The system does not require the farmer to purchase three distinct fertilizers but rather suggests a blended fertilizer which is already all that the soil is deficient in.
It is cheaper, quicker and less complicated to the farmer.

Action A5 - No Action (Soil Already Balanced)

This happens in S0.
The system does not suggest anything since the soil already contains all the things that the crop requires.
This is a step that is equivalent to the system saying:
"You're good. There is no necessity to add something at the moment.

1.3. Formulate problem

Initial state: the measured soil condition from field sensors/lab tests. That is, one of {S0, S1, S2, S3, S4}. (Practically, the system's input is the measured nutrient vector which maps to one of these states.)

Actions: A={A1,A2,A3,A4,A5} as above. Actions available at each state are:

At S0: available action = {A5} (or optionally do-nothing plus monitoring actions).

At S1: available = {A1} (optionally no-op).

At S2: available = {A2}.

At S3: available = {A3}.

At S4: available = {A4} (optionally A1/A2/A3 if blended product not available).

(You can also allow "user override" actions where the farmer chooses other fertilizer — those become extra actions in A.)

Goal test: is_state(S, S0) — the goal is to reach S0 (soil balanced for crop). That matches the KR: ensure there is no nutrient lacking for the crop.

Path cost: a scalar cost associated with performing actions along the path. Possible path cost components:

Monetary cost (price of fertilizer products).

Labor/time cost (time to apply).

Environmental cost (e.g., over-application risk).

Logistical cost (availability, number of products to buy).

For a simple numeric model, define:

cost(A1) = c_N (e.g., \$x)

cost(A2) = c_P

cost(A3) = c_K

cost(A4) = c_{NPK}

cost(A5) = 0

And path cost g(path) = sum(cost(actions)). Choose concrete example values for decision-making, e.g. $c_N = 10$, $c_P = 12$, $c_K = 11$, $c_{NPK} = 28$. With these numbers, fixing multiple deficiencies with separate single-nutrient purchases could cost $c_N + c_P + c_K = 33$, which is more expensive than the blended $c_{NPK} = 28$ — so A4 is preferred for S4.

1.4. Solution

If Initial State = S0 (Balanced) [No action required]
Sequence: S0 → A5 (No_Action) → S0 (Goal)

If Initial State = S1 (Lacks Nitrogen)

Sequence:
S1 → A1 (Apply Nitrogen Fertilizer) → S0 (Balanced)

If Initial State = S2 (Lacks Phosphorus)

Sequence:
S2 → A2 (Apply Phosphorus Fertilizer) → S0 (Balanced)

If Initial State = S3 (Lacks Potassium)

Sequence:
S3 → A3 (Apply Potassium Fertilizer) → S0 (Balanced)

If Initial State = S4 (Lacks N + P + K)

Sequence:
S4 → A4 (Apply Multi-Nutrient Fertilizer) → S0 (Balanced)

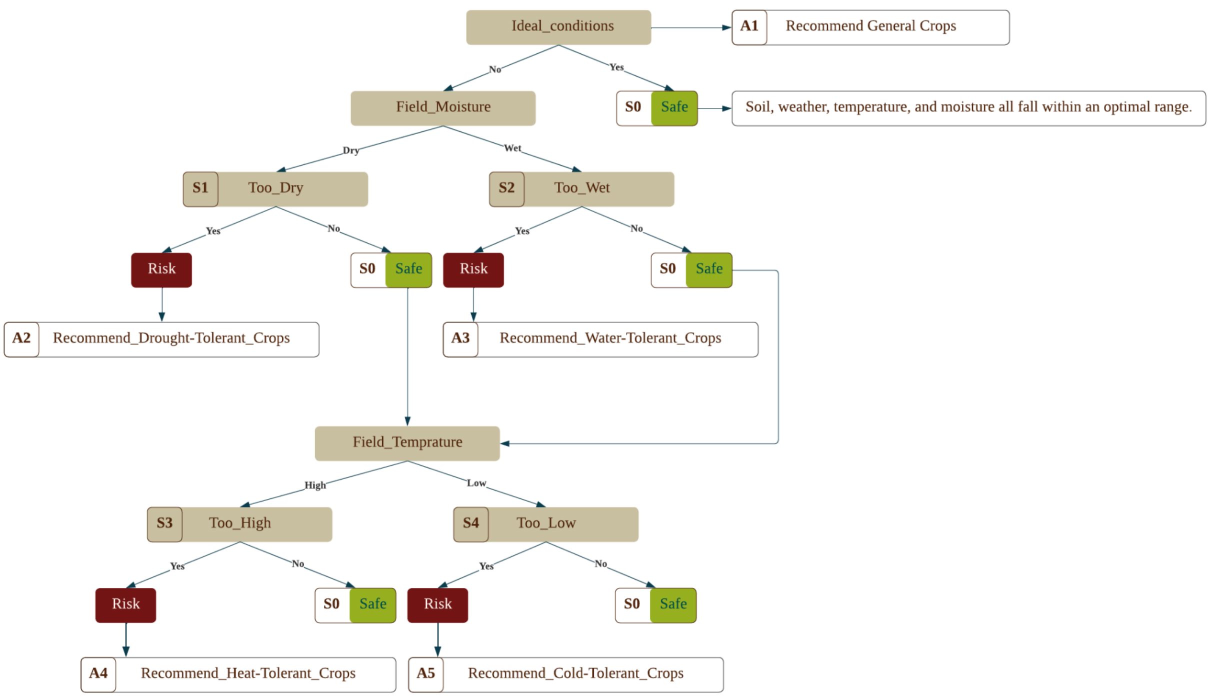
KR2 (Crop Recommendation Suitability)

This part of the system comprehends one thing, not too complicated:

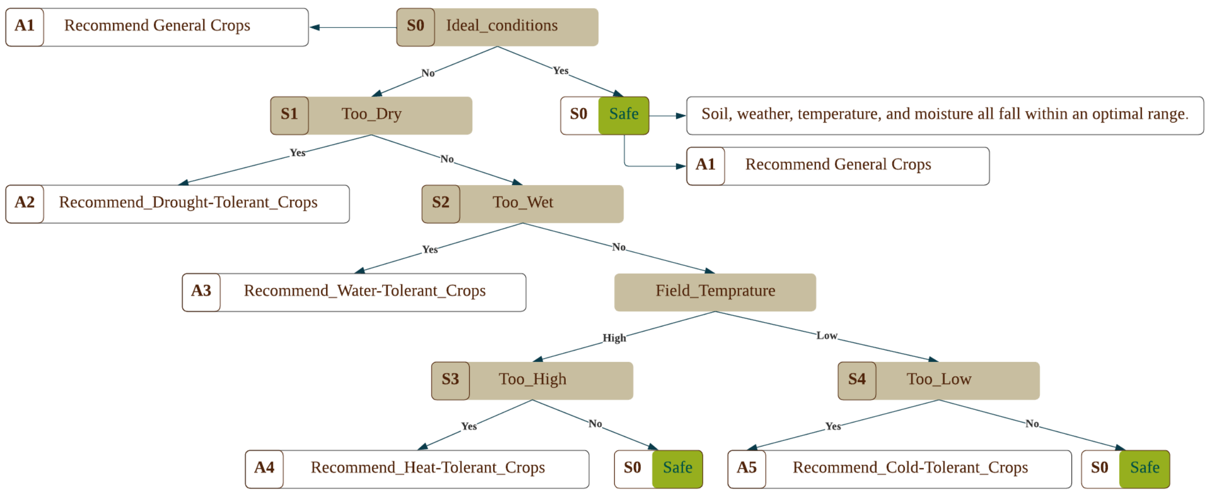
★ Which crop is most suitable for the current field conditions?

To do this, we treat each field condition category as a state, and each possible system recommendation as an action.

Each state shows where the field stands, and each action shows what the system decides to recommend next.



Model 2.0. Conceptual State-Space Model Crop Recommendation States



Model 2.1. Conceptual State-Space Model Crop Recommendation States

2.1 States

State S0 - Field Conditions Are Ideal

The soil, weather, temperature and water level are all perfectly within the optimal range.
There are many crops, if not majority that can grow well here.
The system recognizes the field is flexible and healthy.
It is a “free choice” state, no significant restrictions.

State S1 - Field Too Dry

Moisture levels are below the standard needed for most crops.
High risk of slow growth or crop failure.
The system understands that only drought-tolerant crops will succeed here.

State S2 - Field Too Wet

The soil holds too much water.
Some crops will rot or struggle under waterlogging.
The system identifies that only water-tolerant crops should be recommended.

State S3 - Temperature Too High

The field is hotter than the range preferred by many crops.
Growth will struggle unless the crop is heat-resistant.
The system narrows the options to high-heat crops.

State S4 - Temperature Too Low

The environment is colder than most crops prefer.
Growth slows or stops.
The system identifies that only cold-tolerant crops should be grown.

2.2 Actions

Action A1 - Recommend General Crops

This action occurs when the soil is in S0.
The system confirms; Conditions are great, here are multiple suitable options.

Action A2 -Recommend Drought-Tolerant Crops

This will be initiated in case the soil is in S1.
Examples include crops that survive low water levels.
The field is dry; choose crops that can handle this.

Action A3 - Recommend Water-Tolerant Crops

This move occurs when the soil is in S2.
Soil is too wet; here are crops that grow safely in high moisture.

Action A4 - Recommend Heat-Tolerant Crops

This action occurs in the case of soil in S3.
Weather is too hot; select crops designed for heat

Action A5 - Recommend Cold-Tolerant Crops

Used in S4
Temperature is low; choose crops that thrive in the cold.

2.3. Formulate problem

Initial state: The field's measured environmental condition (moisture + temperature) mapped to one of: {S0, S1, S2, S3, S4}

Actions: A={A1,A2,A3,A4,A5} as above. Actions available at each state are:

At S0: available action = {A1}

At S1: available = {A2}

At S2: available = {A3}

At S3: available = {A4}

At S4: available = {A5}

Goal test: The "goal" is not to fix the state, but to produce the best crop recommendation for the given condition; Provide a crop recommendation that matches the field's real limitations.

Path cost: The cost can represent:

- Expected crop failure risk
- Cost of seeds
- Yield potential
- Market value

A simple numeric example:

- A1 = 1 (low cost, many options)
- A2/A3/A4/A5 = 2 (more constrained, slightly higher cost)

Lower cost = better recommendation.

2.4. Solution

If Initial State = S0 (Ideal Conditions)

S0 → A1 (Recommend General Crops)

If Initial State = S1 (Too Dry)

S1 → A2 (Recommend Drought-Tolerant Crops)

If Initial State = S2 (Too Wet)

S2 → A3 (Recommend Water-Tolerant Crops)

If Initial State = S3 (Temperature Too High)

S3 → A4 (Recommend Heat-Tolerant Crops)

If Initial State = S4 (Temperature Too Low)

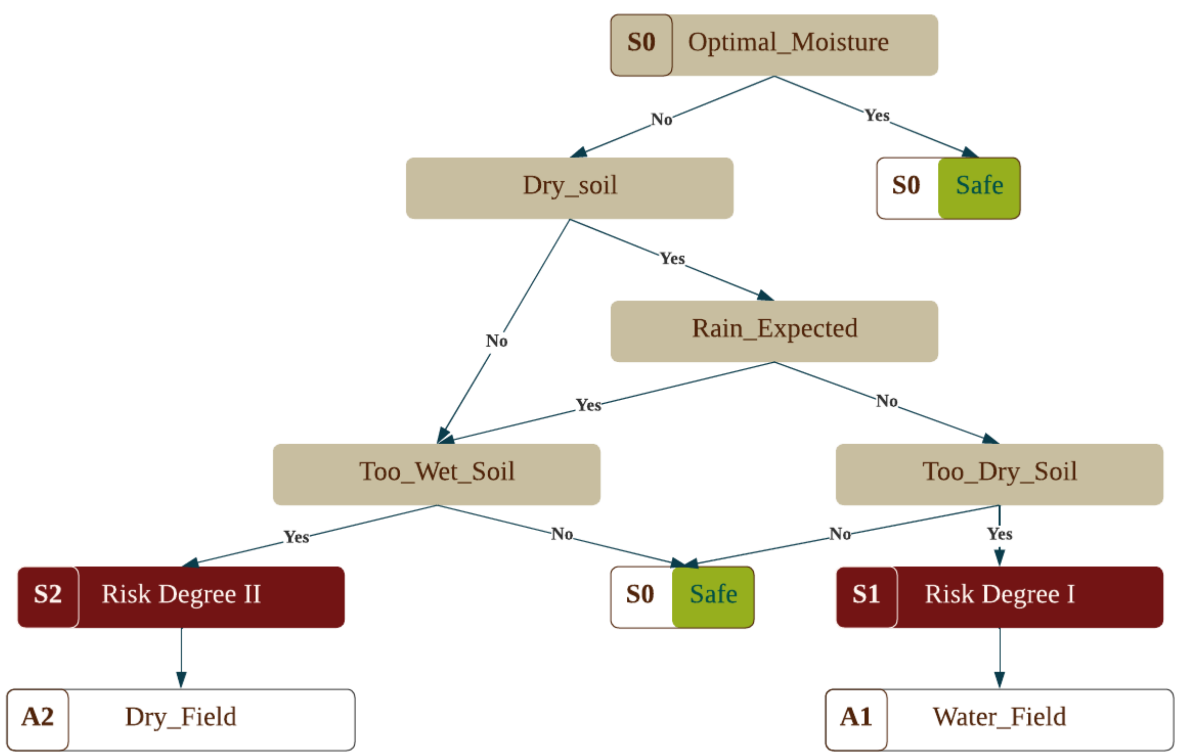
S4 → A5 (Recommend Cold-Tolerant Crops)

KR3 (Irrigation Decision)

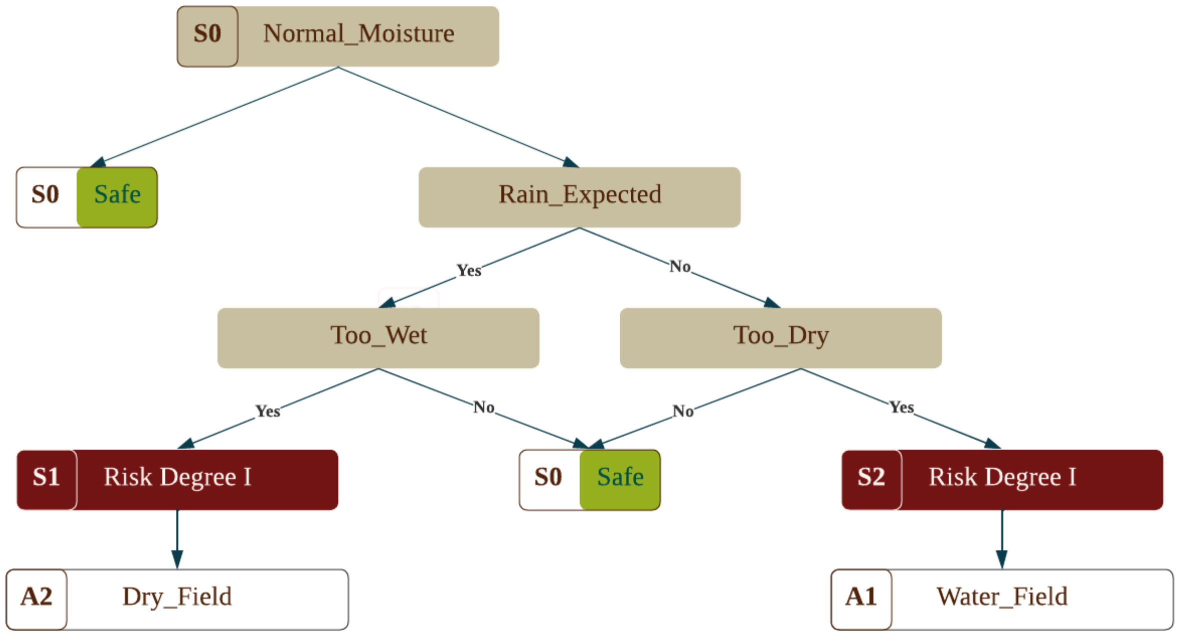
This part of the system comprehends one thing, not too complicated:

★ Do we water the crops now, or wait?

Here, each combination of weather forecast and soil moisture is a state, and each possible irrigation move is an action.



Model 3.0. Conceptual State-Space Model Irrigation Decision States



Model 3.1. State-Space Model Irrigation Decision States

3.1 States

State S0 - Soil Moisture Is Normal

The field has the right amount of water.
No dryness or oversaturation risk is detected.
The system confirms moisture is regular, no action needed.

State S1 - Soil Is Too Wet

The soil contains more water than the crop requires.
This can happen when rain is expected or recently occurred.
If the excess water continues, roots may rot.
Reduction of moisture is needed.

State S2 - Soil Is Too Dry

The soil contains less water than the crop needs.
Rain is not expected, so the dryness will not improve.
Plants may wilt or stop growing.
Water is needed.

3.2 Actions

Action A1 - Water_Field (Irrigate Now)

Used in S2 (Too Dry).
Plants need water urgently.
System irrigates the field to bring moisture back into the normal range.

Action A2 - Dry_Field (Skip Watering)

Used in S1 (Too Wet).
This may include stopping irrigation, improving drainage, or letting the field dry naturally.
Goal: prevent oversaturation and restore balance.

Action A3 - No_Action (Monitoring Only, in Safe Mode)

Used in S0 (Normal Moisture).
Soil moisture is already healthy.
System simply monitors environmental changes.

3.3 Formulate problem

Initial state: The field's moisture level (combined with rainfall expectation) is measured and mapped into one of:
{S0, S1, S2}

Actions: A = {A1, A2, A3}

Actions available at each state:

- At S0: {A3} monitoring only
- At S1: {A2} dry the field
- At S2: {A1} water the field

Goal test:
Return the soil to a safe moisture level (S0) using the correct action for each risk condition.

Once the system applies A1 or A2, moisture should return to S0 Safe as shown in your diagram.

Path cost: Path cost represents the effort or expense needed to correct moisture:

- Water usage (cost of irrigation)
- Time/energy to dry the field
- Risk of crop damage if moisture is incorrect

Simple numeric example:

- A1 = 2 (uses water → more cost)
- A2 = 2 (drying → moderate cost)
- A3 = 0 (no action)

Lower cost = better outcome, but only if moisture returns to S0.

3.4. Solution

If Initial State = S0 (Normal Moisture) [No action needed]

S0 → A3 (No_Action) → S0 (Goal)

If Initial State = S1 (Too Wet)

S1 → A2 (Dry_Field) → S0 (Safe Moisture)

If Initial State = S2 (Too Dry)

S2 → A1 (Water_Field) → S0 (Safe Moisture)