Irrigation: getting water to crops

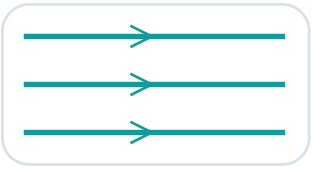
Irrigation supplies water when rainfall cannot meet crop needs. Water may come from rivers, reservoirs or aquifers. The four methods below differ in where water is delivered and how much equipment is needed.

1. FLOOD



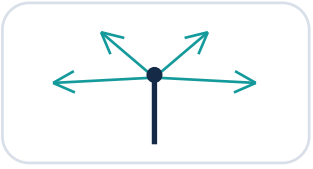
Water spreads over the field surface and infiltrates the soil. Gravity-fed systems can be relatively inexpensive, but excess application can cause runoff, deep drainage and waterlogging.

2. FURROW



Water flows through shallow channels between crop rows, then infiltrates sideways and downward. It suits row crops and uses relatively simple equipment, but uneven flow and runoff can waste water.

3. SPRAY



Pressurized water passes through sprinklers above crops; center-pivot systems are one example. Pumps use energy. Wind can carry droplets away, while evaporation and poor distribution reduce useful delivery.

4. DRIP



Pipes or hoses with emitters release small amounts near each plant's root zone. Targeted delivery limits wetting of unused ground. Installation costs, filtration and cleaning clogged emitters are important trade-offs.

Schematics show delivery patterns, not scale. Agriculture accounts for roughly 70% of global freshwater withdrawals. Withdrawal means taking water from a source; it is not identical to consumption, because some water can return to rivers or groundwater.

Method selection and site conditions: FAO, Choosing an Irrigation Method.
Emitters and localized wetting: FAO, Drip Irrigation.
Global water use and accounting: FAO, Agricultural Water Management.

Scope: College Board AP Environmental Science CED, Topic 5.5, pp. 99-100.

Efficiency, cost and water losses

Drip usually offers the most targeted water delivery. Sprinklers generally improve control compared with surface methods, but weather, soil, maintenance and scheduling affect actual efficiency. No method eliminates all losses.

1. COURSE REFERENCE: APPROXIMATE WATER LOSSES

Method	CED estimate	For 100 units applied
Furrow	About one-third	About 33 units lost
Flood	About 20%	About 20 units lost
Spray	25% or less	25 units or fewer lost
Drip	About 5%	About 5 units lost

These are the CED's simplified evaporation/runoff estimates, not universal field measurements. Its spray upper bound overlaps the flood figure; do not use these numbers to claim that every spray system always beats every flood system.

2. READ THE PERCENTAGE IN THE RIGHT DIRECTION

For an illustrative 5% loss, the retained fraction is 0.95. Delivering 950 L after that modeled loss needs 950 / 0.95 = 1,000 L applied. Multiplying 950 by 0.95 would instead calculate what remains from 950 L. This simplified calculation does not prove all retained water is taken up by roots; soil storage and other flows also matter.

3. CHOOSE FOR THE FARM, NOT ONLY THE PERCENTAGE

Surface irrigation can suit level land and a limited equipment budget. Drip can suit high-value row crops where water is scarce, but needs reliable emitters and maintenance. Spray can cover broad areas but requires pressure and is sensitive to wind. Compare installation, energy, labor, water quality, crop needs and long-term operation.

Approximate loss fractions: College Board, EIN-2.F.2-5.
Efficiency, terrain, climate and costs: FAO, Choosing an Irrigation Method.

Scope: College Board AP Environmental Science CED, Topic 5.5, pp. 99-100.

Three problems, three mechanisms

Irrigation can support food production while changing soils and water stores. Waterlogging, salinization and aquifer depletion are different processes, so a solution must address the cause of the particular problem.

1. WATERLOGGING: TOO LITTLE OXYGEN AT ROOTS

Excess irrigation or poor drainage → Water fills soil air spaces → Oxygen supply to roots declines

Water-saturated soil restricts oxygen diffusion. Roots need oxygen for aerobic respiration; prolonged saturation can impair growth or kill susceptible plants. A rising water table can bring saturation into the root zone.

2. SALINIZATION: WATER LEAVES, SALTS REMAIN

Irrigation water contains dissolved salts. Evaporation and plant water uptake remove water while leaving most salts in the soil. If drainage and leaching are insufficient, salts accumulate around roots. High salinity makes water uptake harder; some ions can also be toxic. Salty groundwater rising toward the surface can add to the problem.

Extension: appropriate drainage and controlled leaching can remove salts, but drainage water must be managed. Simply adding more water can worsen waterlogging.

3. AQUIFER DEPLETION: PUMPING OUTPACES REPLENISHMENT

An aquifer stores groundwater in permeable rock or sediment. Persistent pumping beyond the supply that can be sustained by recharge and groundwater flows lowers water levels and reduces storage. Heavy agricultural pumping has depleted parts of the High Plains (Ogallala) aquifer in the central United States; conditions differ across the aquifer.

Extension: improve scheduling, consider less water-demanding crops and limit total withdrawals. Efficient equipment alone does not guarantee conservation if farmers expand irrigated acreage or use the saved water elsewhere.

Salt accumulation and drainage: FAO, Chapter 7 - Salty Soils.
Groundwater development: USGS, The High Plains Aquifer, USA.
Real water savings and efficiency: FAO, Guidance on Realizing Real Water Savings.

Scope: College Board AP Environmental Science CED, Topic 5.5, pp. 99-100.