

Use of Hydroponics and Aquaponics in Urban Vegetable Farming

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Abstract

Urban food habits have changed faster than the farms that supply them. People want greens that taste like they were picked ten minutes ago, produced with less water, fewer pesticides and within a bus ride of home. Hydroponics and aquaponics two ways of growing without soil are how many cities are beginning to pull this off. Hydroponics feeds plant a precisely balanced nutrient solution in recirculating systems such as deep-water culture, drip-to-waste (rare in cities) and nutrient film technique. Aquaponics goes a step further by looping in fish: bacteria convert fish waste into plant-available nutrients and plants clean the water for the fish. This article unpacks how each approach works, where they shine in tight urban spaces, the practical steps and guardrails that keep systems healthy and how to choose between them.

Keywords: urban farming, hydroponics, aquaponics, controlled environment agriculture, leafy greens, water reuse, LEDs, rooftop farming, nutrient management, food safety

Why cities are turning to soilless growing

City farming lives and dies by three constraints: space, water and reliability. Hydroponics and aquaponics attack all three.

- **Space:** Vertical racking, dense plant spacing and short crop cycles let a single spare room push out an astonishing number of heads of lettuce, bunches of basil or trays of microgreens. You're not waiting on soil to warm or dry and roots don't need to roam they're spoon-fed.
- **Water:** Recirculating hydroponics uses a closed loop; the only significant water losses are plant uptake and evaporation. Aquaponics similarly recycles water, with plants using nutrients that would otherwise require discharge and replacement in fish-only systems.

- **Reliability:** Indoors or in protected greenhouses, you can decouple crops from heat waves, erratic rains and urban dust. Sensors, timers and basic automation take care of the boring but essential: water level, pH and light schedules.

Hydroponics in plain language

Hydroponics grows plants in an inert medium (or water alone) and delivers mineral salts dissolved in water. When you control the ingredients, you control plant growth cleanly and precisely.

Core system types you'll actually see in cities:

- **Deep Water Culture (DWC):** Plants float on rafts over gently aerated, nutrient-rich water. It's forgiving, superb for lettuce and many herbs and easy to scale on rooftops or simple indoor ponds.
- **Nutrient Film Technique (NFT):** A thin film of solution flows through channels, bathing roots. It's neat, lightweight (good for roofs) and extremely productive for small-rooted greens, but it needs clean filtration to avoid clogs.
- **Drip to slabs/cubes (rockwool/coco) or bucket systems:** Essential for fruiting crops tomato, cucumber, pepper, egg plant because you can push targeted recipes and let media buffer moisture. Return-to-reservoir (recirculating drip) is common in urban setups to save water.
- **Kratky and wick systems:** Power-light, starter-friendly options for home balconies. Great for hobby scale; not the workhorses of a serious urban farm.

Aquaponics in plain language

Aquaponics is a partnership: fish produce ammonia; bacteria living on media convert it first to nitrite and then to plant-friendly nitrate; plants remove those nutrients; clean water returns to the fish. You grow two harvests with one set of inputs.

The moving pieces:

- **Fish tank** (tilapia, catfish, carp, trout in cool climates or even ornamental koi where regulations apply).
- **Mechanical solids removal** (clarifier or swirl filter to keep fish manure from smothering roots).
- **Bio-filter** (media where nitrifying bacteria live think of it as your invisible workforce).
- **Plant side** (DWC rafts for leafy greens, media beds for mixed gardens or NFT with excellent pre-filtration).
- **Sump and pump loop** (the low point that simplifies plumbing).

Daily life in aquaponics: feed fish, watch behaviour, test water and adjust pH with fish-safe bases. You'll occasionally supplement iron, potassium and calcium fish feed is a decent but not complete plant fertilizer. The payoff is deep resource efficiency and a compelling "grown with fish" story.

Hydroponics vs. aquaponics: choosing for an urban site

Pick hydroponics if you want: the fastest route to consistent, high-quality greens and herbs with plug-and-play nutrients and minimal biology to babysit. Hydro excels in small indoor rooms with LEDs and in light rooftop greenhouses. Fruit crops thrive with drip and trellis systems, but they need more headroom and stronger structures.

Pick aquaponics if you want: water frugality plus fish as a second product and you enjoy the living-system part. It needs slightly more space per unit of plants to fit fish components and filters and you'll do a bit more water testing. Many growers start hydroponic and later add a decoupled fish loop to diversify.

A practical urban blueprint (balcony, rooftop or spare room)

1. **Define your north star.** Quick-turn leafy greens for neighbours, Restaurant basil or A mixed CSA. The answer changes everything downstream.
2. **Map the site.** Measure floor area and ceiling height. Check electricity, drains, water source and how you'll load/unload produce. For roofs, get a structural engineer's blessing; water is heavy.
3. **Pick the system and crops.**
 - Tight spaces and speed: NFT or DWC for lettuce, arugula, basil, cilantro, dill, mint.
 - Taller ceilings and higher margins: drip-irrigated cherry tomato, cucumber, pepper, eggplant (add trellising and climate control).
 - Crave a circular story: add aquaponics with a DWC bench for greens.
4. **Lighting plan (indoors/low-light roofs).** Modern LEDs can hit the sweet spot of 150–250 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPFD for leafy greens at 14–18 hours/day and higher (250–350+) for fruiting crops. Space fixtures to minimize shadows and budget for heat removal LEDs still produce heat.
5. **Air and climate.** Keep temps in the plant comfort zone (generally 18–24 °C for greens), manage humidity (50–70%) to deter disease and move air across leaves.
6. **Water treatment.** Start with clean water. Dechlorinate (carbon filter or let sit), then nutrient-mix (hydroponics) or cycle the system (aquaponics) for at least a few weeks so bacteria colonize.
7. **Food safety baseline.** Hand-wash station, sanitized harvest tools and clean totes. Keep pets out. Label and record batches. Urban buyers pay for trust as much as taste.
8. **Micro-automation.** Timers for pumps and lights, float valves for top-off and simple EC/pH pens. Add redundancy for aeration an inexpensive battery-backed air pump has saved many fish and crops.

Hydroponic crop quick-start targets (urban scale)

S.No.	Crop	Best-fit system(s)	Typical cycle (days from transplant) *	Category EC (mS/cm)	Notes you'll feel on the job
1	Lettuce (leaf)	DWC, NFT	28–35	1.2–1.8	Heat sensitive; keep roots cool and DO high
2	Lettuce (romaine)	DWC, NFT	35–45	1.4–1.8	Slightly slower; watch tip burn under high light
3	Lettuce (butterhead)	DWC, NFT	32–42	1.4–1.8	Compact heads; great in rafts
4	Arugula	NFT, DWC	21–28	1.2–1.8	Spicy leaf; quick turnover
5	Spinach	DWC	30–40	1.6–2.0	Likes it cool; can be fussy in heat
6	Kale (baby leaf)	NFT, DWC	25–35	1.6–2.0	Reliable, forgiving
7	Swiss chard	DWC, NFT	35–50	1.6–2.2	Cut-and-come-again workhorse
8	Pak choi / Bok choy	DWC, NFT	28–35	1.6–2.0	Fast Asian green; bolts in heat
9	Basil (Genovese)	NFT, DWC	28–35	1.2–1.8	Loves warmth; avoid wet leaves pre-harvest
10	Mint	NFT, DWC	21–30	1.2–1.8	Aggressive roots; prune often
11	Cilantro (coriander)	NFT, DWC	28–35	1.2–1.8	Prefers cooler temps; rapid bolt in heat
12	Parsley	NFT, DWC	45–60	1.4–1.8	Slow starter; long harvest window
13	Dill	NFT, DWC	28–35	1.2–1.8	Aromatic; stems can lodge use gentle air flow
14	Spring onion (scallion)	NFT	30–40	1.6–2.0	Dense planting; tidy roots
15	Watercress	NFT, DWC	21–28	1.2–1.6	Thrives in cool, oxygen-rich water
16	Microgreens mix	Trays, ebb/flow	7–14	0.8–1.2	No fertilizer after sowing for many species
17	Cherry tomato	Drip to media	70–90 to first pick	2.5–3.5	Trellis, prune, manage humidity
18	Cucumber (mini)	Drip to media	50–60 to first pick	2.5–3.5	Needs training; watch for powdery mildew
19	Sweet pepper (mini)	Drip to media	70–90 to first pick	2.2–3.0	Likes steady EC; avoid big swings
20	Eggplant (aubergine)	Drip to media	80–100 to first pick	2.2–3.0	Strong stems; stake early

Operating targets (what you'll dial in)

- **Hydroponic EC and pH:** For most leafy greens and herbs, you'll live between 1.2–2.0 mS/cm and pH 5.8–6.2. Fruiting crops like tomato, cucumber, pepper and eggplant want stronger solutions (roughly 2.2–3.5 mS/cm) and rock-solid irrigation cycles.
- **Aquaponic chemistry:** The “happy compromise” pH is around 6.8–7.0. It's where plants can still take up nutrients and nitrifying bacteria and fish remain comfortable. Keep DO strong with diffusers and avoid temperature shocks fish hate sudden changes more than absolute numbers.

A day in the life of a small urban farm (human-scale)

07:00 Quick walk-through. Are pumps running? Water lines quiet? Take a breath healthy systems smell fresh, not swampy.

07:15 Check water: pH and EC (hydroponics) or pH, ammonia/nitrite/nitrate (aquaponics). Top off reservoirs with dechlorinated water.

07:45 Harvest first morning greens are turgid and cool. Rinse, spin-dry, pack in labelled boxes. Note bed IDs and dates.

09:30 Transplant today's seedlings into open holes in the raft or channels; spot-replace weak plants.

10:30 Sanitation loop: wipe benches, empty catch trays, squeegee floors.

14:00 Prune basil or trellised vines; check airflow and dehumidifiers.

17:30 Feed fish (aquaponics), watch behaviour for two minutes. Happy fish eat fast and calmly.

Once a week: Deep clean one zone; change prefilters; calibrate meters; crop plan review; call restaurants and send a “harvest list” with photos.

Once a month: System audit: energy use, seed success rate, yields per m² and customer feedback. Adjust recipes and schedules.

Energy and light (the invisible bill)

Light is your biggest line item indoors. Leafy greens generally thrive with moderate light levels and cool temperatures, which limits electricity use and AC load. Fruiting crops pay higher margins but demand more photons for longer hours great if you have cheap, reliable power and strong ventilation. Wherever possible, co-locate near existing HVAC, choose high-efficiency LEDs and schedule lights to avoid peak electricity tariffs. On rooftops, a simple greenhouse with roll-up sides plus supplemental LEDs in winter is a sensible compromise.

Food safety and neighbours (because you farm in a city)

- **Keep your loop clean.** In hydroponics, biofilms slowly accumulate; regular tank scrubs and line flushes keep pathogens at bay. In aquaponics, solids management makes or breaks water clarity and root health.

- **No fish-unsafe pesticides.** Work with insect screens, sticky cards, biologicals and spot vacuums. For disease, airflow and dry leaves beat fungicides.
- **Think like a neighbour.** Quiet pumps, tidy deliveries, zero leaks. Protect roofs with trays and secondary containment. Keep a simple spill plan and label electrical circuits.

Business sanity checks

Start with a micro-MVP: a single DWC bench or NFT rack and a few reliable customers you can text personally. Track yields per square meter per week and your real labor time/harvest and washing often take longer than you think. If you later add aquaponics, do it because you want to manage living water and sell a distinctive story (and fish), not because you need it to make hydroponics work.

Common mistakes and how to dodge them

- **Chasing numbers instead of plants.** EC and pH matter, but the leaves tell you the truth: yellow new growth (iron), marginal burn (EC too hot), long internodes (light too low).
- **Dirty plumbing.** Biofilm narrows small NFT channels; schedule a weekly flush.
- **Skipping aeration.** Roots suffocate before they starve. Air stones are cheap/use more than you think.
- **Overstocking fish too soon.** In aquaponics, new systems need weeks to mature. Let bacteria populations' ramp up before you add fish load.
- **Harvest bottlenecks.** The farm can grow faster than you can wash and pack. Design a clean, ergonomic wash line on day one.

Putting it together: a starter roadmap

- **Phase 0 (2–3 weeks):** Germination rack, EC/pH meters, a 200–400 L hydro reservoir, two 1×2 m DWC rafts (or a 12-channel NFT tier) and a simple wash/pack corner. Sell cut mix and basil.
- **Phase 1 (next 2–3 months):** Add a second rack; expand customer list to five kitchens and a small weekly subscription. Dial in light, airflow and postharvest handling.
- **Phase 2 (when ready):** Introduce a small, decoupled aquaponic loop with one fish tank, a clarifier, biofilter and a single raft bed. Start with leafy greens only; keep hydroponics as a stable baseline.
- **Phase 3:** Consider a mixed fruiting zone (drip to rockwool) if space and ventilation allow cherry tomatoes or mini cucumbers while keeping greens as your reliable cash engine.

Conclusion

Hydroponics gives cities a dependable tap of vegetables with astonishing water thrift and speed. Aquaponics adds the poetry of a living loop: fish, bacteria and plants co-creating dinner while trimming nutrient waste. Neither is a silver bullet, both can be beautiful nor do both reward patient

observation. If you're standing on a balcony or bare roof thinking "could this become a farm?" the answer is yes. Start small, stay curious and let your system teach you.

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