Basic requirements of any irrigation systems:

- a dependable supply of water
- a cost-effective and reliable method of getting water to land

A vine needs 250-1000mm water per square meter during growing season, aka ~10 million liters of water per hectare of vines, the actual amount depends on

- evapotranspiration rate of the vineyard
    - shading
    - vegetation cover
    - soil conditions
    - wind speed
    - humidity
    - air temperatures
- rate at which water leaves the vine
    - heat
    - humidity
    - light levels
    - wind speeds
    - stress levels placed upon the crop
        - esp by the crop
        - induced by keeping vine undersupplied with water and only giving it water when absolutely necessary
- general climate
- amount of natural rainfall

Water resources

- natural supplies
    - flowing supply: river, canal; dammed to increase vol of water available
    - static supply: pond or lake
        - con: need to ensure enough water even in dry summers when replenishment at lowest and demand from the crop highest
        - con: water extraction regulation may well preclude taking water from natural sources if below set levels
- man-made supply
    - an irrigation lagoon usually man-made, filled from a convenient spring or from a borehole
        - pro: size can relate to the amount of water needed, can be filled in winter when natural supply is plentiful
    - drawn directly from boreholes
        - pumps needed to bring water up
        - a small buffer lagoon usually needed to overcome fluctuations in supply
        - con: flows are often irregular, esp during summer when demand highest, partially overcome by using irrigation techniques that require use an absolute min of water

Water Quality

- total disolved solids
    - treated by settling through sand beds and filtering through screens and filters before usage
    - esp in systems where water is directly from the source
    - all irrigation systems that use sprinklers or drippers will require clean water to avoid clogging
        - test for pH, calcium, magnesium, iron, carbonate, bicarbonate, sulphides, sulphates, manganese, excess levels of any of which could cause small aperture systems like drippers to block over time
- salinity, levels of soluble salts
    - high levels of salt eg chloride, sodium, boron, bicarbonate, nitrates
    - unsuitable for vines as it prevents root uptake of water
    - leaves deteriorate
    - in general water with no salt or very low levels preferable
    - solutions

        - non-pressurised systems eg flood or channel systems help overcome
        - apply excessive amount of water
        - Rootstocks Ramsey, 101-14, Rupestris du Lot, 99R withstand moderately salty water
            - Israel - where oft only saline water is available in desert regions
        - vines growing on own roots able to deal with salty water too

Irrigation Types: non-pressurized (flood/channel) or pressurized (overhead sprinklers, undervine sprinklers, dripper, leaky hose) requiring a pump

- Flood irrigation
    - when large vol of water available and enough man power to operate sluice and water gates to flood the vineyard evenly
    - only practical in (very nearly) level vineyards
    - eg Mendoza and Chilean vineyards where ample water from Andes available
    - low-cost and effective, broad brush
    - vines on own root as the root-living form of phylloxera is drowned by repeated submersion in water
    - typically flooded ~6 times a season
    - quality of water less important: high levels of solids, saline water ok
- Channel irrigation - furrow irrigation
    - similar to flood but narrow channels dug alongside vine rows and water directed to them from header channels supplied from feeder canals uphill
    - sufficient man power essential
    - improved by laser leveling equipment to construct channels that fill up evenly
    - con: channel erosion when large flows of water used, avoided with riser tubes
    - cost effect, broad brush
    - con: channels easily damaged by tractors and filled with foliage/leaves to be removed
    - pro: some control over phylloxera not as much as flood
    - quality of water less important: high levels of solids, saline water ok
- Travelling overhead sprinklers
    - pro: one sprinkler covers large areas, expensive network of permanent pipes avoided, can be used in several different vineyards in succession
    - con: use large amounts of water as high evaporation levels from water sprayed from air, increase humidity exacerbate disease levels, never reach 100% of the vineyard surface area as it throws in 30-50m radius, uneven results if crosswinds
    - large jets thus clogging less problematic than undervine dripper or sprinkler sys, less risk of damage by rodents or other animals
    - need high pressure pumps
- Fixed overhead sprinklers
    - requires an underground sys of mains and supply pipes, less than sprinklers sys or drippers every row
    - same con as travelling overhead sprinklers: uneven result, humidity++, water++
    - pro: frost protection
    - large jets thus clogging less problematic than undervine dripper or sprinkler sys, less risk of damage by rodents or other animals
    - need high pressure pumps
- Undervine mini-sprinklers
    - on risers attached to supply pipes on the surface of the vineyard typically one every two to three rows
    - 2-5m radius, area determined by type of jet and pressure
    - almost 100% coverage if designed properly
    - supply pipes carrying mini-sprinklers can be damaged by rodents or other animals
    - operate on low pressure and water cleanliness less an issue than drippers
- Undervine micro-jets
    - on risers attached to supply pipes on the surface of the vineyard every row
    - supply pipes carrying micro-jets can be damaged by rodents or other animals
    - operate on lower pressure (than mini-sprinklers) and water cleanliness less an issue
- Leaky hose
    - porous hose usu from recycled vehicle tires
    - at certain pressure level leak water sideways through wall
    - laid along every row of vines usu at (or slightly below - less easily damaged by rodents/animals)

ground level
    - cheap installation/maintenance
- Dripper systems
    - most common
    - pipes in each row attached to lower wire of the trelliswork with drippers fitted at intervals, usu 2 drippers per vine on either side
    - important: drippers not positioned directly beside the vine which cause localized wetting thus localized root distribution; need to be far enough away from the vine for roots to seek water and spread out
    - pro: economy of water use, control over individual rows or blocks of vines, low labor requirement, saline water ok, supply pipes less open to damage from rodents/animals at 600-900mm off ground
    - con: high capital cost, requires very clean water, constant patrolling of drippers to avoid blockages caused by minerals/salts in water, algae, bacterial slimes, necessitating flushing with chlorine regularly
- Most pressurised irrigation systems can also be used for fertigation where liquid fertilisers added to water supply via a dosing pump - effect/direct way of supplying nutrients

Monitoring the water requirement in vineyard

- for plants' needs and economy/water conservation: to know *when* and *how much* does the plant need water
- observe vines and soil condition
- other clues:
    - weather conditions - wind speed, temperature, humidity, recent rain, vineyard floor condition (- vegetation? smooth bare earth or recently cultivated? - affects evaporation rate measured by pan evaporimeter given temperature, humidity, wind speed)
    - vines lacking water show less vigorous growth: shoots less upright, reduced internode lengths, leaves cup and curl esp when hottest, leaf color less green/vibrant than vines with water
    - soils indicate water holding state varying by type, from 100/150mm below surface *cannot be balled indicates water deficiency*
    - many sys controlled by machinery/computers that rely on instruments - tensiometers (sap flow within trunk), gypsum moisture blocks (electrical resistance of soil), neutron probes - to accurately measure the water state: need to be located at where roots are concentrated and willl often be located at 2 or 3 different levels to give a spread of readings, experience over time
    - vine leaves can be tested for water holding capacity with a pressure bomb for Leaf Water Potential of the leaf, given weather condition, time of day, state of the vine, where on the vine the leaf was, experience
    - dendrometer attached to trunk to measure the minute changes in the circumference of the vine as it expands and contracts bc changes in water demand and supply
    - advanced sys: artificial leaves on a target vine to mimick real leaves but from which readings of light absorption and leaf temperature taken
- data combined used to switch on pumps and irrigate vines to the required level

How Much?

- field capacity: diff btw upper and lower limits
- differ according to type:
    - coarse sand holds ~35mm of water per metre of soil
    - find sandy loam ~160mm
    - very fine sandy clay ~200mm
    - rarely uniform to depth that vines root, or water release
- water supply and vine yield
    - growers have incentives to irrigate to increase yield, so many contracts stipulate max yield levels or based on hectareage payment subject to min/max yield limits and quality parameters
    - many growers use water supply as an additional tool to get canopy management right aka regulated deficit irrigation RDI: just below what's needed for max growth to allow vines to produce less leaf area, less vigorous, producer fewer side shoots in latter half of growing season, leading more open beneficial canopy; vines expand its root structure and send out roots in search for water in deeper soil layers
    - cost of water

    - growers tend to use more liberally when water is not restricted or not based on actural usage eg levied per hectare
    - growers more likely to be inventive with their use of water and concentrate on water retention and max water usage when water is charged per litre or cubic meter

Partial Rootzone Drying PRD: keep one side of a plant's root system wetted and the other dry, alternated in 10-15 day cycles

- developed in Australia for grapevines, extended to other plants
- vines confuse and assume drought stress, shut stomata (small pores) on leaves
- reduces transpiration, water usage cut by 30-50%
- fruits and buds better exposed, canopy more open
- shoot growth reduced
- less work in vineyard
- care need to be taken esp in hot regions not overexpose fruit
- intervention needed to finetune the process

Bias against irrigation still persists but with climate change, traditional old world producers see their markets taken by new world producers who can irrigate w/o restriction, this bias is eroded and now irrigated vineyards are much more common in dried parts of France Spain Portugal Italy Germany