Traditional irrigation

between combat against desertification and cultural interaction

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"La passione per la cooperazione", in ricordo di Mario Falciai
Aula Magna del GeSAAF, Università di Firenze
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Summary

Oases

Traditional irrigation

A focus on Lake–Garda lemon houses

Conclusions

Outline

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Oases in agroecological perspective

- Oases are living ecosystem, thanks to the symbiosis between humans and nature[1], founded on irrigation
- Autopoiesis
- Coevolution (rather than *equilibrium*) with the environment and resiliency to climatic changes
- Naturally resilient to water scarcity through spontaneous selection of drought resistant varieties[2]
- Selection of local *cultivars* with contribution to biodiversity (and soil organic matter)
- Richness in ancillary productions
- Valuable products (dates, grapes, spices, citrus fruits)

[1] Laureano, P. (1995). *La Piramide rovesciata: il modello dell'oasi per il pianeta terra*. Bollati Boringhieri. (Available in English.)

[2] Altieri, M. A. (2009). Agroecology, small farms, and food sovereignty. *Monthly review*, 61(3), 102.

Remarks

- Oases and traditional agriculture combat desertification, mitigate hydrogeological hazard and changes effects, with possible fallout also on the climate[3]
- As the soil, oases often are in transition
- As for desertification studying oases requires a structurally multidimensional and interdisciplinar framework
- Oases provide Cultural, Regulating, Provisioning, Supporting Ecosystem Services. According to MA (2005):[4]

> *"Ecosystem services are the benefits people obtain from ecosystems."*

[3] See e.g. the Vienna Soil Declaration, 2015; Morri en, E., Hannula, S. E., Snoek, L. B., Helmsing, N. R., Zweers, H., De Hollander, M., . . . & Duyts, H. (2017). Soil networks become more connected and take up more carbon as nature restoration progresses. *Nature communications*, 8.

[4] Millennium Ecosystem Assessment (MA). 2005. *Ecosystems and Human Well-Being: Synthesis*. Island Press, Washington. 155pp.

UNCCD recalls about traditional knowledge

UNCCD Secreatariat (2005, p.50):[5]

> *7. In the discussion by the Panel it was stated that traditional knowledge:*
>
> *(a) Has an important economic role; generates social and cultural benefits and values; is dynamic and adapts to change; needs an enabling environment to be developed and to reproduce itself; cannot just be listed, as it is not static information but rather time, context and actor–specific living knowledge.*
>
> *(b) Moreover, traditional knowledge also integrates modern knowledge, evolves, and spreads to create regional traditions; it should not be glorified blindly but carefully evaluated in its contribution to sustainable resource management; the term "traditional knowledge" also includes very old, forgotten techniques; it is a plural term, indicating the diversity of the knowledge of other cultures (. . .).*

[5] UNCCD (2005) *Revitalizing Traditional Knowledge. A Compilation of Documents and Reports from 1997—2003*. UNCCD, Bonn, Germany; for further reading UNCCD and World Bank (2017) *Land for life. Create wealth, transform lives*. UNCCD, Bonn, Germany.

Water as a key for reclamation, and ecosystem services

UNCCD Secreatariat (2005, p.51):[6]

> *15. One of the most successful techniques for the rehabilitation of strongly degraded land in the Sahel is the improved traditional planting pit or "zai". This traditional technique was improved in the early 1980's by a farmer in the Yatenga region of Burkina Faso. He increased the diameter and the depth of the traditional pits and put manure in them during the dry season. (...)*
>
> *16. The most widespread system characteristic of the Mediterranean area is the terracing system that can be found in the Middle East, Greece, Italy and Portugal. (...) The aesthetic qualities, the beauty of natural materials, the comfort of architecture and spaces, the organic relationship with the landscape that the ancient towns of the area boast are especially due to the qualities of traditional techniques and to the search for symbiosis and harmony intrinsic in local knowledge. The survival of traditional societies in the whole Mediterranean area depends on the effective, economic and sustainable management of natural resources. In the Mediterranean area, which is characterised by intensive settlement, the environment is not only the result of natural processes, but rather represents a cultural landscape where historical centres are the crystallization of knowledge appropriate to environmental management and maintenance.*

[6] UNCCD (2005) *Revitalizing Traditional Knowledge. A Compilation of Documents and Reports from 1997—2003.*

A recent UNESCO's statement

Dry–stone walls have been inscribed in the list intangible cultural heritage[7]

> *The Intergovernmental Committee for the Safeguarding of the Intangible Cultural Heritage, meeting in Mauritius until 1 December, inscribed nine elements on the Representative List of the Intangible Cultural Heritage of Humanity. The Representative List seeks to enhance visibility for the traditions and know–how of communities without recognizing standards of excellence or exclusivity. The newly inscribed elements are: (. . .)*
>
> *Croatia, Cyprus, France, Greece, Italy, Slovenia, Spain, Switzerland – Art of dry stone walling, knowledge and techniques – The art of dry stone walling concerns the art of building by stacking stones upon one another, without using any other materials except, in some case, dry soil. This know–how is preserved in rural communities where the practice is deeply rooted, and among construction industry professionals. Dry–stone structures have shaped numerous and diverse landscapes with a variety of constructions used as dwellings, for farming and animal husbandry. Such structures testify to the methods used by people from prehistory to the present in organizing their living and working space by optimizing local natural and human resources.*

[7] https://en.unesco.org/news/intangible-heritage-nine-elements-inscribed-representative-list, checked 29/11/2018

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Oases and *hydraulic civilization*

Starr, 2013, p.37, on Central Asia:[8]

> *. . . an important positive force made possible the development and maintenance of civilization and a high culture across Central Asia. Again, the agent was not nature but humankind, specifically, people's gradual mastery of the arts and technologies of irrigation. It was irrigation, and only irrigation, that made possible the rise of civilization on some of the otherwise barren land of Central Asia. In this sense it is fair to call Central Asia a "hydraulic civilization". . .*

[8] Starr, S.F. (2013). *Lost Enlightenment: Central Asia's Golden Age from the Arab Conquest to Tamerlane*. Princeton University Press

Why to study traditional irrigation techniques? I

Some keys of interpretation:[9]

1. They are a cultural heritage and a local identity
2. They are not to be merely musealised because, strengthening and vivifying the landscape, they are a key to understand anthropogenic landscapes
3. They are one axle of the oases and a defense against desertification
4. They are traditional but (often) not endogenous, they go beyond local costumes and are projected in an ecumenical dimension of culture

Why to study traditional irrigation techniques? II

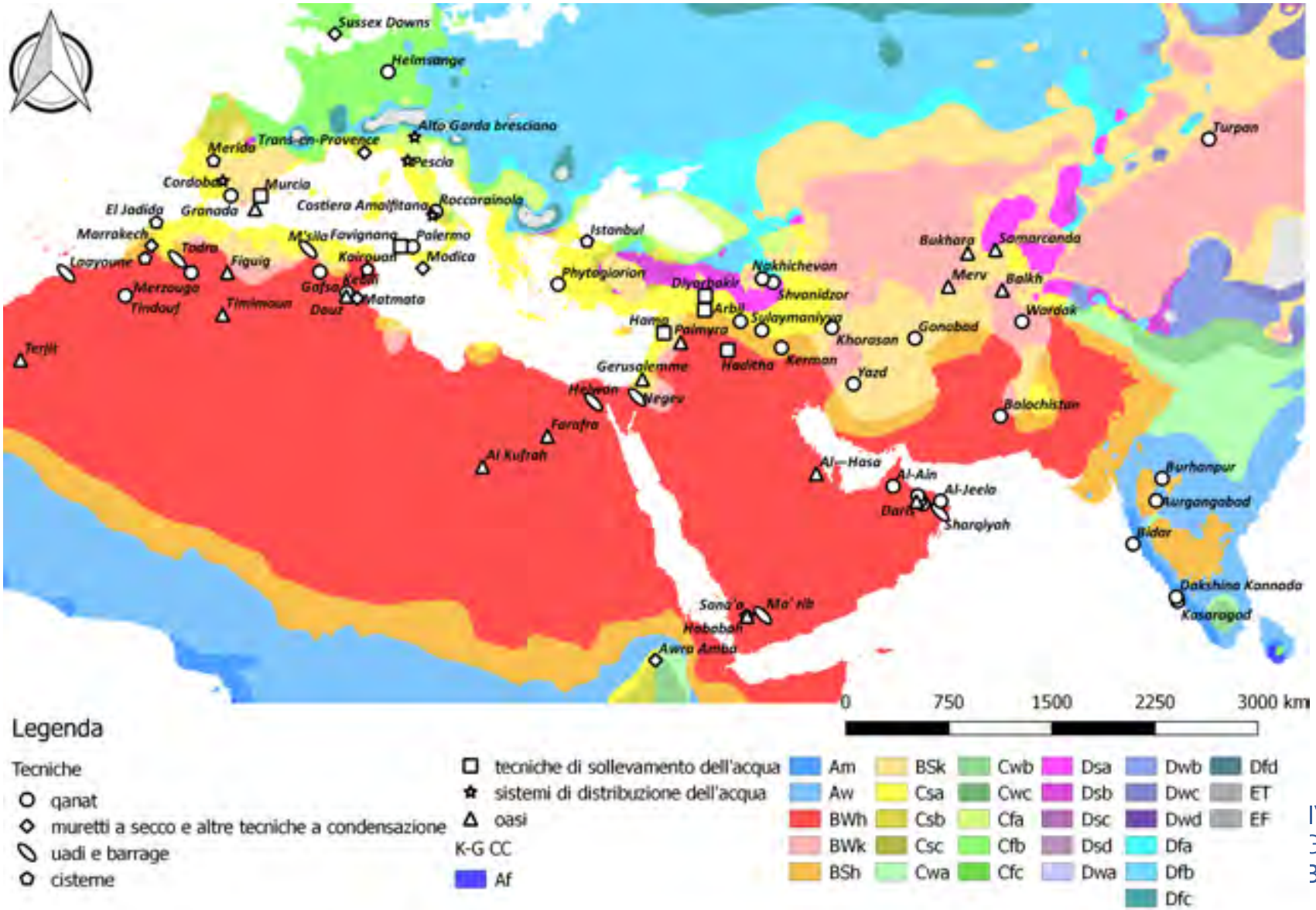
5. They are flexible and dynamic, or in other words *coevolutive*; the very concept of scarcity is linked to the idea of interaction
6. They pose intriguing epistemological issue: often they are not designable in a modern sense, but shall we speak of cultural cross–pollination or evolutive convergence?
7. Traditional techniques allow to cultivate peripheral areas, thus stimulating biodiversity and mitigating hydrogeological risk
8. Arid climates may be considered a proxy of climate change effects in temperate climates
9. *Soils of Mediterranean Europe are prone to desertification and water scarcity; moreover Italian climates, as the Alpine Sublitoranean climate, are typically wet but slopes are often in water scarcity conditions*

[9] Barontini S., Boselli V., Louki A., Ben Slima Z., Ghaouch F. E., Labaran R., Raffelli G., Peli M., Al Ani A. M., Vitale N., Borroni M., Martello N., Bettoni B., Negm A., Grossi G., Tomirotti M., Ranzi R., Bacchi B. (2017) Bridging Mediterranean cultures in the International Year of Soils 2015: a documentary exhibition on irrigation techniques in water scarcity conditions, *Hydrology Research* Jun 2017, 48 (3) 789—801; Barontini S., Badiani B., Boselli V., Peli M., Pezzotti D., Quarta R. & Vitale N., Sul significato culturale delle tecniche irrigue tradizionali in scarsità idrica, *Officina**, 22:10—15, 2018

An hypothesis of classification

1. Collection of the groundwater: *qānāt*, *foggara*, *khettara*, *karez*, *mkayel*, wells
2. Collection of the air moisture: dry–stone walls and cob walls, *tu'rat*
3. Collection of rainwater: *zai*, *wadi*, *barrages*, reservoirs
4. Lifting systems: *shadouf*, *saqiyya*, *naoor*
5. Distribution systems

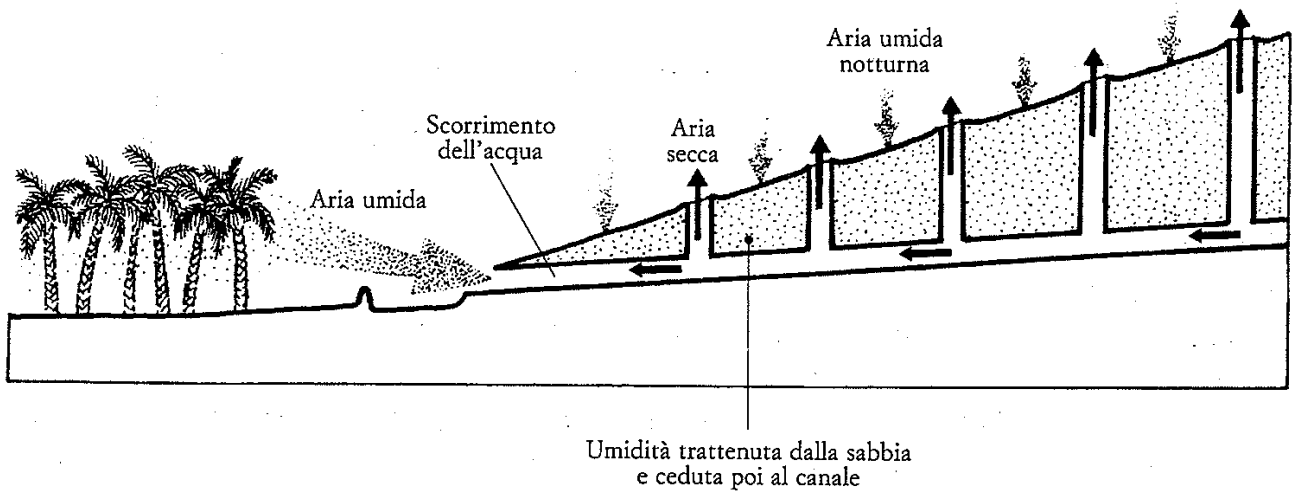
A map of the collected information



The Ptolemaic World

The world map from Leinhart Holle's 1482 edition Ptolemy's 2nd–century *Geography*
(Source: `https://commons.wikimedia.org`, checked 12/12/2018)

Principal and ancillary resources I



Sketch of a foggara (Source: Laureano, 1995, 2013)

Functioning of a *foggara*:

- Principal resource: groundwater drainage
- Ancillary resource: condensation of up–blowing vapor

Principal and ancillary resources II

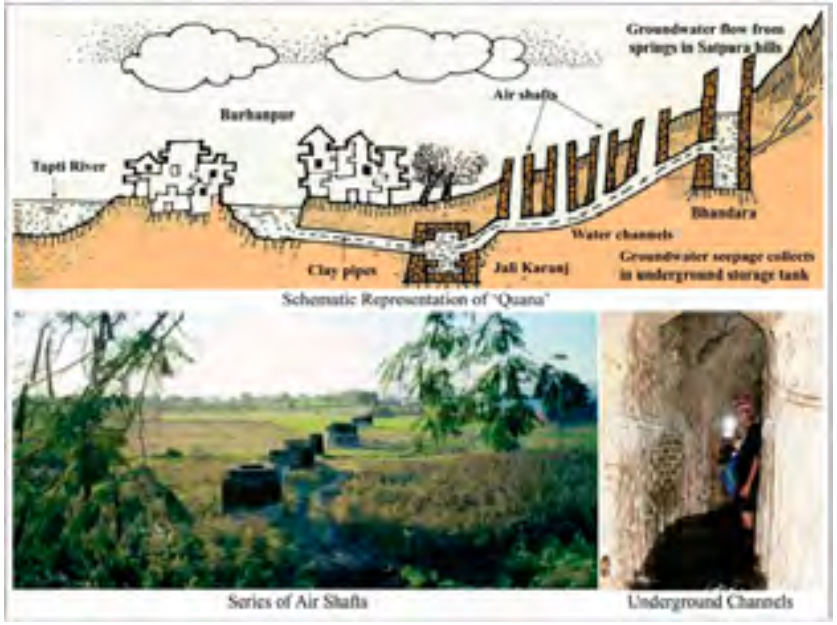
Citrus garden at Pozzallo (Sicilia). Courtesy N. Vitale

Water collection in a citrus garden:

- Principal resource: precipitation
- Ancillary resource: condensation of moist air, reduction of bare soil evaporation

Khettara and *Qānāt*

Kariz in Iran



Khooni bandhara in Madhya Pradesh

Naoor

Noria (naoor) at Casas del Rio (Requena Utiel, Valencia, Spain), Source: Ovsanchez, web.

Saqiya and *Sènia*

Saqiya in Mali (1924, fonte: `https://dianabuja.wordpress.com/`, left) e *"noria"* o *sènia* Western Sicily (1953, fonte: `https://reportagesicilia.blogspot.it/`, right).

Distribution systems

Water distribution system in gardens in Sevilla (Spain, courtesy M. Peli)

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Introduction[10]

Pra' de la Fam lemon house in Tignale (BS, Source: Ecomuseum)

1. *Citrus gardens*
2. Terraces (anthropogenic landscape)
3. Lemon houses nowadays: abandoning and change of destination

[10] Badiani B., Barontini S., Bettoni B., Bonati S., Peli M., Pietta A., Scala B., Tononi M., Vitale N., Lake Garda lemon houses (Italy): Opportunities of a sensitive, marginal area in urban planning, Change and Adaptation in Socio–Ecological Systems, 3(1):111—118, 2017

Local *cultivars* and commerce

A. Gallo, *Le vinti giornate dell'agricoltura e de' piaceri della villa*, 1572, Giornata VII:

> *. . . vi sono cinque sorti di quelli frutti; cioè cedri, limoni, aranci, pomi d'Adamo & limonee. Et che essendo conosciuti i cedri, i limoni, gli aranci, & in parte gli Adami; non però sono conosciuti così bene le limonee, che sono una specie di mezo fra il detto pomo e il limone.*

G. Da Lezze, *Catastico*, 1609—1610, Vol.III, pp.648 e sgg.: In the district of Gargnagno (from Toscolano to Limone, *genti laboriose* and *bellicose*) citrus fruits are cultivated for export *in Alemagna*.

Apogee between 18th and 19th century and decadence

Which paradigm for lemon houses? I

From the industrial district...

1. Well defined productive area;
2. Long lasting production;
3. Involvement of the background territory for the production of raw and pre–worked materials;
4. *Chain of skills*, from the forest cultivation to the export;

...to the oasis

1. Water scarcity conditions;
2. Symbiosis between humans and the environment;
3. Autopoiesis;
4. Resiliency to climatic changes
5. Selection of valuable local cultivars (citron of Salò, lemon of Maderno);
6. Ancillary coltures (bitter orange, caper bush);
7. Systems of lemon houses.

Even if citrus trees are very sensitive to cold climate, the maximum development of the lemon houses was during the Little Ice Age

Which paradigm for lemon houses? II

B. Scaglia, 1994, pp.46—47:

> *[Il limone] era frutto, non della natura ma dell'opera e del capitale degli uomini, che con notevole sforzo e sacrificio economico avevano costruito, col lavoro di generazioni, piccoli orti, scavati nella montagna, sostenuti da muri, il cui fondo terroso era costituito da terra trasportata dalla sponda veronese in quella bresciana su grosse barche.*

The water in lemon houses

A. Gallo, *Le vinti giornate dell'agricoltura e de' piaceri della villa*, 1572, Giornata VII:

> *Et però sono ben fortunati coloro, che o presso o dentro de' giardini hanno buona commodità d'acqua; (. . .) Si come il perfetto terreno è sempre vero padre delle piante; così l'acqua data loro con misura, e a tempo, è anco fecondissima madre.*

Barontini et al. (2016):[11]

1. Great Summer requirement of water by the citrus trees, between 100 and 300 ℓ per tree every 8 days (see also Doorenbos and Pruit, 1978);
2. Root sensitivity to excedent irrigation;
3. Water requirement for concurrent usages: grindstone mills (*mulini da macina*), forge mills (*mulini da forgia*);
4. Remarkable degree of standardization

[11] Barontini S., Vitale N., Fausti F., Badiani B., Bettoni B., Bonati S., Cerutti A., Peli M., Pietta A., Ranzi R., Scala B., Tononi M. & Zenucchini V., L'irrigazione tradizionale delle limonaie del Garda tra scarsità idrica e antropizzazione del territorio, in Castellarin A., Archetti R., Baratti E., Cappelletti M., Carisi F., Domeneghetti A., Gaeta M.G., Paci A., Persiano S., Pugliese A., Samaras A.G. (a cura di), Atti del XXXV Convegno Nazionale di Idraulica e Costruzioni Idrauliche "Ambiente, risorse, energia: le sfide dell'ingegneria delle acque in un mondo che cambia", Bologna, DICAM–Università di Bologna, pp.1235—1238, 2016

Adduction

Open channel across the second garden downstream the intake, upstream (left) and downstream (right) ($B \sim 45\,\mathrm{cm}$, $h \sim 40\,\mathrm{cm}$, drops of the channel bottom $\sim 30\,\mathrm{cm}$ /1 m).

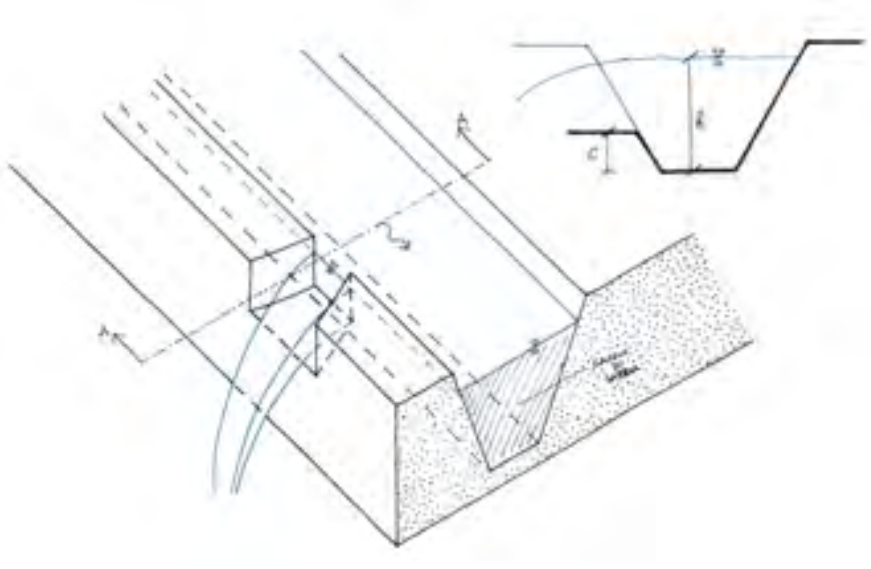
Flumes

Measurement of the slope of a flume in the upslope terrace at La Malora lemon house.

- Flume slopes range between 1% and 10%
- Apart from rare cases, flumes section is trapezoidal and very similar to the minimal friction section, with upper width $B \sim 12\,\mathrm{cm}$.

Spillways

Activated spillway at La Malora lemon house.



Functioning scheme of the spillways.

Squadro and *caladrìa*

Wooden dihedron (*squadro*) to drive the water to the foot of the trees, reconstructed.

Fistula of the *caladrìa* found by the owner, at La Malora lemon house ($L = 55\,\mathrm{cm}$).

Distribution systems

Cordoba, Gardens (A. Mondini, 2013)

Gargnano, Lemon house (2015)

Lemon houses flumes are similar to Arabic irrigation systems.

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Conclusions I

- The proper water management is one of the keys to protect the soil
- Some traditional irrigation techniques allow to cultivate in semi–arid or arid areas, thus contributing to build anthropogenic and autopoietic agricultural ecosystems, resilient to changes, based on the symbiosis between humans and nature
- The remarkable complexity of such ecosystems requires a structurally multidimensional and interdisciplinary approach
- Which future for the traditional irrigation techniques?

Conclusions II

Zavřel, The last tree, 1975