From desert to oasis
The role of traditional irrigation techniques
Lecture 2

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Summary

Oases and traditional irrigation techniques
  Oases
  Traditional irrigation techniques
  Examples

Case study: Lake–Garda lemon houses
  Purpose of the study
  Origin and paradigm for the lemon houses
  Structure of lemon houses and irrigation system
Outline

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Oasis paradigm and traditional agriculture

- Living ecosystem thanks to the symbiosis between humans and nature
- 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
- Selection of local cultivars with contribution to biodiversity (and soil organic matter)
- Richness in ancillary productions
- Valuable products (dates, grapes, spices, citrus fruits)

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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 interdisciplinary framework
- Oases provide Cultural, Regulating, Provisioning Ecosystem Services\(^4\)

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Multidimensionality and interdisciplinarity

Naveh (2001), about an approach to the study of landscapes in view of evaluating their ecosystem services:\(^5\)

*Such a transdisciplinary challenge does not mean that landscape researchers have to neglect their own unique disciplinary expertise of dealing with the land as a whole. Rather they will have to share it with others, such as economists, anthropologists, environmental psychologists, and sociologists.*
An agroecological perspective

*Milpa*, traditional cultivation of pumpkin, beans and maize in Latin America, is an emblem of agroecology. Source: viaorganica.org
From desert to oasis
— Oases and traditional irrigation techniques
— Oases

An agroecological perspective II

Altieri (2002):\(^6\)

*Agroecology goes beyond a one-dimensional view of agroecosystems—their genetics, agronomy, edaphology, etc.—to embrace an understanding of ecological and social levels of coevolution, structure and function.*

▸ Agroecology focuses on sustainability of agroecosystems favouring the traditional agriculture *(which is intrinsically biodiverse, soil conserving and drought resistant)* to gain resilience against climatic changes

▸ Traditional agriculture is strongly related with the etnoanthropological structure

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Gender issues in traditional agriculture

Thurnwald, Hypothesis on the development of agricultural societies
UNCCD recalls about gender issues

UNCCD Secretariat (2005):

Desertification causes the spread of poverty, it exhausts marshes and backwaters, and it causes the soil to dry out which results in an inability to cultivate such things as root vegetables, wild fruit and trees for firewood. It is a vicious circle which degrades the life of the women, whose means of survival depends on the fertility and productivity of the soil.
The women are the guarantors of the survival of the African family, because they are reacting to the gravity of the situation, making agreements and undertaking action plans. They try to find solutions through communication between women of different populations and the organization of inter-village meetings on the management of the territories.
(….) Some traditional technologies are used to fight desertification and to reduce the scourge of drought. Some women, with the help of the children, make fences to surround the towns. After the birth of a child the young mother must plant five seedlings during the period of 20 days that the baby is suckling.

UNCCD recalls about traditional knowledge

UNCCD Secretariat (2005, p.50):8

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 (…).

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Water as a key for reclamation, and ecosystem services

UNCCD Secretariat (2005, p.51):^9

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.

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Outline

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Oases

Traditional irrigation techniques

Examples

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Purpose of the study

Origin and paradigm for the lemon houses

Structure of lemon houses and irrigation system
A focus on traditional irrigation techniques in water scarcity

Barontini et al. (2017): ¹⁰

- Water is essential for soil conservation and agriculture
- Arid climates may be proxies of climatic changes in temperate climates
- **Scarcity, not only aridity**, because scarcity is related to equilibrium and, at a more general extent, to coevolution
- As a consequence, traditional techniques are often intrinsically resilient
- **Cultural interest: often traditional techniques are not designable in a modern sense**
- Alpine sublitoranean climate is tipically humid, but mountains are often in scarcity conditions
- **Technical continuity** in a wide area facing same problems of water scarcity

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An hypothesis of classification

1. Collection of the groundwater: qānāt, foggara, khettara, wells
2. Collection of the air moisture: dry–stone walls and cob walls, tu‘rat
3. Collection of rainwater: wadi, barrages, reservoirs
4. Lifting systems: shadouf, saqiyya, naoor
5. Distribution systems
From desert to oasis

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- Traditional irrigation techniques

A map of the collected information
From desert to oasis

- Oases and traditional irrigation techniques
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The climatic diagram

Source of data: http://www.climate-data.org
Principal and ancillary resources

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

Functioning of a *foggara*:

- Principal resource: groundwater drainage
- Ancillary resource: condensation of up–blowing vapor
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Khettara and Qānāt
Cob walls and dry–stone walls
From desert to oasis

- Oases and traditional irrigation techniques
- Examples

Wadi
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Oases and traditional irrigation techniques

Examples

Saqiyya and Naoor
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Introduction

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

Pra’ de la Fam lemon house in Tignale
(BS, Source: Ecomuseum)
The research

1. Purpose:
   1.1 Drive the lemon houses to the pristine agricultural vocation;
   1.2 Evaluate the benefits from the Ecosystem Services;

2. Methods:
   2.1 Multidimensional, interdisciplinary analysis;\(^{11}\)
   2.2 Link with the stakeholders;

\(^{11}\) The study group is composed by agronomers, architects, geographers, historians, hydrologists, landmanagers, phylologists, phylosophers.
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From the origins to the *orti belli*

G. M. Voltolina, *De hortorum cultura*, 1574, l:146—151:

*Insuper optandae quippe essent hic tibi frondes, Hesperidum, Alcides nostris quas intulit oris; Ispa, inquam, Citrus nostro ponatur in Horto, Difficiles quamvis curas, propriosque labores, Ut generis puer illustris si detur alendus, nobilis exposcit multum semperque morosa.*

A. Gallo, *Le dieci giornate della vera agricoltura, e piaceri della villa*, 1564, f.2v:

Cultivation 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*.

Apogeo 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 (Badiani et al., submitted).

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:

[I]l 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.
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Structure of lemon houses

1. The fields are modular (~20 m²) as a consequence of agricultural needs;
2. Prevailing SE exposition;
3. Up-slope and lateral protection from cold winds;
4. *Casello*;
5. Presence of sources or streams;
6. Remarkable degree of building and agricultural standardisation.
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):

1. Great Summer requirement of water by the citrus trees, between 100 and 300 ℓ per tree every 8 days (see also Doorenbos and Pruitt, 1978);

2. Root sensitivity to excedent irrigation;

3. Water requirement for concurrent usages: grindstone mills (*mulini da macina*), forge mills (*mulini da forgia*).
La Malora lemon house in Gargnano
Irrigation system of La Malora: wide-angle shot of the diversion at Fosso dei Molini. Legenda: a) diversion channel, b) sluicegate for water derivation, c) washtub, d) stilling basin, e) a mill’s diversion, currently filled in.
Adduction

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

- 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 $B \sim 12\,\text{cm}$.

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

Activated spillway at La Malora lemon house.  

Functioning scheme of the spillways.
Spilling measurements

Spilling measurements at La Malora lemon house in Gargnano.

Spilling measurements at Pra’ de la Fam lemon house in Tignale.

Spillways are able to provide a flow ranging between 7 and 15 ℓ/min.
Squadro and caladria

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

Fistula of the caladria found by the owner, at La Malora lemon house (L = 55 cm).
Erogation systems

Lemon houses flumes are similar to Arabic irrigation systems.
Drainage

Foot of the central terrace of La Malora lemon house in Gargnano: covered flume to drain rainfall, seepage water from the up-slope wall and exceeding irrigation water.

Open flume to convoy the drained water from the central terrace.

Drainage flumes were important mostly to drive away Winter rainfalls, it seems that they were not designed to reuse irrigation water.\(^\text{12}\)

\(^{12}\)In contrast, see the traditional irrigation system of the upper Po–river–floodplain, based on the ripigli technique.
Remarks

1. Two limiting factors conditioned the onset and the manage of a lemon house, SE exposure and water availability
2. Water supply to the terraces was provided by a complex distributive network distribution to concurrent users
3. Internal distribution system was standardized, as most of the procedures and structures
4. Water was provided tree by tree presumably continuously, in Summer, in the greatest lemon houses
5. Draining flumes, where present, seem to be used only to drain excess water and not to reuse irrigation water