

# Water in Morocco: Precious, Precarious and Problematic

## Appendix I-IV

### Appendix I --Sewage treatment – link to agriculture and health

Resources:

Atlas – Chapters 14 & 15, 27, 28 – put the problem in context

Cunningham & Cunningham. 2015. Section from text: Environmental Science *that describes basics of sewage treatment.*

Bdour, A.N., M.R. Hamdi and Z. Tarawneh. 2009. Perspectives on sustainable wastewater treatment technologies and reuse options in the urban areas of the Mediterranean region. *Desalination 237:162-174. a very readable discussion of sustainable waste water treatment facilities and the mistakes one makes when applying western technologies to arid environments. A few cases of bad and good examples.*

Bouabid A. & G.E. Lewis. 2015. Capacity factor analysis for evaluating water and sanitation infrastructure choices for developing communities. *Journal of Environmental Management 161:335-343. This paper addresses, in a very formal manner, how to determine the appropriate sanitation infrastructure for a community. I would SKIM the intro, look at the figures and READ the case study on a village in Morocco and Discussion.*

1. What is waste water? Grey water? black water? Storm water?
2. What happens to it in your community at home (recall homework)?
3. Why does industry add another level of complexity?
4. What needs to be removed? How can this be done? Where do the leftovers go? E.g., sludge, water, biogas?
5. What are the biological / hydrological factors that must be considered?
6. What are the human factors that need to be considered when designing a system?
7. Why is it useful to link wastewater treatment to agriculture? Pros/cons? Concerns?

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### Appendix II. Khettara Water Systems of Morocco

## Water in Morocco: Precious, Precarious and Problematic

### Appendix I-IV

Benqlilou, H. and S. Bensaïd. 2013. Protection and performance of the ancestral water supply system 'Khattara' as a sustainable alternative for arid regions. *Water Science & Technology: Water Supply* 13:1452-1462. – *idealistic goal of making kehttara functional again. Nice diagram of a khettara (Fig 2) and some useful "logic maps" for making decisions. Focus on a region south of Agadir but important thoughts about value of Biosphere Reserves...*

Lightfoot, D.R. 1996. Moroccan Kehttara: Traditional irrigation and progressive desiccation. *Geoforum* 27: 261-273. *Although dated (so numbers are "off") this paper focuses on the region we will visit and gives an excellent history of how water was used in the region, reasons for changes – both social and hydrological. Good place to contemplate dams.*

Ecomuseum of the Khettara in the Tifalalet, Morocco – see URL (hope we are going there! This will be a modern take on the Oasis.

You may wish to revisit –“What Scale Water Governance” from “references we will revisit”

#### Guiding questions:

What are khettara water systems? How do they work? What are they used for? Origins/similar systems elsewhere? How will we recognize them?

What other water systems are used for drinking water, irrigation and flood control? What should we look for in the landscape?

Why are the systems around the Tafilalt region disappearing?

- Hydrological changes?
- Social and economic changes?
- What are the benefits of these changes? The cons?

*In your opinion—*

- Why are they a valuable part of a “sustainable territorial development program” e.g., as asserted by the Ecomuseum?
- (to quote El Faiz & Ruf, 2008—a paper we aren’t reading) “How can these systems be maintained, and how can farmers be allowed to innovate without destroying what made the inhabitants of arid regions relatively prosperous?”
- Is it important to sustain historic systems? What other cultural features are lost?
- How does being part of a UNESCO Biosphere Reserve help? Responsibilities???

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# Water in Morocco: Precious, Precarious and Problematic

## Appendix I-IV

### Appendix III. Argan Biosphere Reserve

Resources:

- Atlas Kasbah – an ecolodge recognized for its innovations regarding water use and location in the Argan Biosphere—introducing visitors to this unique ecosystem and its unique culture.
- Aboutayeb, H., B. Kabbachi and A. Ezaidi. 2014. The phytodepuration of wastewater for tourism facilities in rural areas: The Atlas Kasbah Ecolodge—a pilot site in the Argan Biosphere Reserve.
- Polain de Waroux, Y. le, and E.F. Lambin. 2012. Monitoring degradation in arid and semi-arid forests and woodlands: The case of the argan woodlands (Morocco). *Applied Geography* 32: 777-786. A lovely case study of how scientists go about preserving an area.
- El Fasskaoui, B. 2009. Fonctions, defies et enjeux de la gestion et du developpement durables dans la Reserve de Biosphere de l'Arganeraire (Maroc). *Etudes caribeennes* doi: 10.4000/etudescaribeennes.3011. – This comprehensive article is in French except for the abstract=Resumes and my notes throughout. The maps are helpful as are the section titles. The title roughly translates to: *Functions, challenges, stakes in the management and sustainable development in the Argan Biosphere Reserve*

Questions to consider

#### Argan Biosphere Reserve:

1. Revisit: what does the designation “biosphere reserve” mean? Who is responsible for the designation? What features of an area qualify it to be a biosphere reserve? What responsibilities then accrue to managing the area.
2. What are the special biological/geological features of the Argan Biosphere Reserve?
3. What are the unique cultural features in this region?
4. What are the social pressures that are in tension with preserving this area?
5. What are the biological pressures?
6. Based on the article about the dry land forest, what information is needed to determine good management strategies?
7. What did the authors learn? Does water have anything to do with the stress on this forest?
8. Does their work extend or inform approaches to other dry land forests? Where?
9. How does their information help us think about policies?

**Ecotourism:**

## Water in Morocco: Precious, Precarious and Problematic

### Appendix I-IV

1. What distinguishes ecotourism from other forms of tourism?
2. How does the Atlas Kasbah fulfill some or all of these goals?
3. What are the tensions/challenges between the economic value of bringing tourists to an area and maintaining that area? And the benefits?
4. How are kitchen, shower and toilet wastewaters handled at Atlas Kasbah?
5. How is this innovative? Ecological?
6. Could these methods be applied elsewhere? Challenges?

### Summary/Discussion

Given, the three major goals of a Biosphere Reserve (see introduction to el Fasskaoui, 2009), give examples of how each is being met. Consider the roles of various stakeholders—what is in their capacity to do?

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### Appendix IV. Guidelines for final discussion:

Sources/Prompts:

Gleick, P.H. 2016. *Water strategies for the next administration: water policy offers opportunity for nonpartisan agreement*. Science 354:555-556.

You may want to revisit other discussions from Science (in our “revisit” folder)

- *Water security gray or green* – contrasts using natural water management tools with those that are built (dams, water treatment plants etc.)
- *What scale for water governance* – Global or local and why?
- *Emerging solutions to the water challenges of an urbanizing world* – Larson

Gleick makes six assertions regarding water policy in the US. We will divide into groups to discuss each in light of what we have learned in Morocco. In your group, think of specific Moroccan examples and then link these to what Gleick is suggesting for the US. Feel free to consider these simply as “prompts” for discussion and take the ideas where they need to go.

The six assertions are:

1. “Federal agencies, authorities, and policies are often inconsistent, overlapping and inefficient.” --- Consider the role of various levels of governance/control authorizing water use here in Morocco in terms of effectiveness and coordination.

## **Water in Morocco: Precious, Precarious and Problematic**

### **Appendix I-IV**

2. “Basic water science and data collection remain undone.” Consider the types of data we have used to make conclusions or predictions about water use and availability in Morocco. What data are needed? Why?
3. “Critical water infrastructure is often obsolete and decaying”. What aspects of water infrastructure need routine vigilance, repair or may benefit from new designs altogether? What examples have we seen?
4. “Links between water conflicts and national security are clear and growing.” Did we see any evidence of this in Morocco (think broadly about security in terms of food, energy, urban/rural economic/cultural, health, etc.). Is it important to the US that North Africa is extremely vulnerable to climate change?
5. “Many people still lack basic safe water and sanitation.” What is the situation regarding access? What systems are in place? If funds were no object, what systems would you recommend for Morocco? For your community at home?
6. “Climate change impacts on water resources and systems are worsening.” What has been observed already in Morocco and why are these impacts challenging? What are the predictions for 2050 and beyond? (On what are these predictions based?) How will changes in temperature and rainfall alter the human- and bio- spheres in Morocco? If anything were feasible, what would you recommend to mitigate each of these effects?