ALQUEVA
Changing Ecologies of the Montado Landscape
Alentejo, Portugal
In the past decade Alqueva Dam brought a tremendous landscape change in all three sectors—environmental, social and economic. While the dam and reservoir was a project which was carefully executed, there are certain issues which need to be monitored/rectified as the reservoir goes into 5th straight year with full capacity.

The Alentejo region is currently under threats from environmental stress (drought, climate change and habitat disturbances), social stress (with declining population in nearby villages) and is also struggling to attract people to this economically backward region in Portugal. This report presents analysis and recommendations proposed by Environmental Planning Students from UC Berkeley to create and revise holistic strategies that measure the effects of the dam and future proposals to improve human access and ecological values of Alentejo region.
ACKNOWLEDGEMENTS

This workshop was made possible by the generous support from the Portuguese Studies Program (PSP) of the University of California, Berkeley, and led an enthusiastic team of environment planners and landscape architects which included Prof G Mathias Kondolf, Prof John Radke, Pedro Pinto and Anna Serra Llobet of UC Berkeley, Joao Rocha of the University of Evora, and with superb organizational support by Rachael Marzion of UC Berkeley.

We are grateful for the support of colleagues at the University of Evora, including José Gustavo Freitas, Fatima Bernardo, and other students from architecture department for sharing base information and ongoing existing research on the Alqueva Reservoir and region. Staff of EDIA, Beja, were extremely helpful to us in accessing data. José Pedro Salema provided a project overview and provided introductions to EDIA staff with knowledge relevant to our research. Ana Ilhéu, Gabriel Jesusino, José Costa Gomes and Helena Barbosa provided access to relevant environmental documents and data, and kindly organized field visits to the dam and villages around reservoir. We also thank Tommy Bree of ESB international, Dublin, Ireland for his (ultimately unsuccessful) efforts to find English translations of sections of the original Environmental Impact study of 1995. We are grateful to residents of Alqueva, Luz, Ameiera, Monzaraz, and other villages around Alqueva for their generous hospitality during our field visits.

CONTENTS

1.0 Introduction
   1.1 Alentejo, Portugal
   1.2 Alqueva Dam and Reservoir

2.0 Field Visit and Workshops

3.0 Study Groups
   Introduction, Scale and Scope
   3.1 Environmental Impact Analysis
      Diana, Kristen
   3.2 Riparian Buffers
      Kushal, Pablo, Valerie
   3.3 Wildlife Connectivity
      Emma, Kalle
   3.4 Social Connectivity
      Brandon, Tiffany
   3.5 Alentejo Wine Tourism Corridor
      Emilie, Fern, Rocker

4.0 Conclusions

6.0 References
The Guadiana River

The Guadiana River, with a total length of approximately 810km, drains approximately 73,840km², originating in eastern Spain and debouching into the Gulf of Cadiz. Of its total length, approximately 550km is in Spain, approximately 150km in Portugal and the remaining 75 km forms the border between the two countries. The lower 50 Km of the river is tidally influenced. Within Portugal, the river is joined by tributaries that include the Caia, Lucefecita, Degebe and Ardila. There are many reservoirs in the Guadiana basin, 34 constructed in Spain and 4 in Portugal.

Typically the region was dry, lacking water in the summer months. The Alqueva Project has changed this fact dramatically, with its 68 reservoirs and dams, 52 pumping stations and 5 mini hydro plants resting on the Guadiana River. The reservoir provides water to 120,000 ha of agricultural land and provides potential opportunities for other forms of development.
Alqueva Multipurpose Project

The Alqueva Multi-purpose Project is located in the Alentejo region in southern Portugal. This region is located in a Mediterranean climate which is characterized by hot, dry summers and mild, wet winters. The project consists of the Alqueva Dam, the smaller Pedrogao Dam, and 67 additional dams, reservoirs and weirs. The project includes approximately 2,000 km of canals and pipelines in a network that provides irrigation to 120,000 ha of land (EDIA 2015). At 250 km² the Alqueva reservoir is the largest surface reservoir in Europe (EDIA 2015). The main purpose of the Alqueva project is to supply water to 200,000 people in the region for agriculture, industry, tourism, and to generate hydroelectric energy (EDIA 2015). The Alqueva project is run by a semi-public company known as the Empresa de Desenvolvimento e Infraestruturas do Alqueva, S.A (EDIA), with headquarters in Beja.

Timeline

The project was first envisioned in 1957, but was not built until 2002 (Lobo et al 2002). Prior to construction, the project went through an environmental review process which included an integrated environmental impact study, and an environmental impact analysis of the proposed project. After a review of the environmental impact analysis, the project was approved by European Union in 1997 under the conditions that the project follow environmental management guidelines described in the Environmental Management Programme (EMP). The EMP was updated by EDIA in 2005 following the completion of dam construction, in an effort to improve the environmental management programme requirements of the project (EDIA 2015).

Challenges

Portugal already has a number of major reservoirs, but like most reservoirs in the developed world, they were mostly built in the 20th century. Alqueva is unusual in the area covered by its reservoir (at 250 km², the largest in Europe) and the fact that it was built in the 21st century, whereas dam building has mostly stopped in Western Europe and the US. The region surrounding the reservoir faces new opportunities and challenges, as traditional land-uses and human activities are changing and new risks are arising. The most significant change is expansion of irrigated farming and intensification of agricultural production.

In light of its international funding (from the EU Commission), there are expectations that the reservoir status and environmental effects be carefully monitored, and impacts mitigated.
FIELD VISITS/WORKSHOP

Overview

Our group of 12 students from UC Berkeley, organized ourselves into thematic teams to delve deeper into specific issues at a range of scales with data from the Empresa de Desenvolvimento e Infraestruturas do Alqueva, Portugal (EDIA) and assistance from experts in environmental planning/sociology from University of Evora, Portugal.

Prior to going to Portugal, we conducted background research on a range of relevant topics, such that they were familiar with the nature and scale of the project, and the Alentejo region. During a week-long workshop on site, we participated in meetings and conducted fieldwork throughout the region influenced by the new reservoir and interviewed local residents.

Back in Berkeley, we formed teams to attack various identified issues at multiple scales and compiled the team proposals into reports and presentations.

The field visits included:

- Workshop with students and professors from University of Evora.
- Interviews and discussions with farmers in Alentejo.
- Visit to the village of Luz and Museum de Luz.
- Visit to EDIA headquarters, Beja for presentation/screenings with experts monitoring environment and infrastructure strategies for Alqueva.
- Visit to Alqueva irrigation pumping control stations.
- Interview with Alentejo tourism development authorities.
- Visit to Pedrogao and Alqueva Dam and Guadiana river (south) to study the ecology for pre-dam construction river.
- GPS mapping, collection of military charts for identified study areas.

Viewing the perennial channels for R. Guadiana

Old Fisherman R. Guadiana

Disappearing roads in Alqueva Reservoir

Ground truthing

R Guadiana after the Alqueva Dam

Some of the sites visited in and around Alqueva:

- Grupo - UC team
- Grupo LA205 - Alqueva Team
- Grupo LA 205 - Spring 2015
3.0

**STUDY REPORTS**

We identified five issues based on our literature review, field reconnaissance, and interviews with academic and industry experts, holistically considering the environmental, political and social context.

1. **Environmental Impact Analysis**
   - review the environmental impact reports prepared for monitoring the dam in 1996 and 2005 and recommend guidelines for further monitoring.

2. **Riparian Buffers**
   - prepare a soil erosion model using GIS and recommend strategies to create a riparian buffer for improved human access and ecological connectivity.

3. **Wildlife Connectivity**
   - look specifically into connectivity changes for three species and create models to improve wildlife corridors lost to the reservoir.

4. **Social Connectivity**
   - look specifically for connection potential across/around reservoir to improve connectivity between villages and tourism sites.

5. **Alentejo Wine Tourism Corridor**
   - follow the fragmented wine circuits of Alentejo to identify potential to welcome tourists in this region with an interactive wine map.
Environmental Impact Analysis

A Comparative Analysis of the Environmental Management Programme Before and After Dam Construction
-Diana Edwards, Kirsten Jurich

Problem Statement

The objective of our study was to compare the conclusions, recommendations, and requirements of 1996 (pre-construction) EMP to the updated 2005 (post-construction) EMP. We reviewed documents to assess how well their conclusions, requirements and management recommendations addressed likely impacts identified through literature review of impacts documented at other dams and based on sitespecific environmental monitoring.

Methods

We reviewed both the 1996 pre-construction EMP (in English) to the post-construction 2005 EMP (in Portuguese) and summarized the major conclusions, recommendations, and requirements of each monitoring programme and then organized them by theme into a table (Table 1). We then incorporated a description of the known impacts of dams into the table to allow for a side-by-side comparison. This organization of data allowed us to determine gaps in the EMPs, and other topics that areas require additional research.

A major limitation to our study is that most documents that we had access to were in Portuguese, and neither of us speak or read this language. Additionally, we were unable to obtain some documents and data from EDIA that would have aided our study.

Results and Discussion

Our analysis showed that the 2005 EMP had more specific management recommendations and objectives. For example, the 1996 EMP noted that the most severe negative impact of the reservoir involves the relocation of a factory and the village of Aldeia da Luz, a town of approximately 400 people. In comparison, the 2005 EMP provided very specific management objectives including:

- Ensuring the acquisition and expropriation of land and buildings in inundation areas, as well as in the areas that are planned to be affected by future infrastructure; ensuring the construction of urban space in the new village of Luz.

It is likely that the management recommendations provided in 2005 were more specific as a result of “lessons learned” since the beginning of construction of the project and the completion of the dam. The updated recommendations were also likely a result of management needs to have objectives that were measurable and thus amenable to monitoring to assess progress and effectiveness of actions. The 1996 and 2005 environmental management programmes highlighted potentially significant negative impacts to ecology, water flow, and socio-economics. Ecological impacts included the removal of over 1.5 million trees to improve water quality in the reservoir, the interruption of ecological corridors, partial inundation of the Juromenha Guadiana conservation site, and significant loss of critical habitats.

Although downstream sediment transport monitoring was recommended by the 2005 EMP, interviews with EDIA staff indicated that sediment transport is not currently being monitored because it is assumed that the effects of Alqueva on sediment loads is minor due to the sediment trapping by dams upstream.

Our evaluation of both environmental management programmes, and various studies from the region, brought to light a number of under evaluated impacts. We identified that the transition from flowing to standing water catalyzed the emergence of invasive fish and plant species (Ameiurus melas, Eichhornia crassipes, etc.). Additionally, the transition from flowing to standing water resulted in an increase of mosquitos in areas near the banks of the Alqueva reservoir. The mosquitos are considered a nuisance to the people who live and work in the towns and villages near the reservoir (Pers. Comm. with Francisco Gudino; Telheiro, Portugal, 2015).

Recommendations

We have identified additional overlooked or under evaluated issues including stream reprofiling, risk prevention, climate change adaptation, and fire risk management. We recommend that a revised, updated Environmental Management Programme address these issues:

1. Stream Reprofiling

Over 125km of stream have been either ‘reprofiled’ or ‘cleaned’ with the primary objective to drain water off of agricultural fields more efficiently. We recommend that further research be undertaken to determine impacts to affected streams and to assess longterm changes in stream channel and riparian corridor.

2. Risk Prevention

More than 2,000 people reside in the valley downstream of the Alqueva and Pedrogao dams, many potentially at risk from a dam break flood, creating a need for a comprehensive risk prevention plan to be incorporated into a revised EMP.

3. Climate Change

Array of potential climate change impacts requires the immediate attention of EDIA to proactively plan for these forecasted changes.

4. Fire Management Plan

The new, denser agricultural vegetation can result in higher fire risk by providing fuel that can induce increased flame length and rate of spread of wildfire. A new fire management plan will help to control such unexpected events.
Conclusions

Through review of the environmental documents and relevant published literature, we have identified topic areas for which the original (1996) and updated (2005) environmental management programmes lack clarity or require further evaluation. These include issues related to downstream changes in sediment transport, increase in mosquito populations along reservoir margins, effects of stream cleaning and reprofiling for drainage, risk prevention, climate change adaptation, and fire risk management. Consistent with European Union policy and priorities, and the mission of EDIA, we recommend these concerns be addressed in detailed management plans with clear accountability standards in a revised Environmental Management Programme developed by Environmental Impact Analysis of Alqueva Dam.
Riparian Buffers

Analysis and restoration strategy for the buffer zone along the Alqueva reservoir edges
-Pablo J Alfaro, Valerie Francelia, Kushal Lachhwani

Problem Statement

Once a rich active ecological zone which provided habitat to the most beautiful birds of Alentejo region, the current water edge along the reservoir fails to attract flora and fauna due to its barren zone exposed during the summer dry period. The water requirement for irrigation is on the rise but with unpredictable drought this vulnerable zone remains dry for most part of the year. The average seasonal fall in water level is about 5m, but in extreme dry years it can fall 13 m.

The seasonal rise and fall of reservoir levels was predicted by Relatório Interníveis (Nemus et al. 2007) to create wetland areas in flat terrain, that would attract grazing animals. However, most of the reservoir margin is flanked by barren, devegetated zone corresponding to the zone of water fluctuations. Thus we explored possible ways to create riparian habitat along the reservoir margins, which could also stabilize the reservoir shoreline.

Methods

Following the field visit, the issue of the riparian edge at the Alqueva reservoir was further investigated to determine which areas were highly vulnerable to erosion, and what mitigation measures might be implemented to address the water quality and sedimentation issues that result from an exposed edge.

In this study, we attempted to quantify these risks and determine vulnerable zones for erosion using the Revised Universal Soil Loss Equation (RUSLE) (Marine Geodesy, Radke et al).

A=RKSCP
Where A = soil loss
R = Rainfall erosivity index
K = Soil erodibility index
SL = Hillslope length and gradient
C = Cropping management factor
P = Erosion control Practices

Each layer was processed individually as a raster and once the factors were calculated, the values of each raster cell were multiplied to provide a final erosion value.

Alqueva reservoir can be accomplished using a variety of engineered and vegetative techniques. By physically securing the soil, both in the inter fluctuation zone of the reservoir and on the largely agricultural adjacent properties, sedimentation in an already shallow reservoir may be controlled.

Creating Riparian Habitat
Vegetated riparian buffers offer wildlife access to water while also providing shade, shelter, food, mating grounds, and safety from predators. For instance, in the Alqueva region, a well formed riparian habitat has been associated with the presence of several bird species including Hippolais polyglotta, Sylvia atricapilla, Luscinia megarhynchos, and Cettia cetti (Godinho et al., 2010).

Run-off filtration
Given that much of the Alqueva reservoir is bordered by agricultural land, fertilizer and pesti-
cideladen runoff is of great concern. Excess nitrogen and phosphorous picked up during rain events contribute to water quality issues including the growth of algae and increased eutrophication. A vegetated barrier can help to trap these nutrients and other chemicals that would otherwise travel directly into the reservoir from neighboring farms.

**Additional Benefits**

Looking at the current tourism circuit in the region, the output of this study also helped us to identify regions that deemed to be ideal for heavier foot traffic and hence encourage tourism infrastructure. Slightly sensitive areas could be first restored and monitored for environment regeneration. This will provide a good balance between human access and protected buffer along the reservoir’s edge.

**Wildlife Associations**

There are several potential associations between habitat and wildlife along the riparian buffer. The proposal considers creating a natural transition between habitats starting from the reservoir as follows:

### Riparian Brushland and Shrubland

The dense shrub buffer could provide habitat for several species of native bats who live in Iberian riparian brush lands, like the Mediterranean Horseshoe Bat. Also we could find smaller birds associated with dense scrub areas and riparian corridors, like the Cetti’s warbler (*Cettia cetti*), Eurasian wren (*Troglodytes troglodytes*), and Short Toed Treecreeper (*Certhia brachydactyla*).

### Buffer Alternatives

Considering the large scale of the intervention perimeter and the high cost of construction and maintenance, the proposal takes soil bioengineering practices as an effective alternative to conventional “hard” solutions such as riprap armor, and also providing new riparian habitat benefiting species that lost much of their riparian habitat to inundation by the reservoir. The biotechnical techniques are well described by Serdoura at al (2003), and include coconut fiber roll, brush mattress, and joint planting.

### Conclusion

Creating a riparian area around the perimeter of the reservoir would help to address a range of issues including the loss of riparian habitat for wildlife, filtration of runoff, prevention of erosion and sedimentation, and the creation of a more attractive shoreline.

However, successfully establishing riparian vegetation within the zone of fluctuating reservoir levels may be challenging. We recommend using biotechnical approaches that yield both bank stabilization and wildlife habitats. Given the uncertainty about how different methods will perform along the margins of the reservoir, we recommend that pilot projects be undertaken in a various of settings (bank material, exposure to wave action, etc), with the results monitored to inform future projects.
Wildlife Connectivity

Assessing Wildlife connectivity in Alqueva watershed
-Emma Ding, Katie McKnight

Problem Statement
With the fragmentation of wildlife habitats, migration corridors assume greater importance. These corridors provide linkages between habitats, generally large patches of natural vegetation, thereby connecting two or more larger areas of similar wildlife territories. Corridors are critical for the maintenance of ecological processes such as the movement of animals and continuation of viable populations. The area around Alqueva Dam has been identified as one of the world's twenty five biodiversity hotspots, increasing the significance of the potential environmental impacts from this project. Among the negative environmental impacts posed by the presence of the dam, there has been a notable decline in polecat and wildcat populations. In addition, population lynx, who was absent before the dam is also studied as it was introduced again in Guadiana. The aim of this study was to understand the impact of Alqueva Reservoir on various threatened species through analyzing the changes in habitat suitability and corridor connections from pre and post-dam conditions.

Methods
We analyzed the catchment area draining directly into Alqueva reservoir, and included an additional 3 km wide strip around the catchment to take ridgeline effects on biodiversity into account. The area analyzed totaled approximately 1,970 km². Using imagery from 1990 and 2006, representing pre- and post-dam conditions, respectively, we mapped habitat suitability and least-cost animal migration routes.

Based on established habitat preferences for each species, we produced habitat suitability maps for European wildcat (Felis silvestris silvestris), European polecat (Mustela putorius) and lesser kestrel (Falco naumanni) habitats. European wildcats have strong preferences for Mediterranean scrubland but also utilize a host of other landscapes including oak woodlands, upland and riparian forests and cereal plantations. Based on existing literature, each land type was weighted depending on the degree of preference by European wildcats.

We applied an ecological corridor mapping method known as the “least-cost path” model. Least-cost paths are routes that have the lowest “cost” to traverse between two locations. “Cost” refers to the difficulty encountered by an animal in moving from one site to another, and is a function of time, distance, or other criteria defined by the user. Least-cost path analysis has been widely utilized in ecological corridor mapping research at various scales, including the regional scale of the Midwestern United States, state scale of Montana, and city scale in Beijing, China.

Result
Between 1990 and 2006, the overall area of suitable habitat for the European wildcat increased 16%, while habitat for European polecat and lesser kestrel decreased by 9% and 19% respectively. For all three species, the average habitat patch size decreased. European polecat experienced the most habitat fragmentation with a decrease in average patch size from about 270 to 100 hectares, an approximate 64% decrease compared with pre-dam conditions. The average patch size for European wildcat decreased from 110 hectares to 70 hectares, approximately 38% smaller than pre-dam conditions. The lesser kestrel experienced a similar shrinkage of around 37% in average patch size, changing from an average size of 550 to 350 hectares. Least-cost path analyses resulted in different spatial pattern distributions of ecological corridors for each species. The total area of ecological corridors increased for European wildcat, European polecat and lesser kestrel by 6.7%, 1.2%, and 7.7% respectively between the studied time periods making it difficult for them to move around.

Discussion
The drivers of farmland abandonment are difficult to assess, but through the late 20th century, the Alentejo region experienced “social desertification” in which young people moved to the cities, and large areas of farmland were abandoned. Farmland abandonment can lead to shrub encroachment, so continued desertification immediately prior to dam construction could have been responsible for the 16% increase seen in European wildcat habitat. The presence of Alqueva Reservoir, however, may be changing this dynamic, as irrigation water from the reservoir reaches more areas and results in intensification of agriculture. Since lesser kestrel rely heavily on dry land uses, such as cereal crops and fallow lands, the 19% decrease in lesser kestrel habitat may be due to conversion from non-irrigated to heavily irrigated crops from increased water availability.

Furthermore, fragmentation greatly increased for all species, which reflects the barrier between eco-regions posed Alqueva Reservoir. The European polecat experienced the greatest fragmentation, approximately 33% more than the other species studied. This could be a result of grassland and...
forest conversion to farmland from increased availability of irrigation water from Alqueva Reservoir

**Recommendations**

More current landuse data could greatly increase the overall usefulness of wildlife connectivity studies. EDIA or other relevant organizations could achieve this by performing unsupervised classifications on current Landsat imagery and confirming classifications through field investigations. More biological surveys in the Alentejo region would inform more accurate suitability parameters for specific wildlife habitat preferences.

Furthermore, as a more holistic approach is needed to analyze natural ecosystems and ensure connectivity between remaining habitats, a “circuit scape” model could supplement the least-cost path model. Circuit scape models consider a traveler’s preference in path selection. Although the inputs of a circuit scape model are similar to those needed for a least-cost path model, the outputs expand to include surface data describing the possibilities of travel.

**Conclusions**

In summary, a holistic management plan is needed to retain and enhance the existing vegetative cover and resultant wildlife habitats. This might include:

- Expansion and protection of key corridors which were not affected by creation of reservoirs between 1990 and 2006;
- Preservation and improvement of habitat quality to maximize network connection between large patches of vegetation;
- An increase in publically available resources outlining specific ecological and habitat needs of vulnerable species, especially for threatened carnivore species (polecat, otter, Iberian lynx etc.).
**Social Connectivity**

*Reaching for a Connection: Understanding and Reconnecting the Alqueva Dam Region*

**Tiffany Eng, Brandon Harrell**

**Problem Statement**

Potential impacts on social connectivity for residents living within the vicinity of the reservoir were not adequately assessed in prior documents. Preliminary studies have documented that prior to the construction of the Alqueva reservoir, those residing in the small towns along the Guadiana River used to maintain close relationships with friends and relatives living in nearby towns. Before 2002, families living in villages such as Campinho, Amieira, Estrela, Luz, and Sao Marcos do Campo could easily access other towns via walking, bike or car.

**Objectives**

The objectives of our study were to assess loss of social connectivity resulting from Alqueva Reservoir and to propose new project to restore connectivity and to promote the co-benefits of local economic development as well as social and environmental sustainability. To support these goals, we propose three principal efforts:

**New Bridge Connections**

- One lane footbridges could enhance linkages between certain towns on opposite sides of the lake that are experiencing high rates of social desertification. This resident connectivity project will focus on the eastern and western edges of the lake, including the towns of Aldeia da Luz, Campinho, Estrela, and Sao Marcos do Campo.

**Bike & Pedestrian Pathways**

- Creating a designated route around the Alqueva reservoir could increase local mobility while increasing and strengthening opportunities for tourism. These paved roads would connect towns and local tourist attractions - from the historic castles and museums to local marinas and golf courses.

**opportunities for local economic development through tourism**

- The bike and pedestrian pathways project will also focus on identifying new locations and opportunities for future tourism projects that can build off of the region’s unique landscape and rich cultural heritage.

- These projects intend to produce a variety of social, economic, and environmentally sustainable developments for the Alqueva region. Through the process of increasing financial investment and external attention to this area of the Alentejo, such endeavors have the potential to protect and maintain the region’s natural and historical resources, promote economic growth, and prevent against environmental degradation.

**Network Analysis**

The maps above illustrate how the two proposed bridges and network of regional pathways could improve accessibility for both local residents and tourists. We present a transportation analysis of the current Alqueva region with dark red areas indicating the areas that can be accessed via automobile in less than ten minutes from the nearest towns. In comparison, Figure 8 presents a transportation analysis that demonstrates a greater level of connectivity between villages after implementation of our proposed bridges #1, #2, as well as of the Guadiana River via various informal roads and bridges.

Before the completion of the Alqueva Dam, the Guadiana River was intersected by a series of small bridges. These bridges served local towns with economic, social, cultural, and even ecological purposes. After the inundation by Alqueva Reservoir, most of the historical routes were lost. The former bridges that once existed are also displayed in the map on left in dashed orange lines. With the loss of these former connecting routes, much of the easy accessibility between the villages has been lost.

**Methods**

**Measuring Social Connectivity**

For the villages of Luz, Estrela, Povoa de Sao Miguel, Telheiro, and the town of Alqueva, residents tended to maintain the least positive opinions about the Alqueva Dam Project’s ability to improve their daily lives. Before the construction of the dam, villagers used to take trails or commute by small private vehicles to visit the opposite sides
attractions, as well as their ability to maintain a low average hill grade that would be feasible for cycling.

Result

New Bridges

We proposed new bridges to improve connectivity between Luz and Campinho, and Luz and Estrela.

Bike/Pedestrian Connectivity

This second project would increase local mobility between villages and would expand opportunities for tourism by creating bike and pedestrian pathways around the lake and across the midsection via the footbridges. The designated route would be paved to promote cycling activities but could also permit walking and local auto commutes.

Opportunities for Local Tourism

The two footbridges would also serve as a central segment of the bike and pedestrian paths so that accessibility would be enhanced for both local residents and tourists alike. While many of the proposed routes follow along rural dirt roads, some of the paths near the southwest region of the lake occasionally merge with the main highways. With the exception of the road between Amieira and Sao Marcos do Campo and the road leading up to Monsaraz, the following trails are all very accessible via bicycles and often maintain a pleasant hill grade of between 1-3 percent.

Identification of Potential New Bridge Locations

In order to restore lost connections between the towns of Luz, Estrela and Sao Marcos do Campo, we examined various possibilities for paving roads and constructing small bridges across previously connected locations. We accounted for whether or not a potential site was near the towns that were unhappy with their post-dam impacts, whether or not the divide was short enough in distance to construct a bridge, opportunities for tourism on either side of the lake, and whether or not a location could enhance the bike and pedestrian pathways.

Identification of New Bicycle/Pedestrian Routes

We proposed new pedestrian and bike paths, were chosen based on their proximity to towns and local social desertification.

When crafting solutions for increasing local economic development via tourism however, it is important to note that such endeavors should be planned and developed carefully with the region in mind. Steps that could ensure social, economic, and environmental sustainability include: working with local residents to create plans that meet their needs while preserving local culture, developing cross sector partnerships to secure longterm funding and investments, creating plans that respect and preserve local habitats, and advancing tourism models that maintain pro-poor and pro-environmental ideologies.
**Problem Statement**

While rich in natural and cultural resources, Alentejo's tourism industry is nascent. There is a huge opportunity to create stronger connections between environmental, cultural and wine tourism industries that can tap into the full potential of the region.

The Alentejo wine industry and wine tourism is on a growth trajectory. With traditionally sustainable wine growing practices, the region has a strong basis for 'eco' credentials. As the industry continues to grow, this will increase the demand for resources, importantly water for viticulture, and increasing risk of environmental impacts. Alentejo wines are relatively unknown internationally. How do the region's wines compare to other leading regions? What can be done to expand their presence in the global market?

We chose three topics, shown in the diagram below, to address these questions and analyze the environmental and economic impact and opportunity of Alqueva on Alentejo's wine industry.

---

**Alentejo Wine Tourism Corridor**

Ecological Wine Tourism Corridor to improve the tourism in Alentejo region

-Rheker A Alex, Fern Unnatoriumwaranggoon, Emilie Wolfson

---

**Alentejo Vineyards**

The Alentejo vineyard area spans almost 22,000 ha. It is an up and coming region for wine production. For the past few years the region has been producing more than 100 million liters of wine annually, and the industry is quickly growing. As of 2014, Alentejo represents 23.5% of the overall Portuguese certified wine production.

Like many types of agricultural production, grape growing and wine making consume a substantial amount of water. At the current production level, viticulture in the region uses over 48 million m³ of water for irrigation alone. Aside from viticulture, more water is needed during the production process. According to the Association of Winegrowers of Alentejo, it takes around 4 liters of water to produce 1 liter of wine during the bottling process. Given that water is hugely important for wine production, the presence of Alqueva Reservoir has potential implications for the industry. One vineyard we visited uses water from the Alqueva and their production has expanded since. But many vineyards are supplied by their own reservoirs.

Wine making uses less water than other “wet” crops grown in Alentejo such as corn and tomatoes. Alentejo is also particularly productive for grape growing, with the average yield higher than that of other areas of Portugal. Yet, as a crop, grapes occupy only about 6% of agricultural land, while water intensive crop like corn occupies around 18% (EDIA, 2013).

While there is a high level of awareness of environmental sustainability in the winemaking industry in Alentejo, in practice, record is mixed. Through anecdotal evidence, we gathered that the region’s wine producers use Integrated Production and Integrated Pest Management. However, the Wine Tourism Office confirmed to us that there is still a substantial use of pesticides. Our research revealed that some vineyards use life cycle analysis for the wine production evaluation and carbon footprint assessment. Some vineyards employ water, energy and waste audits. However, these
Applicable Lessons from Global Wine Regions

<table>
<thead>
<tr>
<th>Sonoma, California</th>
<th>Tuscany, Italy</th>
<th>Alentejo, Portugal</th>
<th>Languedoc-Roussillon, France</th>
<th>Mendoza, Argentina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediterranean</td>
<td>Mediterranean</td>
<td>Mediterranean</td>
<td>Mediterranean</td>
<td>Continental</td>
</tr>
<tr>
<td>FACT: CLIMATE</td>
<td>FACT: CLIMATE</td>
<td>FACT: CLIMATE</td>
<td>FACT: CLIMATE</td>
<td>FACT: CLIMATE</td>
</tr>
<tr>
<td>FACT: DISTANCE</td>
<td>FACT: DISTANCE</td>
<td>FACT: DISTANCE</td>
<td>FACT: DISTANCE</td>
<td>FACT: DISTANCE</td>
</tr>
<tr>
<td>FACT: AVERAGE</td>
<td>FACT: AVERAGE</td>
<td>FACT: AVERAGE</td>
<td>FACT: AVERAGE</td>
<td>FACT: AVERAGE</td>
</tr>
<tr>
<td>FACT: TOURIST BUDGET</td>
<td>FACT: TOURIST BUDGET</td>
<td>FACT: TOURIST BUDGET</td>
<td>FACT: TOURIST BUDGET</td>
<td>FACT: TOURIST BUDGET</td>
</tr>
<tr>
<td>FACT: ECONOMIC APPEAL</td>
<td>FACT: ECONOMIC APPEAL</td>
<td>FACT: ECONOMIC APPEAL</td>
<td>FACT: ECONOMIC APPEAL</td>
<td>FACT: ECONOMIC APPEAL</td>
</tr>
</tbody>
</table>

Rossillion, France; and Mendoza, Argentina. For Sonoma, California, US; Tuscany, Italy; Languedoc-Roussillon, France; and Mendoza, Argentina. For the Alentejo Regional Tourism Office and Vihnos portuguese.

Global Comparison

How do global wine tourism regions with similar profiles to Alentejo compare in environmental, economic, and tourism and marketing factors? What lessons can Alentejo learn from similar regions? We compared four other wine regions with similar environmental features; most share a Mediterranean climate and a wide variety of soil types and grape varietals. These wine regions are Sonoma, California, US; Tuscany, Italy; Languedoc-Roussillon, France; and Mendoza, Argentina. For various reasons these regions are about 10 to 20 years ahead of where Alentejo is now in terms of global recognition for quality price ratio and wine tourism destination.

Interactive Map and Website

As an output for this exercise, we offer an interactive map integrated in an online portal to be used by authorities, visitors and potential business stakeholders for development of Alentejo wine corridor. The interpretive map provides an opportunity for a multi-activity tourist itinerary that incorporates wine, culture, history, and ecology. Instead of creating a stand alone platform, we wanted to be sure to add to the existing strategies and features currently within the Alentejo Regional office, which has several tourism strategies as well as a website offered in multiple languages. Their website has suggestions on where to sleep, where to eat and what to do and includes numerous photos. Furthermore, the website currently advertises different itineraries for backpackers, active seniors, couples and families with the opportunity to print and share routes.

Recommenndations

Alentejo is rich is resources—history, culture, ecology, wine, and gastronomy. Tourism existed before Alqueva, but the recent change has brought future opportunities for recreation. This is both a challenge and opportunity for the region. Based on our research and analysis, we offer recommendations for strengthening the future of wine tourism in Alentejo.

For the Alentejo Regional Tourism Office and Vihnos de Alentejo

- Develop innovative and connected “wine clusters” that network Alentejo wine and tourism agents to achieve economies of scale and secure a more competitive position in the wine world.
- Emphasize local food, culture, and traditions as “tie-ins” to the wine tourism experience. Alentejo has a long history with wine: oldest appellation designation in the world, a large number of number of grape varietals, and set within the context of the compelling montado landscape, the source of cork that is essential to fine wine (from the cork oak, Quercus suber).
- For actors in the Alentejo wine industry
  - Irrigate sparingly to develop a reputation for quality. Starved vines make for stronger wines.
  - Develop incentives for more robust, and sustainable practices for wine growers.
- For potential tourists
  - Spend at least a couple of days in Alentejo! It will be among the highlights of your time in Western Europe.

More information: https://sites.google.com/site/l204winetourism
CONCLUSIONS

The ecological and social integrity of the Alentejo region has endured a major transformation due to the construction and subsequent impacts of the Alqueva Multi-purpose Project. EDIA has done commendable job of maintaining a strong database and network on certain topics, such as the distribution of irrigation water and monitoring of some ecological resources upstream of the dam.

However, our analysis of the original (1996) environmental impact assessment and the updated (2005) environmental management programme, augmented by literature review and our field observations and expert interviews, identified several topic areas that were inadequately addressed or otherwise require further evaluation. These include downstream effects on sediment transport, increase in mosquitos along the shore of the reservoir, stream cleaning and repprofiling to improve drainage of irrigated lands, loss of social connectivity due to loss of former river crossings, prevention of risk from potential dam failures, climate change adaptation, and fire risk management. We recommend that these topics be addressed in sufficient detail in a revised Environmental Management Programme.


