ALQUEVA

Changing Ecologies of the Montado Landscape
Alentejo, Portugal

2001

2015

Source : University of Evora Masters of architecture Alqueva report
Map Data : Google, Digital Globe, Google Earth Pro - 2015

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Map Data : Google, Digital Globe, Google Earth Pro - 2015

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Cover Image
Alqueva Reservoir - Map Data : Google, Digital Globe, Google Earth Pro - 2015

May 2015

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.

ALQUEVA | LA-205 Spring 2015

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.

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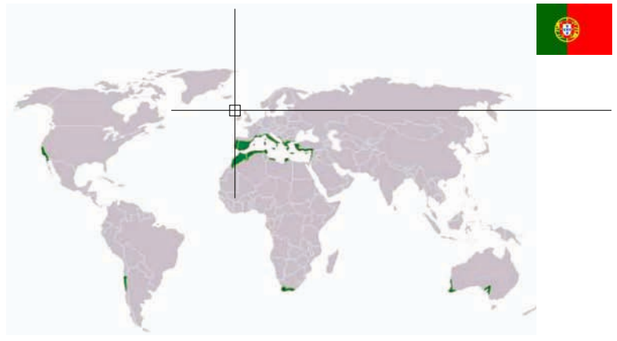
1.1

ALENTEJO, PORTUGAL

The Montado Landscape

The Alentejo, the land beyond the Tagus, comprises an area of more than 26,000km², almost 33% of continental Porrtuguese territory in southern Portugal. The area is defined by the river Tagus to the north, the Algarve range to the south, Spain to the east and the Atlantic Ocean to the west.

With its Mediterranean climate, characterized by long and dry summers and more than 3,000 hours of sunshine annually, the region supports the distinctive Montado Landscape, undulating landscapes of oak savannah, as well as olive groves and vineyards. The region is sparsely populated and essentially agricultural, with a subsoil rich in mineral resources and groundwater.



Mediterranean Climatic Region|Around the world
source : modified graphic
Maps : outline-world-map 2009

The Guadiana River

The Guadiana River, with a total length of approximately 810km, drains approximately

Location of Alentejo Region, Portugal
source : "LocalRegiaoAlentejo" by Reiartur - Licensed under CC BY 2.5

67,840km². 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 73 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.

The Montado Landscape
source: Photo by Mia It- Licensed under CC BY 2.0

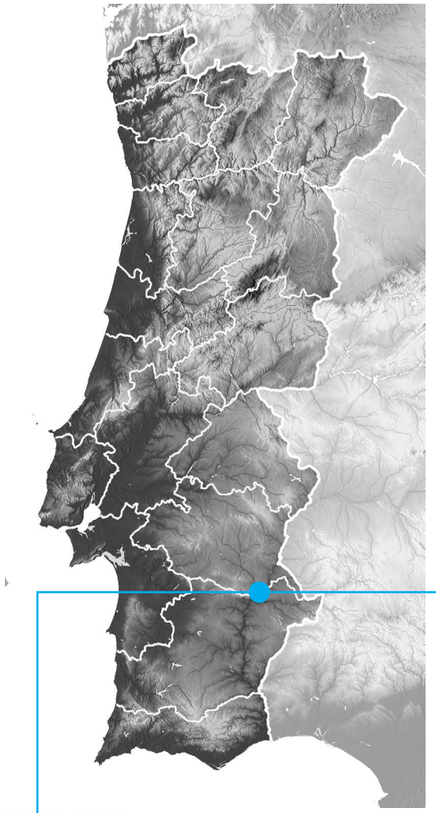
1.2

PROJECT ALQUEVA

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.

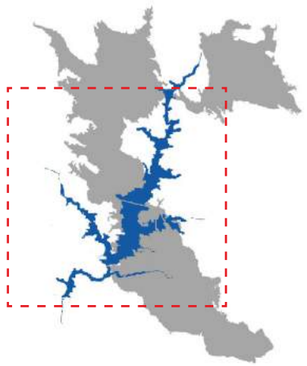
Alqueva Dam, Alentejo
source : Photo by Frutaslegumesdeflores - Licensed under CC BY 2.5



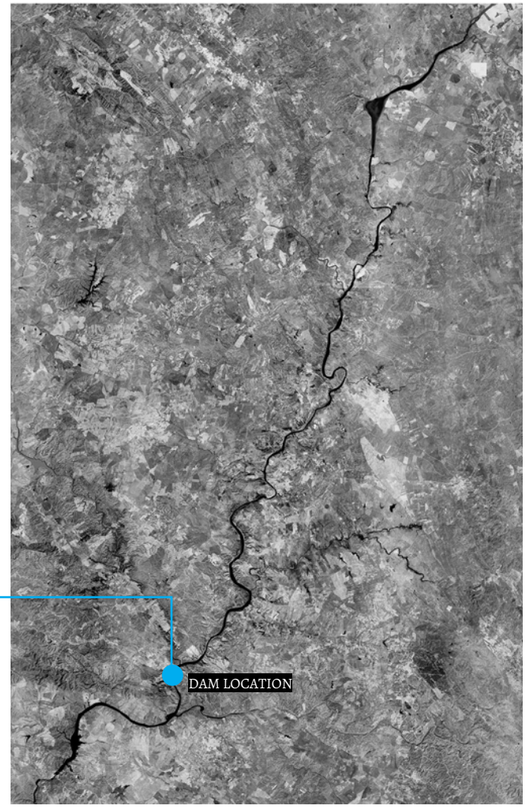
FACTS ALQUEVA

source : Class work, LA205

Surface Area : 250 sq km
Shoreline : >1100 km
Maximum Fluctuation : 13 m
Average Fluctuation : 5 m
Highest Water Elevation : 152 m



Comparison of Alqueva Reservoir and San Francisco Bay
source : Class work, LA205



Shifting Boundaries : Alqueva, Alentejo
source : Class work, LA205
Map Data : Google, Digital Globe, Google Earth Pro - 2015

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.

2.0

FIELD VISITS/WORKSHOP

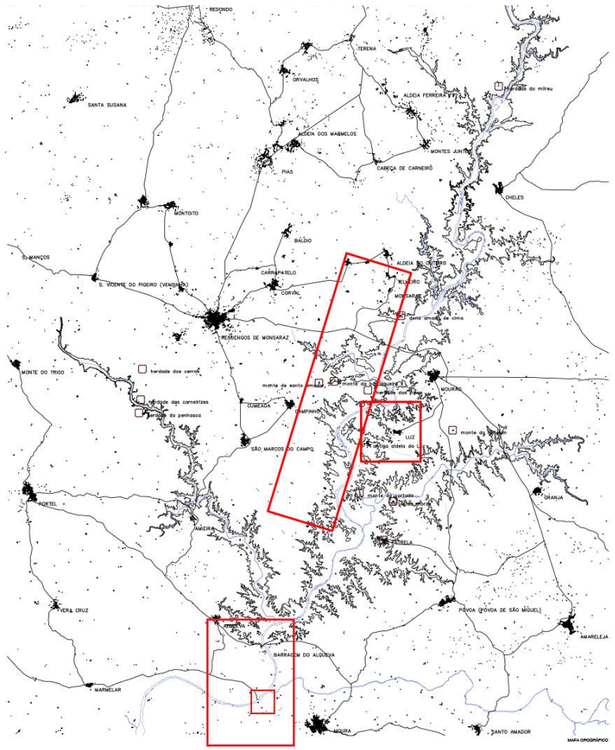
Overview

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 eo Alqueva Sa (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 field work 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.

Some of the sites visited in and around Alqueva
source : Class work, LA205



UC Berkeley Team with Evora University professors at the Dam

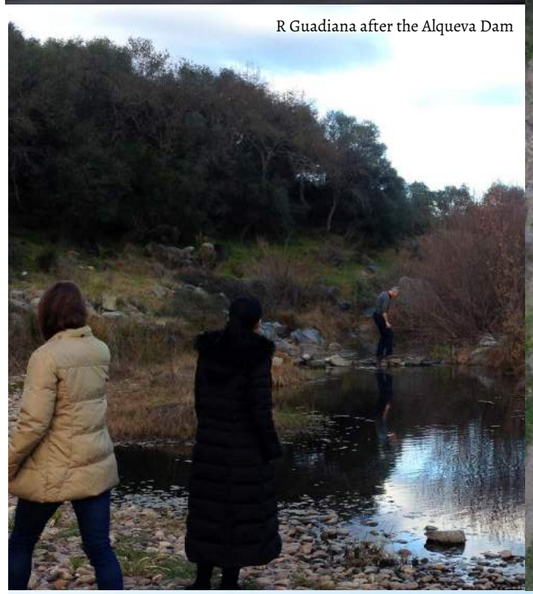
The field visits included

- 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 insfrastructure strategies for Alqueva.
-visit to Alqueva irrigation pumping control stations
-interview with Alentejo tourism develpment 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.

Ground truthing

Detour-R Guadiana

Disappearing roads in Alqueva Reservoir



R Guadiana after the Alqueva Dam

Old Fisherman R. Guadiana

Viewing the perennial channels for R. Guadiana
source,all images : students-LA205

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3.0

STUDY REPORTS

We identified five issues based on our literature review, field reconnaissance, and interveiws 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 recommendstrategies 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.

Conceptual Diagram-Scale and scope of various study groups
source : Class work, LA205
Map Data : Google, Digital Globe, Google Earth Pro - 2015

River Guadiana downstream of Alqueva Dam
source : students-LA205

Montado landscape transformed by irrigation from Alqueva Dam
source: students-LA205

3.1

Environmental Impact Analysis

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

Problem Statement

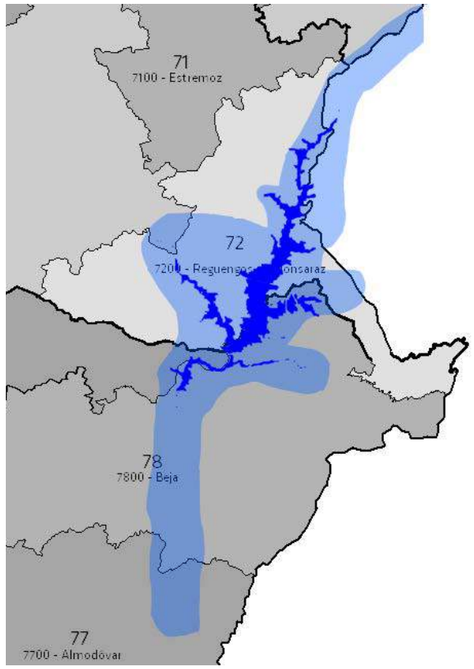
The objective of our study was to compare the conclusions, recommendations, and requirements of 1996 (pre-construction) EMP to the updated 2005 (post-construction) EMP. We reviewed documents to assess how well their conclusions, requirements and management recommendations addressed likely impacts identified 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

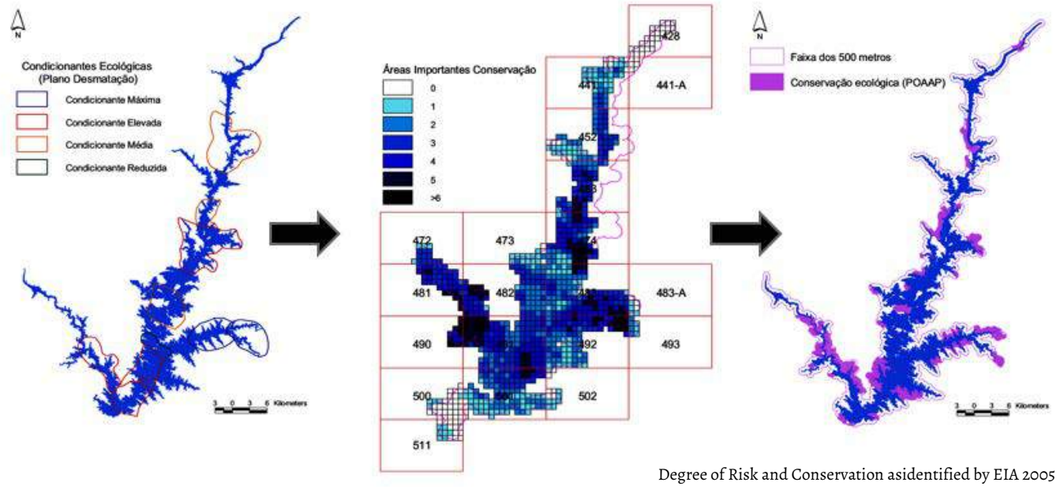
Our analysis showed that the 2005 EMP had more specific management recommendations and objectives. For example, the 1996 EMP noted that the most severe negative impact of the reservoir involves the relocation of a factory and the village of Aldeia da Luz, a town of approximately 400 people. In comparison,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



Zones of Environmental Impact as assessed by EDIA
source : modified-SEIA

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



Degree of Risk and Conservation asidentified by EIA 2005
source : EDIA

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:

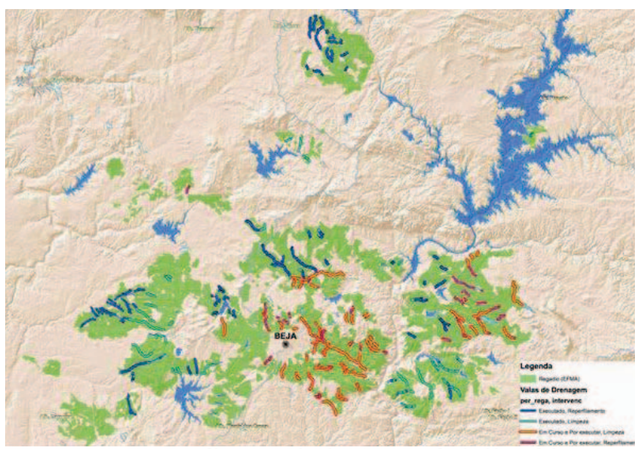
1. Stream Reprofiling
Over 125km of stream have been either 'reprofiled' or 'cleaned' with the primary objective to drain water off of agricultural fields more efficiently. We recommend that further research be undertaken to determine impacts to affected streams and to assess longterm changes in stream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

Result Matrix developed by Environmental Impact Analysis of Alqueva Dam

source : class work - LA205

General			
	Known Impact	1996 EMP	2005 EMP
Objectives	Not Applicable	• Provide an independent view on environmental management planning for the most complex water and environmental development project in Europe. • Assessment of the conclusions of past studies • Identification of gaps in knowledge • Recommendations for implementation of environmental measures	• Describe and evaluate relevant environmental indicators in the project area. • Identify and assess the main environmental impacts as a result of the project. • Define mitigation, compensation, and minimization measures in order to reduce negative impacts and maximize positive. • Provide environmental information to support decisions in selecting design alternatives. • Ensure the protection of sensitive and vulnerable areas of ecological value. • Assess the potential barrier/trap effect of dams, reservoirs and network channels in the project area. • Propose appropriate mitigation measures for the design phase and ensure integration of mitigation measures during the implementation phase.
Surface and Ground Water Quality			
	Known Impact	1996 EMP	2005 EMP
Inundated /Reservoir Area	Increased water pollution due to increased irrigation runoff. Salinization of disconnected floodplains.	Guadiana River was already polluted because of upstream inputs. • Predicted water quality in the reservoirs will be equal or lesser than A.3 class. Advanced treatment is required for potable use. Use for recreation or animal watering will be threatened by cianoficea blooms. • Nutrient control must be carried out from the beginning to prevent advanced cutrophication levels.	Prevent the degradation of water quality through the decontamination of land and waste removal including: • Decommissioning and decontamination the Portucel plant, and surrounding areas • Decontamination of agricultural and livestock facilities, and surrounding areas • Removal of existing dumps in inundation area • Cleaning and decontamination when dismantling and demolishing the old village of Luz
Irrigated Area		• The main area of concern is the assumed increase in the use of agrichemicals as farming intensity increases. • The salinity of groundwater will increase as groundwater dissolves a large amount of evaporative salts. • Salinity would also increase due to agricultural inputs. • Recommendation to monitor water quality.	Recommendation for integrated monitoring that considers: • Salt dynamics in soil and aquifer • Soil quality and groundwater Avoid increasing the salt content of the soil and aquifers by promoting actions for structuring and washing.
Downstream		Water quality in the river downstream Pedrogao dam will depend strongly on the number dams and the operational conditions of the two main reservoirs. It was foreseen that water quality will improve from Pedrogao to Pula do Lobo/mouth of Chanca river. But for some parameters (DO, chlorophyl-a) water quality may become worse downstream	Recommendation for monitoring downstream surface water quality.
Cultural			
	Known Impact	1996 EMP	2005 EMP
Inundated/Reservoir Area	Inundation of culturally important sites.	Recommendations: • Conduct a detailed survey of the irrigation area • Excavation of sites in the reservoir areas according to their scientific significance and extent of possible damage	Recommendations: • Ensure the development of cultural heritage monitoring plans for the project area. • Assess the effectiveness of impact minimization measures implemented to protect and safeguard the archaeological remains in the project area. • Investigate the need for implementing additional measures for registration and protection of cultural heritage in the project areas.
Regional	Not Applicable	Potential positive impacts include an increase of knowledge of archaeological, historical, and ethnic of the area as a result of future academic and tourist interest.	Recommendations: • Identify and characterize cultural heritage in the project area. • Promote and develop cultural heritage enhancement projects in the project area. • Ensure the development of the cultural heritage conservation projects. • Ensure the implementation of measures that protect cultural heritage during the project construction. • Develop cultural heritage enhancement projects in the project area.
Socio-Economic			
General	Not Applicable	Impacts are expected to positively affect the future economic development of the region. The project is considered as an engine of growth for the region.	• Compensate for negative social impacts, including inundation of land and buildings. • Develop studies and projects for restoring infrastructure affected by the project. • Promote "Alqueva Space" as a catalyst for economic activity, and a basis of local and regional employment.
Inundated/ Reservoir Area	Resettlement, compensation of displaced communities.	The most severe negative impact involves relocation of about 400 people and a factory. There are also more widespread fiscal and monetary negative impacts.	Recommendations and specific objectives: • Ensure 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. • Ensure the construction of urban space in the new village of Luz. • Ensure the support necessary to move the population to the new village of Luz. • Minimize the potential psychosocial impacts resulting from the relocation of the village of Luz. • Compensate for the loss of jobs due to the closure of the Portucel plant. • Ensure the replacement of electricity, telecommunications, sanitation, and water supply infrastructure within the inundation area.
Regional	Case Study: Irrigated areas in the Tagus basin (Spain) have tempered rural depopulation.	Goal: To create "an investment-conducive environment" Recommendations: • Vocational training for personnel. • Create "advice agencies" for future entrepreneurs and existing businesses • Market and publicize the area to attract investors • Fiscal incentives to lure investments to area	Recommendations: • Restore national, municipal and local roads and facilities affected by dams, reservoirs and irrigated areas that are a result of the project. • Promote and support urban and environmental development of the riverside villages. • Promote and develop the necessary tools to boost the business community in the project area.
Environmental			
	Known Impact	1996 EMP	2005 EMP
Fish passage	The single most negative effect of dams is disruption of fish migration.	• Provide fish passed in order to minimize negative impacts.	Recommendations: • Promote the implementation of fish passages • Develop technical studies of mitigation measures proposed in order to evaluate the potential barrier effect/trap of the irrigation network channels.
Sediment	Sediment retention reduces the storage capacity of reservoirs. Reduction in nutrient load downstream.	Recommendations: • Long-term monitoring of sediment transport in the downstream estuary; • Periodic monitoring of sediment transport in the river between Alqueva and the estuary; • Detailed, periodic bathymetric surveys of the estuary and the surrounding waters.	• Evaluate sedimentation in project reservoirs through regular bathymetric surveys.

Environmental			
	Known Impact	1996 EMP	2005 EMP
Vegetation	Modification in riparian habitat along reservoir banks. Inundation of vegetation. Modification and disruption gene flow of some species.	Vegetation communities listed in NATURA 2000 as well as endemic, rare, and threatened species and plants in danger of extinction will be affected by the project.	• Promote the development of native vegetation on the river and reservoir banks
Habitat/Species Conservation			
General	Reduction in biodiversity. Disconnection in habitat corridors leading to low species richness.	The project will cause a loss of biodiversity, and elimination of plant and animal species, a substitution of existing species and a reduction in genetic variability.	Recommendations: • Promote sustainable land use to promote nature conservation areas • Develop studies and projects for ecological restoration • Promote the creation of ecological corridors
Inundated/ Reservoir Area	Habitat changes (aquatic and terrestrial). Loss of post-spawn adults as a result of disconnected aquatic system.	Modification of habitats in the area of the future reservoirs is expected as a result of the project. Recommendations: • Arrangements to enable fish migration are necessary. • Strengthen islands as a refuge spaces, feeding and breeding habitat	• Compensate for the loss of habitats including riparian corridors and Mediterranean scrubland as a result of inundation.
Irrigated Area	Habitat reduction as a result of agricultural conversion.	Alteration of the living conditions in the irrigation zone is an expected impact of the project. 50% of species in the irrigation area will be affected by the project and as a result there are substantial opportunities for mitigation by avoiding irrigation in sensitive areas. A detailed mapping of the flora and fauna of the irrigation areas has to be performed to select areas of high ecological value that must not be included in the irrigation scheme.	•Develop habitat management methodologies with simultaneous goals of natural heritage and ecological conservation.
Regional	Not Applicable	Recommendations • Protection of sensitive areas in and around the irrigation zone and reinstallation of rare plant species. • Creation of ecological corridors from the corn steppe Montforte/ Alter do Chao to Castro Verde, and from the Ardilla River to the Sado River. • Periodic (every two years) monitoring of the above areas. This effort should include mapping of wildlife and drawing up proposals for improvement of the ecological situation.	Promote the Montado landscape, and the sustainable use of Holm oak.
Agricultural			
	Known Impact	1996 EMP	2005 EMP
General	Higher yields, and more diverse crops.	Main purpose of project: a primary irrigation network extending ~680km, with some intermediate dams; Secondary and tertiary irrigation networks extending ~1620km. Provides water to Benefits 120,000 ha of agricultural land.	Recommendations: • Promote appropriate farming practices, including the application of fertilizers and pesticides and irrigation techniques. • Encourage scientific and technical information in the field of irrigated crops.



Stream Reprofiling Across the Alentejo region after building of Alqueva Dam

source : Barbosa

Conclusions

Through review of the environmental documents and of relevant published literature, we have identified topic areas for which the original (1996) and updated (2005) environmental management programmes that lack clarity or require further evaluation. These include issues related to downstream changes in sediment transport, increase in mosquitos 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 priroities, 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

3.2

Riparian Buffers

Analysis and restoration strategy for the buffer zone along the Alqueva reservoir edges

-Pablo J Alfaro, Valerie Francella, 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.

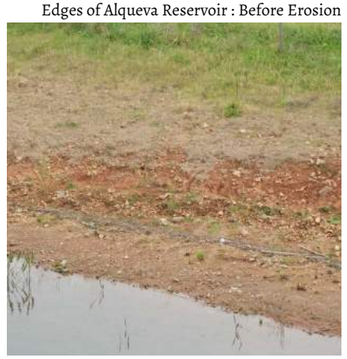
The seasonal rise and fall of reservoir levels was predicted by Relatório Interniveis (Nemus et al. 2007) to create wetland areas in flat terrain, that would attract grazing animals. However, most of the reservoir margin is flanked by barren, devegetated zone corresponding to the zone of water fluctuations. 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) model (citation). The attempt is to overlay zones for human access and zones for environmental restoration with the final output of soil erosion map

Edges of Alqueva Reservoir : Before Erosion



Edges of Alqueva Reservoir : After Erosion

source : students-LA 205

Calculating Erosion Using RUSLE

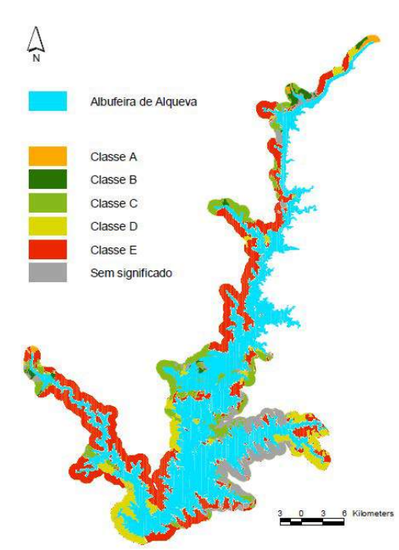
Locations of greatest susceptibility to erosion were identified using the Revised Universal Soil Loss Equation (RUSLE) (Marine Geodesy, Radke et al).

A=RKLSCP

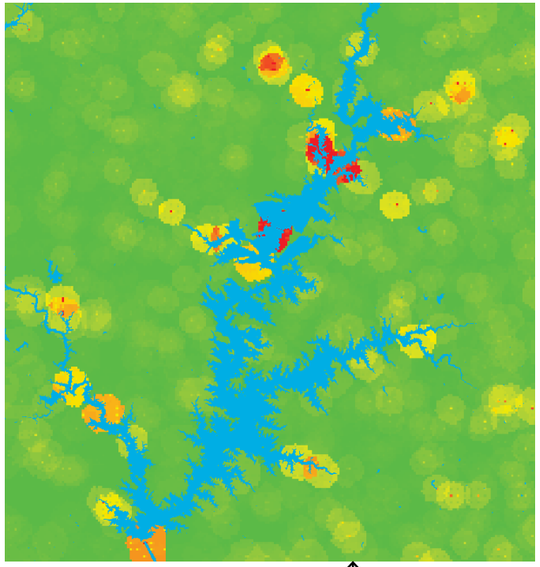
Where A = soil loss

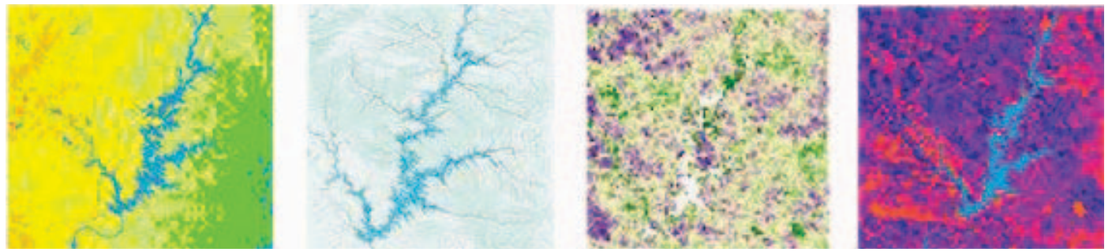
R = Rainfall erosivity index
K = Soil erodibility index
SL = Hillslope length and gradient
C = Cropping management factor
P = Erosion control Practices

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.



source : modified-EDIA





R Factor

LS Factor

K Factor

C Factor

Soil Erosion Susceptibility Analysis using RUSLE model

source : class work - LA 2050

Results

Overland soil erosion and shoreline erosion within the zone of fluctuating reservoir levels around the Alqueva reservoir can lead to delivery of sediment into the reservoir and degrade water quality. Along the total of 1100 km long shoreline, 22% (specifically near Monsaraz) was found to be highly erodible with slope and terrain contributing as the major factor. Although erosion is clearly occurring along the newly formed edge of the Alqueva reservoir, it is but a component of a larger issue concerning the lack of a riparian buffer around the reservoir. This is an issue both on EDIA property, and on the mostly agricultural lands adjacent to the reservoir.

Erosion and Sedimentation Control

Controlling erosion and sedimentation along the 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-

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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 armoring, 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.

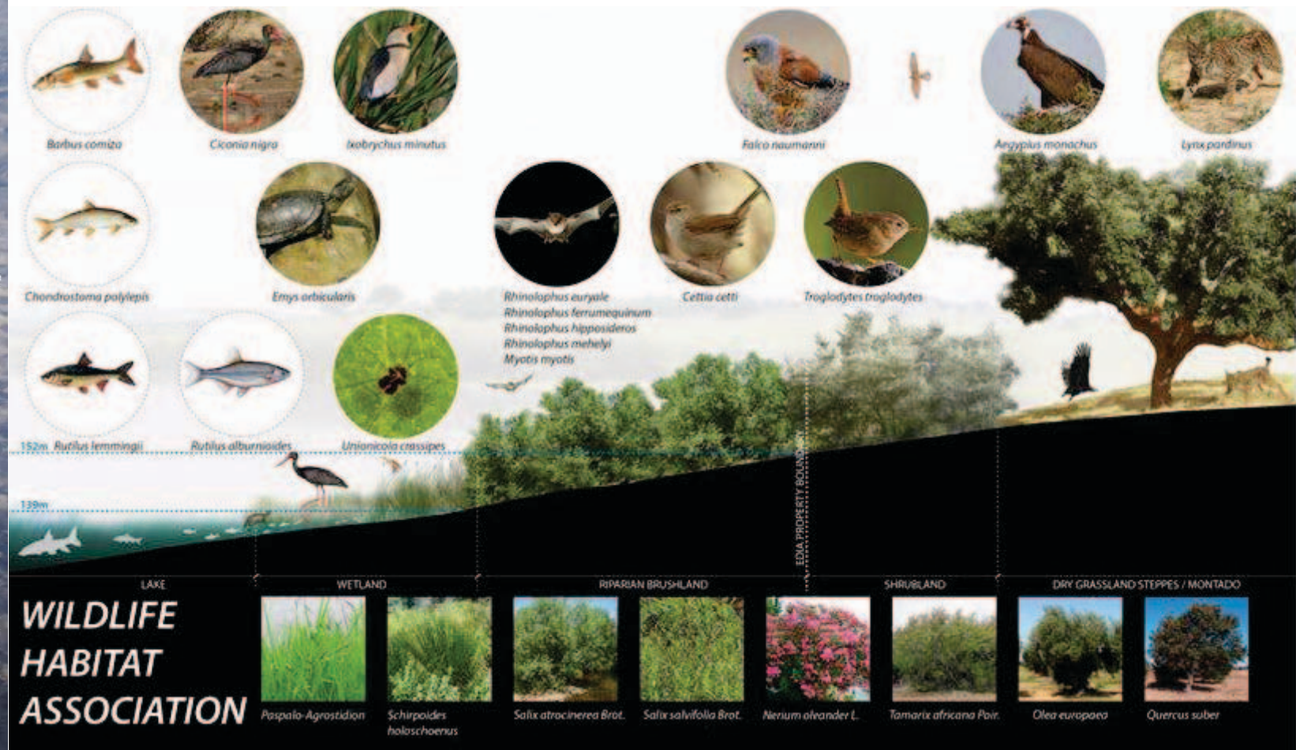
However, successfully establishing riparian vegetation within the zone of fluctuating reservoir levels may be challenging. We recommend using biotechnical approaches that yield both bank stabilization and wildlife habitats. Given the uncertainty about how different methods will perform along the margins 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.

Coconut Coir Roll

Joint Planting

Brush Mattress

source : class work - LA 2050



3.3

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

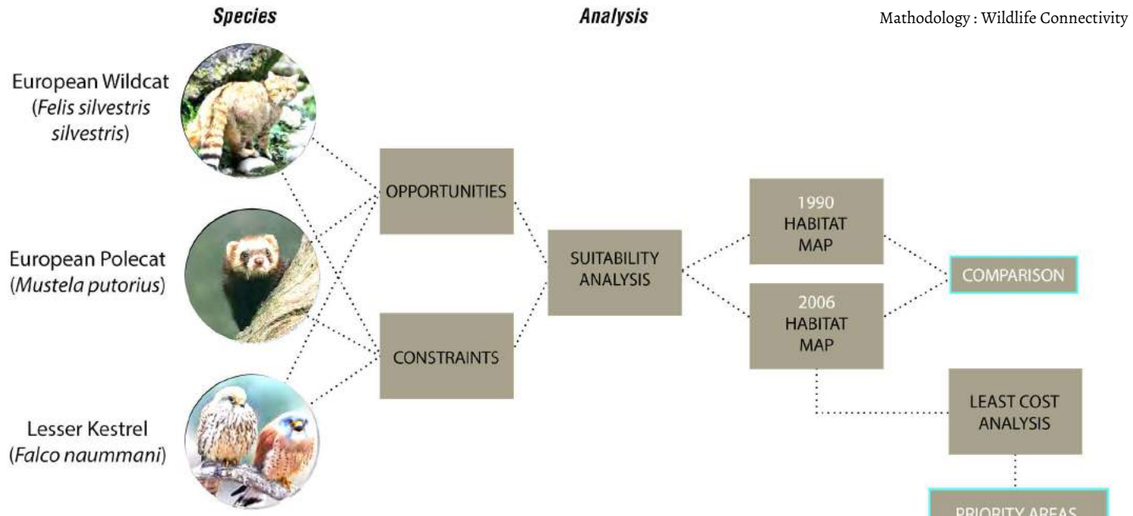
We analyzed the catchment area draining directing into Alqueva reservoir, and included an additional 3 km wide strip around the catchment to take ridgeline effects on biodiversity into account. The area analyzed totaled approximately 1,970 km2. Using imagery from 1990 and 2006, representing pre- and 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 scrub land 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

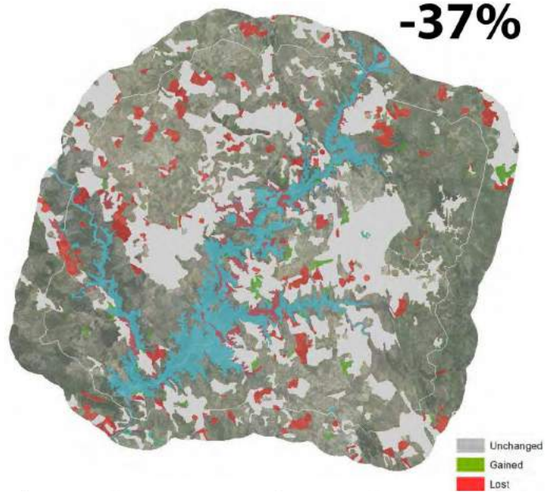
The drivers of farmland abandonment are difficult to assess, but through the late 20th century, the Alentejo region experienced "social desertification" in which young people moved to the cities, and large areas of farmland were abandoned

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

Lesser Kestrel

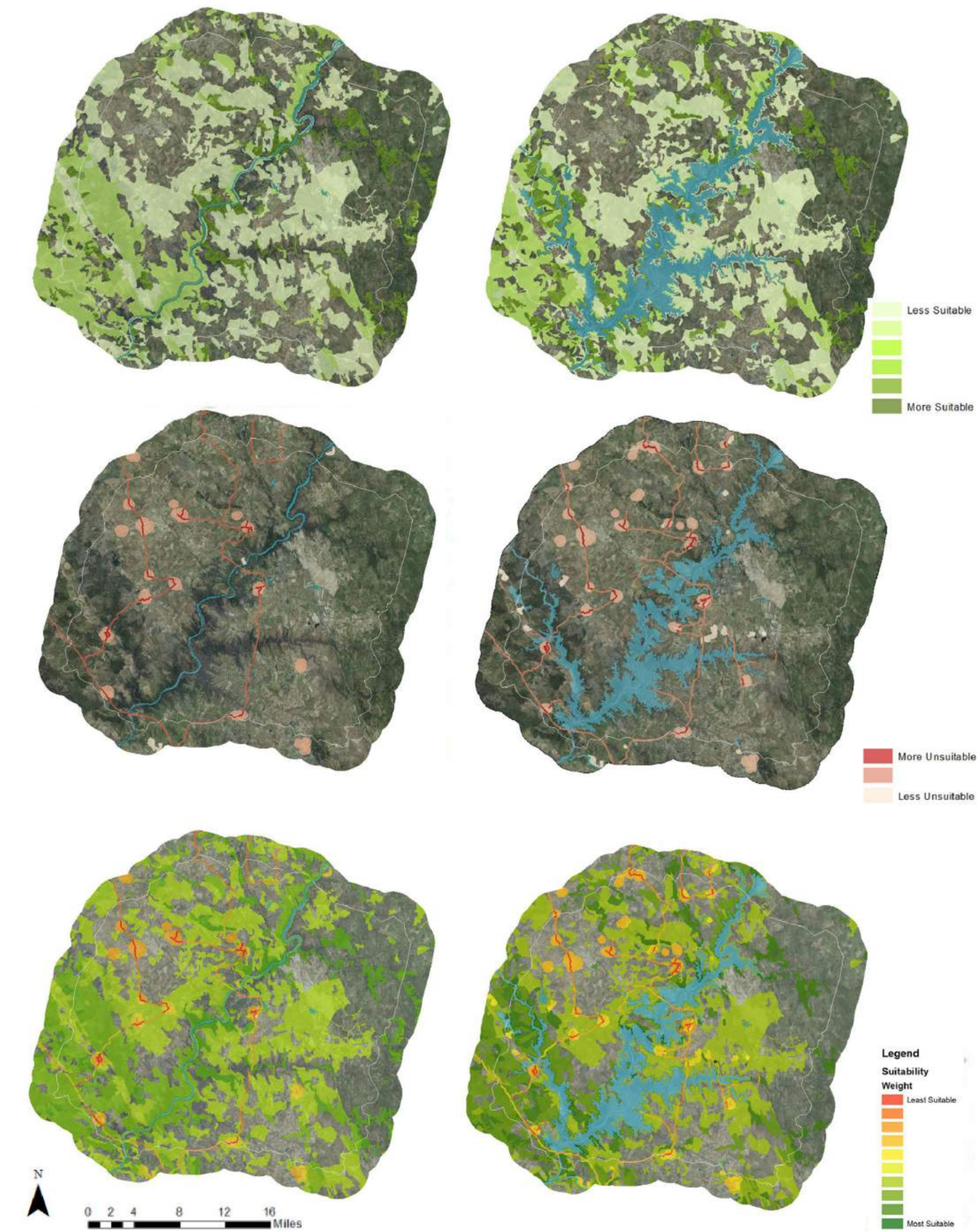
-37%



Assessment for Habitat Cover change
source : class work - LA 2050

Suitability Analysis and Least Cost Factor Analysis for 3 Species identified for wildlife connectivity

source : class work - LA 2050



Fragmented Habitat Corridors due to formation of Alqueva Resrvoir

source : Photo by "Mauricio Abreu"

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.).

Proposed Vegetation for an prototype corridor

source : class work - LA 2050

3.4

Social Connectivity

Reaching for a Connection: Understanding and Reconnecting the Alqueva Dam Region
-Tiffany Eng, Brandon Harrell

Problem Statement

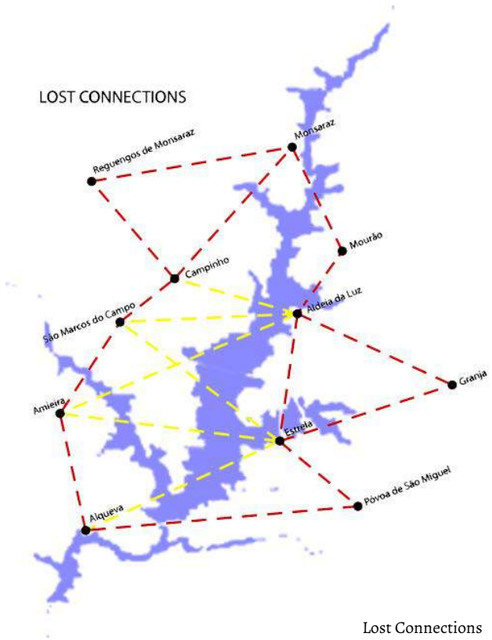
Potential impacts on social connectivity for residents living within the vicinity of the reservoir were not adequately assessed in prior documents. Preliminary studies have documented that prior to the construction of the Alqueva reservoir, those residing in the small towns along the Guadiana River used 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

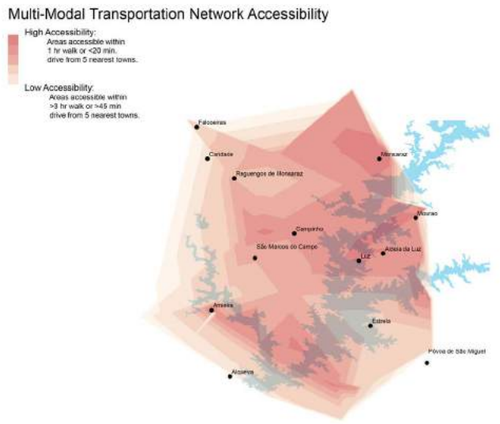
The objectives of our study were to assess loss of social connectivity resulting from Alqueva Reservoir and to propos new project to restore connectivity and to promote the co-benefits of local economic development as well as social and environmental sustainability. To support these goals, we propose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

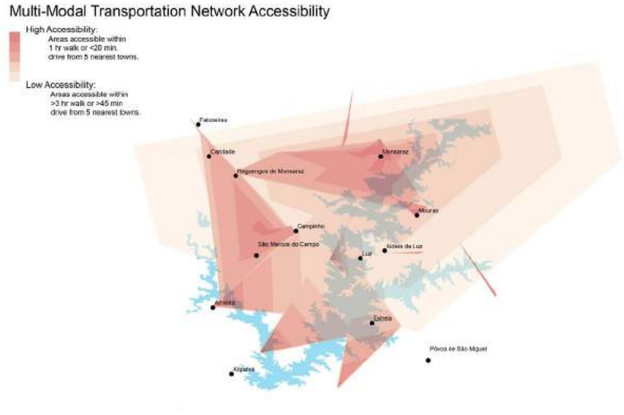
New Bridge Connections-One lane footbridges could enhance linkages between certain towns on opposite sides of the lake that are experiencing high rates of social desertification. This resident connectivity project will focus on the eastern and western edges of the lake, including the towns of Aldeia 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.



Lost Connections
source : class work-LA 205





Analysis representing ease of accessibility before and after the construction of dam
source : class work-LA 205

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.

Methods

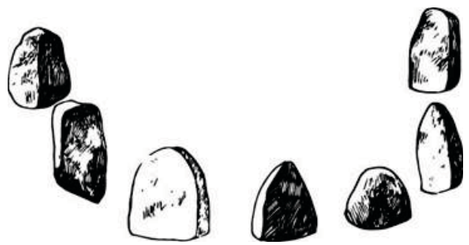
Measuring Social Connectivity

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 dams, villagers used to take trails or commute by small private vehicles to visit the opposite sides 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.

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 presented a transportation analysis of the current Alqueva region with dark red areas indicting 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



Potential Historic sites across social circuits
source : sketches by Tiffany Eng-LA 205

well as the bicycle and pedestrian paths.well as the bicycle and pedestrian paths.

Identificaton 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 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.

Examples for potential bridge connections to restore connectivity
source : class work-LA 205
Map Data : Google, Digital Globe, Google Earth Pro - 2015

Conclusion

While the Multipurpose Alqueva Project did achieve a number of important infrastructure improvements such as paved roads to increase villages' external accessibility, it is evident that the dam project could have done much more to improve local mobility and serve as an "effective factor of development". As many local residents continue to long for certain aspects of their lives pre-Alqueva project, it is crucial that constructive steps are taken to achieve greater social and economic opportunities for those living in and around this area, in order to preserve the Alqueva region's important cultural heritage and economic resources while preventing against 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.

View of Village Luz from Campinho

Site sketches of important tourist destinations on the circuit
source : sketches by Tiffany Eng-LA 205

3.5

Alentejo Wine Tourism Corridor

Ecological Wine Tourism Corridor to improve the tourism in Alenejo region
-Rucker A Alex, Fern Uennatornwaranggoon,Emilie Wolfson

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

source : class work - LA205

Alentejo Vineyards
source :vinhosdoalentejo.pt

opportunity of Alqueva on Alentejo's wine industry.

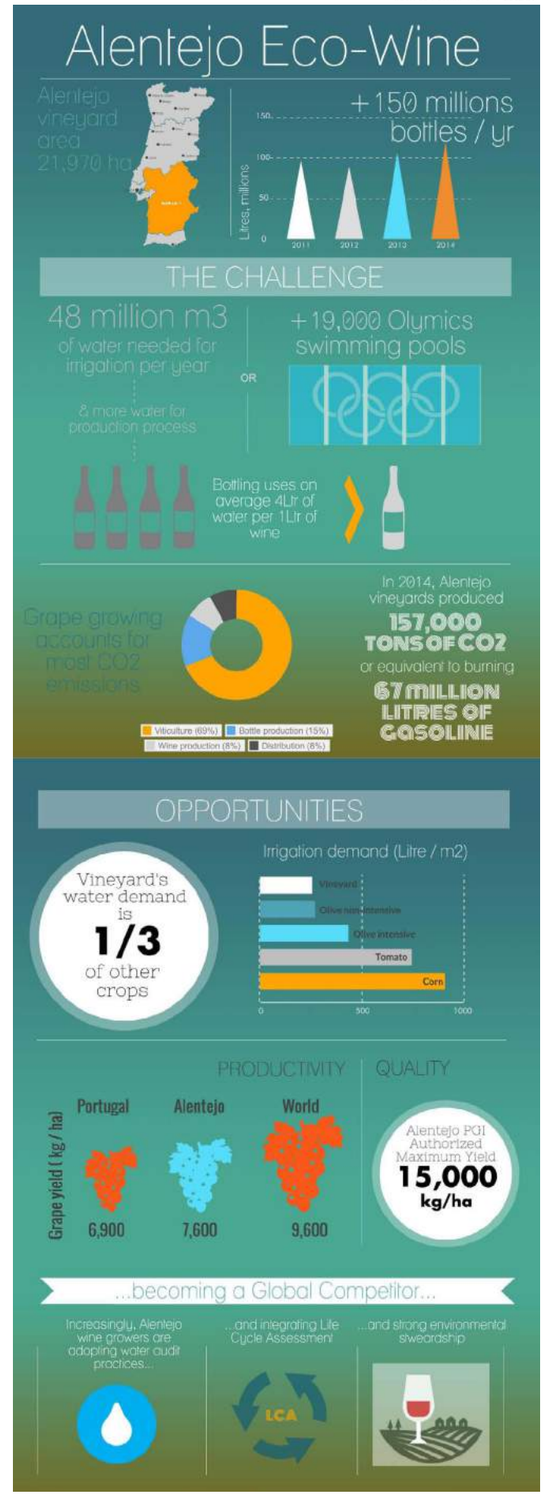
Alentejo Vineyards

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 Alentjo, 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

source : class work - LA205



Applicable Lessons from Global Wine Regions

	Sonoma, California	Tuscany, Italy	Alentejo, Portugal	Languedoc-Roussillon, France	Mendoza, Argentina
					
FACT: Climate	Mediterranean	Mediterranean	Mediterranean	Mediterranean	Continental
—> Lessons for Environmental Management	Irrigate sparingly to develop a reputation for quality. Starved vines make for stronger wines. Take advantage of the soils, altitude, and sun as variables to enhance the terroir (and marketing) of wine.				
FACT: Average Tourist Budget	$176/day [10]	$108/day [10]	$50/day [10] (comp: Ericeira)	$107/day [10] (comp: Marseilles)	$32/day [10]
—> Lessons for Economic Appeal	Cater to a range of budgets and side interests, but reinforce the cost-quality ratio. "An affordable Tuscany." 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.				
FACT: Distance from Vineyards to Major City	60 minutes to San Francisco	100 minutes to Rome	80 minutes to Lisbon	55 minutes to Montpellier	15 minutes to Mendoza
—> Lessons for leveraging Existing Tourism	Provide infrastructure and transportation options that enable tourists on different budgets to access, and linger, in wine country. Emphasize local food, culture, and traditions as "tie-ins" to the wine tourism experience. Alentejo boasts a long history with wine: oldest appellation designation in the world… second largest number of grape varietals… home to wine-cork oak tree.				

More information: https://sites.google.com/site/la204winetourism

source : class work - LA205

tools are not yet disseminated widely in the region, but their use is increasing. Going forward, the Alentejo wine industry may want to adopt more robust sustainable practices as it continues to expand and tries to establish its presence in the global market. A greater focus on sustainable practices will also support the region's overall eco-tourism strategy.

Global Comparison

How do global wine tourism regions with similar profiles to Alentjeo 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-Rossillion, 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 back-packers, active seniors, couples and families with the opportunity to print and share routes.

Recommendations

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

-Provide a downloadable Wine App with accurate GPS and directions (in multiple languages besides Portuguese)
-Improve signage on roads for wineries and other tourist attractions
-Cater to a range of budgets and side interests, but reinforce the cost-quality ratio. "An affordable Tuscany."
-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, Qurecus suber).

For actors in the Alentejo wine industry

-Irrigate sparingly to develop a reputation for quality. Starved vines make for stronger wines.
-Take advantage of the soils, altitude, and sun as variables to enhance the terroir (and marketing) of wine.
-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.

4.0

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 reprofiling 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.

View of the reservoir from the dam

source : students LA 205

6.0 REFERENCES

Ashiagbor, G., E.K. Forkuo, P. Laari, & R. Aabeyir. (2013). Modeling soil erosion using RUSLE and GIS tools. International Journal of Remote Sensing and Geoscience, 2(4): Pp. 7- 17.

Cakula, A., V. Ferreira, & T. Panagopoulos. (2010). Recent Researches in Environment, Energy Systems and Sustainability. pp. 33-38.

Dunn, T. & L. Leopold. (1978). Water in Environmental Planning. W. H. Freeman and Company. San Francisco.

EU Joint Research Centre. (2014). K Factor. European Soil Portal. Retrieved February 2015: http://eusoils.jrc.ec.europa.eu/library/themes/erosion/Erodibility/Data/index.cfm

Ferreira, V. & T. Panagopolos. (2011). Predicting soil erosion at the Alqueva Dam Watershed: Seasonal Variation. Recent Research in Environment, Energy Systems and Sustainability. Pp. 99 – 104.

Ferriera, M.T., P.M. Rodriguez-Gonzalez, F.C. Aguiar and A. Albuquerque. (2005). Assessing biotic integrity in Iberian rivers: Development of a multimetric plant index. Ecological indicators 5: pp. 127-149.

Foster, G.R. Toyo, T.E., & K.G. Renard. Comparison of the USLE, RUSLE1.06c and RUSLE2 for Application to Highly Disturbed Lands. (2003). Government of Arizona. pp.154-160.

Godinho, C. Rabaca, J. E. & Segurado, P. (2010). Breeding bird assesmblages in riparian galleries of the Guadiana River basin (Portugal): the effect of spatial structure and habitat variables. Ecological Resources, 25: pp. 283-294.

Joanaz de Melo, J. & C. Janeiro. Alqueva dam and irrigation project: hard lessons learned from good and bad assessment projects.

Karaburun, A. (2010). Estimation of C factor for soil erosion modeling using NDVI in Buyukcekmece watershed. Ozean Journal of Applied Sciences 3(1), pp. 77-85.

Lobo, Gonçalo, Nuno Videira, Paula Antunes, Rui Santos, and Ângela Guimarães Pereira. "The Alqueva Project: A Review of the Evaluation Process." Actas del III Congreso iberico sobre gestion y planificacion del agua, Sevilla: November 13-17, 2002, p. 76-79.

Lynch, J. A., Corbett, E. S., and Mussallem, K. (1985). Best management practices for controlling nonpoint-source pollution on forested watersheds, Journal of Soil and Water Conservation 40, pp. 164-67.

Panagos, P., Ballabio, C., Borrelli, P., Meusburger, K., Klik, A., Rousseva, S., Tadic, M.P., Michaelides, S., Hrabalíková, M., Olsen, P., Aalto, J., Lakatos, M., Rymszewicz, A., Dumitrescu, A., Beguería, S., & Alewell, C. Rainfall erosivity in Europe. Sci Total Environ. 511 (2015), pp. 801-814. DOI: 10.1016/j.scitotenv.2015.01.008

Panagos, P., Meusburger, K., Ballabio, C., Borrelli, P., Alewell, C. (2014). Soil erodibility in Europe: A high-resolution dataset based on LUCAS. Science of Total Environment, 479–480: pp. 189–200.

C. Godinho et al. "Breeding bird assemblages in riparian galleries of the Guadiana River Basin (Portugal): the effect of spatial structure and habitat variables". The Ecological Society of Japan, 2009.

Instituto Superior de Agronomia, ICN. "Uma Estrategia de Gestao Agricola e Florestal para a Rede Natura 2000. Relatorio Final, Anexos". Lisboa, 2006

Woodward, S. E., and Rock, C. A. (1995). "Control of residential stormwater by natural buffer strips," Lake and Reservoir Management 11, 37-45.

Young, R. A., Huntrods, T., and Anderson, W. (1980). "Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff," Journal of Environmental Quality 9, 438-497.

Barbosa, Maria Helena Neves. 2014. Requalificacao e gestao de ribeiras em areas irrigadas mediterranicas: aplicacao ao perimetro de rega do EFMA. University of Lisbon.

Betâmio De Almeida, António. Dam and Valley Risk Management An Example of Social Perception Research. National Academy of Engineering.

Betâmio De Almeida, António. Dam Break Flood Risk Management: An Integrated Project. Technical University of Lisbon.

Bettencourt, Pedro and Maria Grade. 2009. Environmental Impact Assessment of a Mega Project in Portugal and Spain – the Alqueva Project. IAIA09 Conference Proceedings: Impact Assessment and Human Well-Being, 29th Annual Conference of the International Association for Impact Assessment, 16-22 May 2009, Accra International Conference Center, Accra, Ghana.

EDIA. 2005. Environmental Management Programme for the Alqueva Multi-purpose Project (Programa Gestão Ambiental de Empreendimento de Fins Múltiplos de Alqueva.)

European Commission 1996 Environmental measures necessary to carry out the dam project, Region of Alentejo, Portugal. European Commission Directorate General (DG XVI)For regional Policy and Cohesion, Brussels.

EDIA. 2015. EDIA Website. http://www.edia.pt/en/. Accessed February 1, 2015.

ESB International, Fichtner, Procesl. 1996. Environmental measures necessary to carry out the Dam Project, Region of Alentejo, Portugal Final Report.

European Environment Agency. European Climate Adaptation Plan. Climate-ADAPT Program, Climate Adapt Website: http://www.climate-adapt.eea.europa.eu. Accessed on January 20, 2015.

European Commission.
Gamboa, Miguel. Dam Break Emergency Response Information System. National Civil Engineering Laboratory.
Graf, W. L. 1999. Dam Nation - A geographic census of American dams and their large-scale hydrologic impacts. Water Resources Research, April 1999, Vol. 35, No. 4, pp. 1305-1311.

Gudino, Francisco. 2015. Personal communication with Francisco Gudino, Telheiro, Portugal.

Huntjens, Patrick, et al. 2010. Climate change adaptation in European river basins. Reg Environ Change 10:263–284.

Joanaz De Melo, João, and Carla Janeiro. 2005. Alqueva Dam and Irrigation Project: Hard Lessons Learned from Good and Bad Assessment Practice. N.p.: New U of Lisbon & Centro De Estudos Da Avifauna Ibérica.

McKnight, Katie and Emma Ding. 2015. Ecological Corridors and the Impact of the Alqueva Dam. University of California, Berkeley. Department of Landscape Architecture and Environmental Planning.

Ministry of Environment. 2009. Impact Assessment Guidelines. European Commission.
Nilsson, C. & Berggren, K. 2000. Alterations of riparian ecosystems caused by river regulation. Bioscience, September 2000 / Vol. 50, No. 9.

Santos, Maria J., Nuno M. Pedroso, Joaquim P. Ferreira, Hugo M. Matos, Teresa Sales-Luís, Íris Pereira, Carla Baltazar, et al. 2008. Assessing Dam Implementation Impact on Threatened Carnivores: The Case of Alqueva in SE Portugal. Environmental Monitoring and Assessment 142, no. 1–3 (July 2008): 47–64.

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