Alqueva dam and irrigation project: hard lessons learned from good and bad assessment practice

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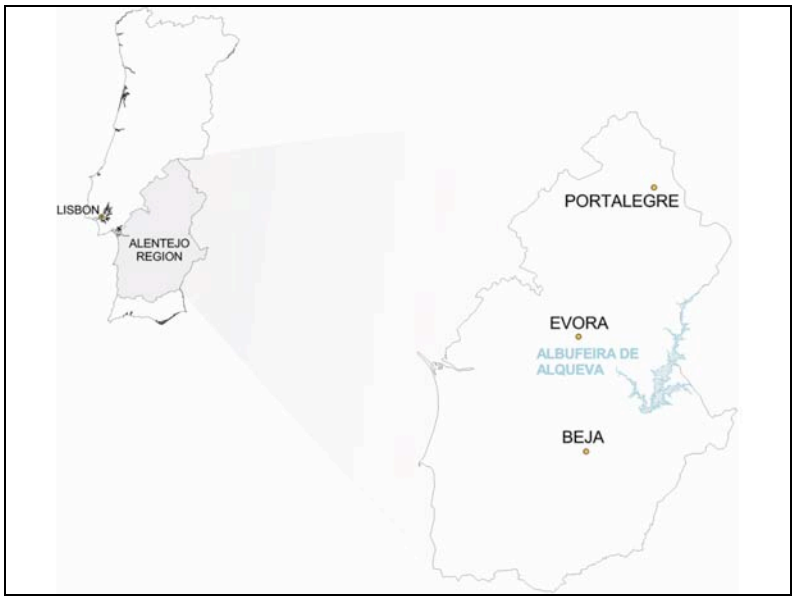
Abstract

The Alqueva dam and irrigation project involves the largest reservoir in Europe and an irrigation network to cover 110000ha of land, with three main goals: water management, regional development and promotion of agriculture. This paper reviews the major impacts and assessment procedures of the project. Lessons learned from this difficult process are discussed. Flooding has already provoked large ecological and social impacts, e.g.: loss of natural and cultural heritage in the Guadiana valley, cutting of ecological corridors, pressure over endangered species such as the Iberian lynx; and the resettlement of hundreds of families. On the plus side, the project created some water management capacity on the Portuguese side of the Guadiana and some local development in a traditionally depressed region. When the project is full-fledged, greater impacts are expected, including water pollution, soil salinization, barrier effect, destruction of wetlands, and possible biological contamination of water transfer from the Guadiana to the Sado basin. However, the resulting economic benefit is expected to be rather low. Local social benefit is expected mostly from public investment. Overall, the enterprise is certainly not sustainable - environmentally or economically. This myriad of problems and opportunities generated a huge amount of information and uncommon assessment procedures, including an observation committee and strategic-level environmental studies. They managed to curb some of the worst impacts of the project, but had little influence on key decisions. Many of the approved mitigation measures were not put to practice. The reference framework of the project has changed dramatically in the past decade (the project concept goes back to the 1950´s and the technical solutions to the 1970´s), so an altogether new strategy is called for. Strategic environmental assessment may be part of the answer.



1. Project concept and history

Alqueva is located in the Alentejo, a region of Portugal that occupies nearly one third of the territory but only contains about 5% of the population of the country, in a rural, sparsely populated land. For many decades, it has been one of the regions with lower development indexes; it has of course developed, along with the rest of the country, especially in the past thirty years, but the gap between national and regional social and economic indexes has not improved much. The dominant land uses are cereal cultivation, mostly wheat (a landscape sometimes called cerealific pseudo-steppe), and the montado, a managed pastureland under cork-oak or green-oak cover. Natural or semi-natural Mediterranean scrub subsists in the mountains, riverbanks and uncultivated areas. The climate is of Mediterranean type, with hot dry summers and moderately cold, rainy winters; average rainfall across the region goes from 400 to 900 mm/year, but varies widely from year to year; droughts and floods are frequent events.

The Alqueva dam and irrigation project was born half a century ago, based on a concept popular at the time: major investment in public works should generate economic development in depressed regions. The scheme was first proposed in the early fifties under the *Plano de Rega do Alentejo* (Alentejo Irrigation Plan). This plan called for the irrigation of 150 000 ha of land, with most of the water coming from a major reservoir on the river Guadiana at Alqueva. The reservoir should guarantee a transfer of water of up to 1000 hm^3/year for a three-year severe drought period, that is a useful storage of about 3000 hm^3. At the time, the Guadiana basin had few dams (all in Spain), the natural flow at Alqueva averaging about 4800 hm^3/year.

The concept had a number of implicit principles, some of which may now seem preposterous, but that were considered quite reasonable at the time:

- Irrigated crops would have a much higher added value, and hence development potential, given higher yield combined with low cost of labor, water and energy;
- Investment in the dams and irrigation scheme would be non-refundable public money;
- The target destination of crops would be Portugal, then a rather closed market with a deficit of many agricultural products;
- Environmental constraints were not an issue, be it water consumption, pollution, climate change, soil or nature conservation;
- Social and economic effects were assumed positive as a matter of fact (all over Europe there was a development boom and Portugal was lagging behind).

Studies on the proposed scheme went on for many years, with little practical issue. In the early decades, the impediments to the advancement of the project were chiefly the colonial war in the 1960's, and in the 1970's major political and economic crises preceding and succeeding the 1974 revolution. By the 1980's, the economic and political situation had stabilized, and the opposition was raised by environmental and political movements, due to the perceived high environmental impact and dubious social and economical advantages of the enterprise. However, at the time, public debate was highly emotional and ideological and very little technical information transpired, as described e.g. by Melo (2002).

The project was finally approved in 1994, based on the technical solutions developed in the early 1970's. Despite public outcry and an integrated environmental impact assessment commissioned by the European Commission (SEIA 1995), no significant revision of the project concept was performed.

Later in this paper, we discuss the decision process and EIA in more detail. For now, let us just propose that the "go-ahead" decision of the Portuguese Government lacked any credible economic foundation (never mind grand speeches to the contrary), and was in fact based on two other major reasons:

- *Geostrategic*. The Alqueva dam was (still is) a major piece in the Portugal-Spain negotiations about the international rivers and water management. By 1994, Spain had built dozens of dams in the Guadiana basin, cutting the average flow of the river Guadiana by half. In addition, the lower Guadiana is the only part of the international basins where Portugal is upstream from Spain;
- *Socio-political*. In the ever under-developed region of Alentejo, the forty-year-delayed Alqueva project had become the myth of a magic development-deliverer. Many local people believed it because they could find nothing else to believe, and this made it virtually impossible to create alternatives, or to avoid the project at all – to many, it became a political necessity, irrespective of economic or environmental consequences.

By February 2002 the Alqueva dam was nearly completed and the reservoir begun to be filled. By June 2004, the water had risen to the 147 m level (it has not increased since because of the drought of the past year). Some other components are completed or under construction, with a total investment to date of some 800 million Euros. Other components of the project are under study, representing investments of about twice as much. To date (June 2005), no overall revision of the project concept was undertaken.

2. Project configuration and goals

As approved in 1994, the EFMA - *Empreendimento de Fins Múltiplos de Alqueva* (Alqueva multiple-use enterprise) is composed of the following components (www.edia.pt):

- The Alqueva dam and reservoir, centerpiece of EFMA and the largest artificial lake in Europe. The dam has a total height of 96 m, of which about 84 m above the riverbed, up to level 154 m (above average sea level). The maximum storage level is at 152 m and the minimum operation level at 130 m. The flooded area (at level 152) will be 250 km^2, storing 4150 hm^3 of water, of which 3120 hm^3 is useful capacity, leaving 1030 hm^3 of "dead volume" under level 130. Bellow the dam there is a hydroelectric power plant with a total electrical power output of 240 MW. Predictions estimate an energy production of electricity of about 380 GWh/year;
- 23 km downstream from Alqueva is the smaller "counter-dam" of Pedrógão, with a height of 39 m and a maximum volume of 54 hm^3. It stores water discharged from Alqueva, that is then pumped up again and later reused, in order to optimize the economic value of electricity production at peak consumption hours;
- A major pumping station at Álamos, near the village of Amieira by the river Degebe (tributary to the Guadiana). This station will pump water about 100 m up from the reservoir to the beginning of the irrigation network. This huge elevation is due to the location of most of the land to be irrigated on the plateau, much higher than the deep Guadiana valley;
- An irrigation network composed of nine satellite reservoirs, a primary network of 680 km of canals, plus a secondary network of 4400 km of pipelines, intended to service 110 000 ha of land, most of it in the Sado basin;
- Several support and impact mitigation projects, including road rerouting, resettlement of displaced people, removal of constructions and vegetation from the flooded area, among others.

The official goals for the project, stated in 2005 by EDIA, the state-owned company charged with managing the Alqueva project, are the following (www.edia.pt): strategic water reserve; changing the agricultural model in Alentejo; electricity generation; promotion of tourism; combat of desertification and climate change; intervention in the conservation of natural and cultural heritage; promotion of local employment.

In table 1 a summary of the degree of fulfillment of these goals is presented.

Table 1 – Degree of fulfillment of stated goals of the Alqueva project

Goal	Results to date
Strategic water reserve	- Represents only 2 to 4% of stored volume; - Quality not guaranteed, expected to be bad in foreseeable future - Better negotiation capacity before Spain
Changing agricultural model	- Against European policy and trend of international markets - Water price, soil, water quality and immigration issues
Electric power	- Available power relevant - Major income source for EDIA - Energy production marginal at national scale
Tourism	- Bad water quality and deserted inter-levels (up to 180 km2; 1 km width on average) will not attract water-side tourism - Other kinds of tourism made possible due to water availability - Eco-tourism unexploited, especially in unflooded valleys
Combat desertification and climate change	- Not at all! Woodcutting and dam construction emitted more CO_2 than will be saved in many years of hydroelectricity production - Desertification is not deterred by irrigation, but by forestation
Intervene in environmental and cultural heritage	- Much work done, though very far from level of destruction - Many agreed measures not performed or not completed
Employment	- Total fiasco during construction, probable fiasco in future

3. Environmental impacts of the project

3.1. Ecological impact of the reservoir

44% of all plant species and 35% of terrestrial vertebrate species in the world are confined to 25 "biodiversity hotspots" occupying 1.4% of the land surface of the Earth. One of these hotspots is the Mediterranean including the southern half of the Iberian Peninsula (Myers *et al* 2000). The Guadiana valley and surrounding area are among the most significant sites in this region (ICN 1998, 2000).

Major ecologic impacts of the reservoir include:

- Cutting down over 1.5 million trees to avoid their rotting in the water and causing further pollution of the already heavily polluted Guadiana;
- Interruption of ecological corridors along the river valleys;
- Partial flooding of the Natura 2000 (European Nature conservation network) Juromenha-Guadiana site;
- Significant loss of habitat of endangered species such as the Iberian lynx (*Lynx pardinus*), the wild cat (*Felis silvestris*), the otter (*Lutra lutra*), the black stork (*Ciconia nigra*), the royal eagle (*Aquila chrysaetus*), the Bonelli eagle (*Hieraaetus fasciatus*), the royal owl (*Bubo bubo*) and the saramugo (*Anaecypris hispanica*).

3.2. Impact of irrigation

The main original goal of the Alqueva project was to change the agricultural model of Alentejo, shifting to irrigation. There are however a number of significant hurdles with this.

First is the issue of soil aptitude for irrigation. According to Sequeira et al., 1995, following the classification of FAO (Food and Agriculture Organization, UN), of the 110 000 ha of land supposed to be irrigated, the soil aptitude is as follows:

- 17% S1 (best aptitude)
- 50% S2 (medium aptitude)
- 23% S3 (strong limitation)
- 10% N (no aptitude)

The limitations are related to a number of factors, including slope inclination, soil composition, depth and structure. Especially relevant is the risk of salinization or alkalization (namely sodium accumulation). This in turn depends on irrigation water quality. Part of the problem is that water quality in the Guadiana is quite poor: it receives the drainage of 300 000 ha of irrigated land in Spain, plus the untreated or partly treated effluents of the city of Badajoz and several towns and industries in Portugal and Spain, totaling some two million inhabitants-equivalent. Furthermore, much of the land proposed for irrigation will drain back into the Alqueva reservoir, increasing the concentration of conservative pollutants such as salts; the true magnitude of this impact will depend on the rate of water uptake over water discharged as ecological flow. In the face of current situation of generalized pollution in the Guadiana basin, the water quality will not be adequate to most uses, present or pretended (Sequeira, 2000a, Louro, 2003). This means that FAO N and S3 soils should not be irrigated at all, and irrigation of S2 soils should be subject to stringent restrictions and control. Insisting on using polluted water for irrigation would result in severe soil degradation and impairment for future agricultural use.

The second issue is the contamination of surface and especially ground water. Many aquifers in the region are vulnerable to water pollution, especially by nitrates, and significant levels of pollution have been registered for years (e.g. INAG 1997, Sequeira 2000b). This is happening although the intensity of irrigation now is a fraction of what it will be with the Alqueva project fully operational. Under both the European Water Framework Directive and the Portuguese Water Plan (*Plano Nacional da Água*), further pollution of such groundwater reserves is unacceptable, because they are strategic water supply sources for large populations, and such pollution is long-lived. The vulnerable areas have long been identified, but the impacts were never properly computed, so restrictions to irrigation related to water quality are not yet defined. On the other hand, nutrient pollution of surface water is a source of eutrofication, already a problem in both the Guadiana and the Sado rivers.

The third issue is the network of canals, that implies three major types of impacts: border effect, with ensuing habitat fragmentation and possible loss of small populations; trap effect – animals (and people) fall into the canals and have a difficult time coming out, with a mortality rate of over 74% (Godinho & Onofre 2003); and major loss of water through evaporation and infiltration.

The fourth issue is the degradation of protected habitats. The Natura 2000 site “Moura-Barrancos”, although outside designated irrigation areas, will probably be affected by loss of ecological corridors if nearby areas are irrigated. This is one of the very few places where the Iberian lynx has been recently identified in Portugal. The “important bird area” (IPA) of “Planícies de Évora”, designated by BirdLife International, will be affected by conversion of existing pseudo-steppe into irrigated land.

3.3. Impact of changing water flow in the Guadiana

Building a dam causes major changes in the natural water flow. It is true that presently the water flow in the lower Guadiana is anything but natural, due to water abstraction in Spain. Nevertheless, Alqueva dam and irrigation are putting and will put more pressure on the river and estuary habitats. Total flow will be diminished and natural floods will disappear. Major impacts are the following:

- *Loss of sediments discharged to the sea*. It is estimated that some 70 to 80% of the natural sediment flow in the Guadiana is now retained in Spanish dams. Alqueva will cut the remainder by half, either by settling in the reservoir or by eliminating natural floods downstream (most sediment flow is transported during floods). The sediments will thus settle in the riverbed, affecting river habitats, instead of reaching the beaches near the estuary, where they should compensate sand loss to the deep sea;
- *Lowering water table downstream*. Flow reduction and absence of floods are known to provoke lowering water tables and reduced recharge of groundwater. In turn, this implies the reduction of wetlands, with major impact on birdlife and other species (WCD, 2000);
- *Reduction of fish biodiversity*. Fish species adapted to naturally torrential rivers such as the Guadiana will have their habitat severely reduced. They will disappear in the reservoir because

they cannot compete with species adapted to a lake-type habitat, and they will be affected by a flow regime downstream quite different from the natural flow. This last effect can be mitigated by a careful ecological flow regime, but so far this has not been defined;

- *Affection of fish nurseries*. All estuaries, the Guadiana being no exception, act as fish nurseries for species that are sea faring as adults. It is expected that the Alqueva project will degrade the Guadiana estuary nursery, although no agreement has been reached as to the magnitude of this impact. Part of the uncertainty stems from the indefinition about flow regime and water abstraction.

Environmental criteria for water flow, regarding both ecological and socio-economic uses, area a key tool in minimizing the effects of changing water flow. Unfortunately, as yet, they have not been studied in sufficient depth and therefore no consequent rules are defined.

3.4. Impact of Guadiana-Sado water transfer

The water transfer from the Guadiana to the Sado basin will be performed by a tunnel from Loureiro dam (in the Guadiana basin) to the Alvito reservoir (Sado basin). Major impacts expected from this transfer will be the following:

- *Worsening water quality in the Sado basin and estuary*. Because of bad water quality of the Guadiana and cultural intensification in the irrigated land, a worsening water quality situation in the Sado river and estuary is expected. Of major concern is eutrofication, already a problem in some parts of the system;
- *Risk of biological contamination*. Different river basins usually carry different species and biological communities. Water transfer is a major cause of biological contamination (CBA, 2000). In the case of Alqueva, there is a standing recommendation for hydraulic segregation of water coming from different basins: water from Alqueva should not go into the river Sado, but be confined to segregate reservoirs from where it should only exit to the irrigation system, to minimize biological contamination risk (CAIA, 2002). However, the projects to implement this principle into practice have yet to be reviewed, and to be subject to EIA (CE, 2001).

3.5. Social impacts

Alqueva has been for many years the *leitmotiv* of all regional development exercises in Alentejo. It has been hailed as the salvation of the region by many, and denigrated as a totally useless and socially harmful “white elephant” by many others. Neither prophecy is coming true, although the final balance has yet to be made (probably many years from now). In the meantime, a number of both positive and negative social impacts can be evaluated already:

- *Transfer of Aldeia da Luz*. This village, population 400, was totally resettled near the reservoir, to the point of maintaining neighborhood relationships. The quality of the buildings and equipments is much better in the new village. It had been an expected thing for many years, and there was no real opposition to the transfer, which was conducted with great care; but it was nevertheless quite traumatic for the people involved. It is curious to note that one of the most difficult issues was the transfer of the graveyard (of both Aldeia da Luz and Estrela, another village nearby that need not be fully resettled), because of psychological and religious implications;
- *Loss of agricultural land*. Despite its stated goal of renewing agriculture in Alentejo, the first effect of Alqueva was to eliminate the livelihood of landowners and workers in the reservoir area. Those people were compensated, of course, but it was still a problem, made worse because those people feel (probably with good reason) they are in no way benefited by Alqueva;
- *Alqueva as catalyst*. So far, Alqueva has not generated much in the way of productive irrigated agriculture. However, it did serve as a catalyst for a number of public works, such as roads, museums, sports facilities, health centers and other public utilities. It has also caught the attention of some investors towards the Alentejo, in such varied things as the regional

agriculture fairs of Ovibeja (Beja) and Feira do Montado (Portel), processing, certification and trading of choice regional products (olives, olive oil, wine, cheese, black pork and other animal products), plus various kinds of tourism, from golf to cultural and eco-tourism. One may rightly point out that none of these things has anything to do with irrigation, and could perfectly be done without any big dam. On the other hand, the fact of the matter is that all those ideas were sitting idly by before Alqueva came about, and were forwarded thereafter;

- *Employment*. Hardly any local workers were employed in the construction of the dam, a pattern common to major public works. As for the future, the example of southern Spain shows that irrigated agriculture depends on immigrant labor, rather than local labor. Increase in local employment will be marginal, centered on agriculture services or on activities unrelated to irrigation;
- *Loss of cultural heritage*. The flooding of over 180 km^2 of land to date (possibly going up to 250 km^2) has provoked the disappearance of hundreds of archaeological sites, including some of the most interesting Paleolithic rock engravings in Portugal and Spain. As many other things in Alqueva, in has a double reading: on one hand, much good archeological and recovery work was paid for by the project, in the most conspicuous sites; on the other hand, general archaeological surveys were worried and definitely insufficient, and many potentially interesting sites are probably lost forever, with surface telltale signs obliterated by water and sediments.

3.6. Economic impacts

One of the striking features of Alqueva is that it is based on economic and development concepts of the 1950's that were never updated. The result is a project that, although with some undeniable benefits, makes no overall economic sense. This is not the place for a detailed economic analysis, but a few indicators shall illustrate the problem:

- The expected increase in income of local populations (eventually resulting from a public investment well over 2000 million Euros) will be less then 1% $year^{-1}$. In other words, the Alqueva project does not bring development to the vast majority of the supposedly interested people, nor does it have any economic return to the Portuguese State. Some people and businesses will certainly benefit, chief among them the construction sector, but not the population at large;
- There are completely new paradigms and reference frameworks in the agricultural market, profoundly different from those that supported the Alqueva concept. This was easy enough to predict by 1994 (and was indeed foreseen by many reviewers, critics and supporters of Alqueva alike – see e.g. GEOTA 1994), but now it is out there for all to see. Three key issues are: (i) the new European Water Framework Directive, that among other things imposes targets for water quality and the principle of full cost pricing for water users; (ii) the negotiations regarding liberalization of agriculture markets under WTO, the Doha Round, that will probably result in some lowering of commodity prices in the international market; and (iii) the European Common Agriculture Policy, that is (slowly but inexorably) moving away from the subsidies to production, towards support of quality, health- and environmental-friendly products and processes. The speed of these changes is debatable, but their direction is unequivocal;
- The Portuguese Government set the price of water from Alqueva at 0.08 EUR/m^3 until 2008. Nothing is decided thereafter. This is of course a purely political price, that only covers, barely, the operation cost of the system (no investment return is counted in, let alone environmental or opportunity costs). That price is also the limit for viable production of irrigated commodities at current market prices. Full cost pricing, that is the only reasonable pricing criterion for a commercial operation, will push up Alqueva water price to about 0.20 to 0.25 EUR/m^3 (more if environmental costs are accounted for). The outcome of this process is anybody's guess, but in the meantime the message being sent loud and clear to the farmers is: no need to save water, it is cheap and inexhaustible, splash at will!

- In general, it can be said that the mere existence of the water in the Alqueva reservoir creates potential and appetites for a number of activities. However, the bad water quality (INAG, 2001) means that for a long time to come such potential is severely impaired;
- Given the picture above and current budgetary constraints, it is pertinent to ask whether the Portuguese Government should freeze the whole project and think it over while they can. Further blind investment into a project concept out of the 1950's will very likely end in tears.

4. Impact mitigation and compensation

The scale of environmental impacts of Alqueva led to the definition of a comprehensive Environmental Management Plan (PGA), complemented with a Mitigation and Compensation Plan (PMC), that was one of the conditions for the European financing of the project. This included 48 major measures. By the end of 2004, 7 of those measures were completed, 27 were under way, 4 had been abandoned and 16 had not begun.

The abandoned measures were important practical things, related to nature conservation and fish habitats. The measures completed were mostly studies, undoubtedly relevant, but that so far had no results – namely in revising environmentally harmful standing policies and practices. One of the measures, the vegetation cutting in the area to be flooded, although necessary, was conducted with repeated and blatant disrespect for standing environmental constraints (Silva, 2003).

Some of the most important measures have been incomprehensibly delayed or not even begun, the most important being those that effectively compensated the impacts. Chief among those are the reposition of cut trees and woods (especially the green oak montado and the riverside gallery), plus the critical creation of ecologic corridors to replace those gone. Those should have begun ten years ago – so they might be useful by now.

Unfortunately, standing policy by EDIA and the Portuguese State has often been to do as little as they can get away with the before public opinion and the European Commission. In the last revision of the PGA (EDIA, 2005), a number of measures have either vanished or been diluted in such a way as to become ineffective. Again, chief among these is the issue of ecological corridors and nature sanctuaries. The information gathered in the myriad studies was little taken into account when revising the plans. Of particular concern remains the situation of the Iberian lynx that still appears in the region but holds at present no viable local population; the region is nevertheless essential as an ecological corridor between other lynx habitats (Pedroso *et al*, 2003).

Another important measure, championed by environmental NGOs, often discussed with but never formally accepted by European or Portuguese authorities, was the need for a phased fill-up of the reservoir, very important to mitigate ecological and social impacts, and to let compensatory measures produce effects. The operation of the reservoir at lower levels, say 147 instead of 152, would drastically reduce the impact, as shown in a number of studies (SEIA 1995, ECOS 2000, ONGA 2001). Table 2 indicates the differences in major impacts of the flooding as a function of maximum operation level. Because the irrigation component of the project is phased and water abstraction will probably be much less than originally predicted (depending on water price and quality), actual water needs will be diminished and delayed as compared with official goals. The "optimistic" scenario in the table corresponds to amounts of water abstraction of 2/3 of the official goals, the "pessimistic" to 1/3. In all scenarios, the so-called strategic goals (Guadiana water management and emergency reserve in severe droughts) are always fulfilled, since they require never more than 4% of storage capacity The only advantages to be gained by increasing immediately the water level from 147 to 152 would be in terms of jurisdiction (the status of once flooded "hydric public domain" allows for better control by the Portuguese State than land merely owned by the State, has happens today); and electricity production (that would be marginally lower, say about 7%, for a given quantity of water discharged – PAS 2004).

Table 2 – Impact as a function of chosen maximum operation level

Maximum operation level	**152**	**147**
Flooded area	250 km2	182 km2
Destruction of river gallery in the Guadiana valley in Portugal, upstream of Alqueva	100%	80%
Destruction of association *Myrto-Quercetum rotundifoliae*	50% of national area 30% of world area	20% of national area 12% of world area
Destruction of association *Genistetum polyanthi*	50% of national area 40% of world area	2% of national area
Fulfillment of strategic reserve	yes	yes
Year when given water level is needed for irrigation, according to 3-year guarantee rule (official, optimistic and pessimistic scenarios)	official: 2031 optimistic: never pessimistic: never	official: 2017 optimistic: 2024 pessimistic: never

All in all, it can be said that Alqueva generated an amazing amount of studies and paperwork, and also many practical measures never before put to practice or attempted.

On the other hand, most compensation measures have yet to be implemented, and are still a far cry from the scale of the destruction already occurred, let alone the one still to come with the irrigation projects.

5. Impact assessment and decision making

The Alqueva project is a very complex case study, with examples of environmental impact assessment practice ranging from the very good to the very bad. In this chapter, we highlight some features of the process from the point of view of EIA practice.

- Early 1980's – Alqueva was the first project with major environmental impact studies in Portugal. It is still, to date, the project with more environmental information ever in Portugal;
- 1992-1994 – a formal EIS is undertaken for the Alqueva dam and reservoir, under Directive 85/337/CEE. Strategic issues are not discussed, public participation is limited to the minimum, feeble requirements of the time, and there is no influence on key decisions (e.g. project concept, size and location of dam);
- 1995 – an integrated environmental impact statement is commissioned by the European Commission. Several important issues are reviewed (e.g. impacts of irrigation and changing water flow, social as well as ecological impacts). However, most issues are not studied in depth, the project concept is not touched, and no "zero alternative" is considered. A comprehensive package of mitigation and compensation measures is approved, including terms of reference for future studies;
- 1996 – the Government agrees with environmental NGOs to conduct a study on the phased filling of the Alqueva reservoir. This study will come up with too little, too late, producing no immediate effects;
- 1997 – the observation committee (Comissão de Acompanhamento Ambiental das Infra-estruturas de Alqueva, CAIA) is created. This institution proves to be an effective post-evaluation tool. It ensures dialogue and inter-institutional coordination between government agencies, ONG and local authorities; it has also provided an independent control of EDIA, the state-owned company that manages Alqueva. The effectiveness of CAIA relies on two things: goodwill of all members to cooperate; and the existence of a small technical staff. However, CAIA proved to be unable to discuss policy or strategic issues, such as the development model, the conditions for the closing of the dam, or the phased filling of the reservoir;
- 2001 – following CAIA's request, the "preliminary EIA for the irrigation sub-system Alqueva-Baixo-Alentejo" is submitted to CAIA by EDIA. This is a planning tool that performs a

strategic-level evaluation of consequences of the overall irrigation system (complementing the integrated EIS of 1995);

- 2002 – CAIA issues its report on the afore mentioned preliminary EIA. Two conclusions are of paramount importance: (i) the need to improve studies on soil and groundwater pollution; and (ii) the need to redefine the whole hydraulic system to avoid direct contact between waters from different basins;
- 2003 – environmental NGOs suspend participation in CAIA due to systematic failure of the Government to comply with established agreements and refusal to discuss strategic issues;
- 2003-2004 – EIA for individual projects, namely the transfer of water from the Guadiana to the Sado, fail to comply with significant previous demands. Most conducted no proper scoping;
- 2005 – review of environmental management plan by EDIA downgrades key ecological measures.

6. Conclusion

Alqueva is perhaps the most complex project (or should we say program) ever put forward for environmental evaluation in Portugal. Its implications are far-reaching, and the breadth of issues enormous. It can be said that Alqueva fulfils (if somewhat inefficiently) some relevant goals, such as the regional water reserve or the catalyst for the development of Alentejo. The dam is an acquired fact, but it seems that all the rest is open for discussion, from the financial equation to the development model to the compensation of major ecological and social impacts.

At present, Alqueva generates more questions than certainties:

- What will the water management policy be?
- What will be the water price and who will pay for it?
- What will water quality be?
- How much land is usable for irrigation?
- What development model for Alentejo?
- What international constraints, from European policy to international markets?
- How fast should the reservoir be filled?
- How will social and ecological goals and compensatory measures be met?
- How will the next steps be funded?

There are no simple answers to these questions, but we leave nevertheless some ideas:

- Decisions must me made with proper information: strategic impact assessment, adequate scoping and post evaluation are indispensable tools to complement traditional project EIA;
- We should assume, in Alqueva as in other projects, that the environment is an essential pillar of a sustainable development;
- We must rethink the concept of Alqueva together with a development model of Alentejo;
- We should put less emphasis on top-down directed subsidies, and more on supporting whatever really works from bottom-up local initiatives;
- The people, be it local inhabitants, NGOs or interested agencies, must be heard.

Acknowledgements

This work would not have been possible without the dialogue and support of many persons and institutions, although the opinions stated are our exclusive responsibility. We wish to thank first and foremost to all the representatives of environmental NGO at CAIA and the organizations that supported them (GEOTA, LPN, QUERCUS, CEAI, SPEA, FAPAS and CPADA, assembled in the Platform Sustainable Alentejo); to all members of CAIA, with whom it was always possible to disagree amicably and to whom who owe much knowledge; and, last but not least, to the Universities where we got both the scientific background and the fruitful dialogue with many colleagues and students.

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