Environmental and social impacts of Aposelemis dam (Crete, Greece) according to lakeside population’s perception

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Abstract. The current research investigates the environmental and social impact observed today within the vicinity of the Aposelemis dam in NE Crete, Greece. The areas investigated consist of the two adjacent villages of the reservoir, namely; Potamies and Avdou village, respectively downstream and upstream of the dam structure and lake. The research was based on local stakeholders’ opinion, observation and perception, and was conducted through semi-interviews based on a detailed multiple-choice questionnaire format. The present investigation, as a continuation of our former research (presented at ICED2020), examines the environmental and social impact from a different perspective, and focuses exclusively on narrow dam region, attempting to explore current impacts as well as any observed differences between the upstream and downstream village. Provided the intense objections of local communities in the past, presently expressed local opinion is also investigated. The public acceptance of potential hypothetical scenarios concerning area’s future exploitation is moreover explored. The investigation concluded in groundwater resources quantity differentiation between the upstream and downstream area, and also in evaluation differences concerning opinion about everyday life, landscape and the project itself. Current investigation’s results set the basis for management towards sustainability, with emphasis on the environmental and social aspects of the term.

1. Introduction

The Aposelemis dam is located in northern central-eastern Crete, Greece, in vicinity with the villages of Potamies and Avdou, respectively downstream and upstream of the dam-reservoir, while former Sfendyli village is currently submerged in the lake (figure 1 & figure 2). The dam has a height of 61m and a reservoir’s impounding of approximately 25.3 hm³ [1].

The Aposelemis water supply project was implemented in order to provide drinking water for Heraklion city, Agios Nikolaos and additional areas of the wider intermediate region [2]. The dam commenced in supplying drinking water during late 2015 [3], while the total Aposelemis project – consisting also of a tunnel diverting surface water from uphill Lasithi Plateau into the reservoir – begun its full operation in early 2019 [1]. During the total Aposelemis project operation of recent winter periods (2019 – today), while high precipitation rates occurred within the wider area, the
reservoir rapidly achieved the maximum capacity level, and subsequently controlled overflow procedures took place for security reasons [1].

The total Aposelemis project was characterized of a long term planning and construction period [3], encountered various technical difficulties [4, 5] and significant opposition and objections from the local communities in the past [3]. The history of project’s disapproval concerns various actions and protests against implementation, including submission of appeals to the Council of State and to the European Commission in 2001 [3].

![Study area of Aposelemis dam and reservoir (Google Earth Pro, 2021).](image)

As a continuation of our former research concerning impacts of the total Aposelemis project [1], the current investigation focuses exclusively on the narrow dam-reservoir region, attempting to explore today public opinion and perception of the lakeside area, and also to record any observed environmental impact.

Several works deal with the acceptance of environmental problems [6, 7, 8, 9] and even with water use. However, in the best of our knowledge, the differentiated impacts of dams between upstream and downstream communities are rarely studied [10].

2. Methodology
The research was conducted through semi-interviews with local citizens / stakeholders of the lakeside villages based on a detailed questionnaire format. In general, the snowball approach was implemented.

The questionnaire matrix was designed especially for the dam-reservoir Aposelemis region during our former study [1] and was currently updated. It consists of a two-page multiple-choice format of 32 question fields, covering topics of knowledge / attitude, past opinion, today opinion, environmental observation, opinion for the future and personal characteristics. The updated questionnaire format is given in English at the Appendix.

The sample of participants covered both the upstream village Avdou and also the downstream village Potamies, both genders and a variety of ages, educational levels and occupation groups. In total sixty (60) questionnaires were collected; thirty (30) for each area (upstream and downstream).
Considering the semi-interview approach as well as the resident population of 371 and 357 inhabitants of Potamies and Avdou village respectively [11], it is estimated that the investigated issue has been satisfactorily accessed.

3. Results

According to research findings, a significant percentage of the public opinion expressed objections, hesitation and/or scepticism concerning project’s implementation in the past (figure 3). The main recordings concern issues of local community’s lack of participation in project’s design, insufficient information, and scepticism of environmental and social consequences. The majority of the participants stated that Sfendyli’s resettlement was unsatisfactorily managed, mostly referring to the fact that the promised organized relocation never took place [3].

Although general past opinion does not differentiate between the upstream and downstream area, today opinion in evaluating certain aspects does. Therefore, the total Aposelemis project today is evaluated positively among the majority of Avdou village participants (upstream area), but negatively for the majority of Potamies village interviewees (downstream area). A significant percentage of Avdou participants claim to like the project today, while the majority of Potamies participants state that they either don’t like or are disturbed by the project (figure 3). Everyday life in Potamies village is stated as significantly different since project’s implementation, mainly estimated as negative, while the majority of Avdou participants claimed to observe some kind of alterations in everyday life in both negative and positive aspects. Another contrast concerns the evaluation of the new landscape of the area, which is recorded as “better” and as “worse” according to the majority of the upstream and downstream residents respectively (figure 3). Those opinions are quite apprehended due to the fact that while Avdou village enjoys a view of the lake, Potamies village has a view of the dam’s wall (figure 2c).

Figure 2. (a) Aposelemis dam-reservoir region under full capacity conditions (photograph taken from the SE), (b) Submerged Sfendyli village under full reservoir conditions, (c) Potamies village and Aposelemis dam structure (view from the downstream), (d) Avdou village and Aposelemis reservoir.
In addition, significant differentiation concerns the feelings of the lakeside population between upstream and downstream area. In Avdou village participants state not to be significantly concerned about living near the dam-reservoir, as well as “felt glad” that the reservoir was filled during recent winter periods (2019-2021). However, participants of Potamies downstream village state that living...
near the dam increases feelings of “insecurity”, reaching “anxiety, stress and/or even fear” during the cases of emergency controlled dam overflow procedures of recent winters (figure 3).

Moreover, recorded observation of groundwater resources, differentiate between the upstream and downstream area. Observations from Potamies village (downstream) report exclusively cases of decreased groundwater volume, lower water level and even cases of completely dry wells. However, in Avdou village (upstream) observations concerning groundwater quantity in wells vary between “decreased volume”, “no difference” and “increased volume”, in association with local characteristics and well’s position.

Indicative comparison of the research results on public opinion between the upstream and downstream area via selected questions is presented in figure 3.

Concerning the natural environment, public opinion of the total lakeside area observes significant rise of insects (i.e. mosquitoes) within the lakeside area, higher humidity levels, and increased bird populations (figure 4a). According to the interviewees, Aposelemis river downstream flow is currently significantly reduced, acquiring notable volume only during dam’s controlled overflow procedures.

The majority of the total lakeside public opinion estimate lake’s water quality as poor, referring to materials and structures existing in the reservoir according to local observations (i.e. battery chemicals, asbestos cement sheet materials, building materials, potential agricultural pollution etc). According to the residents, imported fish species exist in the reservoir, altering the native ecosystem of the lake. In addition, local community was concerned by an incident of dead fish during August 2019, which however was not attributed to wastewater pollution according to the corresponding study [12].

Participants stated to be significantly disturbed during the traffic interruption of the new lakeside road, caused by a slope landslide event in late spring 2020 (figure 4b). Investigating the influence of recent covid19 pandemic applied restrictions in association with the opinion about the project, public opinion declares generally uninfluenced. However while certain percentage of the upstream area stated “appreciating the landscape and the walks at the lake”, certain percentage of the downstream area participants claimed that “project’s existence caused additional daily disturbance”.

![Figure 4.](image)

**Figure 4.** (a) Bird population at the reservoir of Aposelemis dam, (b) Slope stability issue (landslide) at the new alignment, which led to road’s traffic interruption for over a month during late spring 2020.

According to local public opinion of the total lakeside area, certain leisure activities occur at the lake (i.e hiking, cycling, fishing etc), while during August 2019 the first lakeside running race was organized by the local community. During the current investigation, the public opinion of the area declares generally interested in the hypothetical scenario of controlled leisure activities organization and / or ecotourism implementation at the lakeside region (figure 5).

Concerning the hypothetical scenario of project’s use for energy production, participants appear to be equally “for” and “against” (figure 5). Although the disagreement concerning extensive structures of energy production (i.e. hydroelectric dams) is apprehended, “clean” energy production may occur
through smaller structures such as a small hydro turbine in the tunnel [13] and / or stand-alone solar systems (photovoltaic systems) installation in water pumping stations of the project [14].

Figure 5. Answers to Questions No 26 & 27, concerning the public opinion of the total lakeside area on hypothetical scenarios of future exploitation.

4. Discussion & Conclusion
Considering the existing literature gap concerning studies that focus on the differentiated impacts of dams on upstream and downstream communities [10], the current investigation within the Aposelemis dam-reservoir area aims to explore any differences based on recorded local observation and opinion. Public’s perceptions vary according to the residence area, practices, and the degree of emotional attachment to the natural environment of an area [15].

According to McCartney (2009), the relationships between biophysical and socio-economic aspects of systems are not well understood, and the social implications of the alteration of ecosystems cannot be foreseen [16]. The current research highlighted differences between the upstream and downstream village in certain aspects, concerning the evaluation of the project in everyday life, landscape, mental health and groundwater resources.

Based on current investigation’s findings, the main suggestions and / or good practices towards the sustainability of the dam-reservoir area concern the following:

- Organization of controlled leisure activities and ecotourism implementation at the lakeside area appear as a greatly accepted scenario by the local community. However, the activities should be organized with special care, according to ecotourism UNESCO principles [17], providing socio-economic benefits for the local communities, while respecting the natural environment. Broader involvement of affected individuals in decision-making processes facilitates implementation [18].
- As Wilk-Woźniak et al. (2021) noted, “keeping the catchment tidy and unpolluted is the basic recommendation for managing of dam reservoirs” [19], the lakeside area should be clean and safe. Therefore, suggested actions concern the aspect of cleanliness and neatness regarding materials’ removal from the reservoir and proper wastewater treatment for the catchment area, as well as the aspect of safety (i.e. safe road conditions) including security at the lakeside area (referring to an assault event near Sfendiylı village in early 2021).
- Finally, small and “gentle” structures concerning renewable energy production (i.e. small hydro turbine [13], solar systems [14] etc) could be introduced at the area.

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Appendix: Questionnaire format (in English)

QUESTIONNAIRE FOR THE INVESTIGATION OF ENVIRONMENTAL IMPACTS OBSERVED WITHIN THE APOLEMS DAM REGION

ATTITUDE - EXPECTATIONS

1. Where do you live (z.know of any lake dwelling villages)?
   - Yes
   - No
   - Other

2. How long do you live here? (in years)
   - < 40 years
   - 40-20 years
   - 20-10 years
   - 10-5 years
   - > 5 years

3. Did you acquire any assets that were expected due to Alopenis dam project implementation?
   - Yes
   - No
   - Other

PAST OPINION

4. Did you observe a decline in population before the project's implementation?
   - Yes
   - No
   - Other

5. If yes, please explain why:
   - In my opinion, the local community did not participate in the project's design.
   - In my opinion, there was not sufficient community information during the project's implementation.
   - Other

6. What is your opinion of the project residents' resettlement?
   - Significantly difficult
   - Slightly difficult
   - No difficulty

7. Have you worked at the project during/on the construction period?
   - Yes
   - No
   - Other

TODAY OPINION

8. How do you evaluate the total Alopenis project today?
   - I like it
   - I don't like it
   - It disturbs me
   - Other

9. Has your everyday life changed since the project's implementation?
   - Yes
   - No
   - Other

10. If yes, your everyday life has changed. 
Press [1] to continue:
   - Very good
   - Good
   - Medium
   - Poor
   - Very poor
   - Other
   - Other

11. How do you evaluate the new landscape?
   - Better
   - In similar
   - Worse
   - Other

12. In your opinion, the quality of the reservoir's water...
   - Very good
   - Good
   - Medium
   - Poor
   - Very poor
   - Other

13. How do you feel living near the dam?
   - Feel good
   - Feel indifferent
   - Feel it is necessary
   - Other

14. During the last period of 2019-2020 and 2021, that the dam's reservoir was filled with water...
   - I was pleased
   - I was uninterested
   - I felt it was not necessary
   - Other

15. Concerning the Emergency Plan of controlled dam's overflow during winter periods of 2019, 2020 & 2021, did you feel worried?
   - Yes
   - No
   - Other

16. Do you consider the total Alopenis project successful?
   - Yes
   - No
   - Other

17. In your opinion, are there any impacts due to the project on your daily life? Yes, social benefits
   - Yes, economic benefits
   - Yes, environmental
   - Other

18. Did the new roads traffic interruption due to lake dwelling events during late spring 2019? If yes, please explain:
   - Yes, negatively
   - Yes, positively
   - Other

19. Did the pandemic restrictions influence your opinion of the project?
   - Yes, negatively
   - Yes, positively
   - Other

ENVIRONMENTAL OBSERVATION

20. Have you observed any environmental alterations due to the project, concerning...
   - Animals & birds
   - Plants & trees
   - Other

21. Have you observed any surface water alterations (Alopenis river) due to the dam project?
   - Increased volume
   - Decreased volume
   - Other

22. Have you observed any groundwater alterations (in wells) due to the dam project?
   - Yes
   - No
   - Other

23. Have you observed any soil moisture alternations (in springs) of the area (i.e., changes in the dam's reservoir)?
   - Yes
   - No
   - Other

24. Which lake dwelling activities take place at the dam's area?
   - Hiking
   - Fishing
   - Other

OPINION FOR THE FUTURE

25. In your opinion, could the new lake upgrade contain cultural activities in the area (i.e., lake or lake attractions) organization in August, 2015?
   - Yes
   - No
   - Other

26. Are you interested in the hypothesis scenario of controlled lake activities organization at the lake area (i.e., creating infrastructure, taking activities, nature observation etc.)
   - Yes
   - No
   - Other

27. What is your opinion on the hypothesis scenario of project's use for energy productivity?
   - Agree
   - Disagree
   - Other

28. PERSONAL CHARACTERISTICS

29. Gender: Male / Female

30. Age group: 13-24 / 25-39 / 40-54 / 55-64 / > 65

31. Educational level:
   - Elementary school
   - High school
   - Technical studies
   - Postgraduate studies

32. Profession/Occupation:
   - Lawyer
   - Teacher
   - Other

33. Residence:
   - Rural
   - Urban
   - Other
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