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Connecting Visions for a Collaborative Development of El Oulfa Pond (Casablanca, Morocco): Involvement of Civil Society and Scientists

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Abstract: In urban context, wetlands play a proven role in retaining pollution, alleviating the impacts of climate change, and enhancing the well-being of citizens. Managing these ecosystems requires formulating an integrated development policy reconciling protection, enhancement, and the satisfaction of economic and social needs. Achieving this goal requires the establishment of a holistic and collaborative vision that engages all stakeholders. This paper focuses on rehabilitating the El Oulfa Pond located in Casablanca, outlining the role of civil society and scientists in producing quantitative and qualitative data. This work aims to facilitate an informed decision-making process concerning the pond's development. The quantitative analysis enabled us to characterize the water quality and identify the biodiversity of El Oulfa pond. The outcomes underscore that 60% of the bird species whose presence around the pond is confirmed require a habitat in a wetland. Some species identified are classified as rare, or endangered. 23% of the recorded plants are indicative of a natural area of ecological Interest. These characteristics are important to take into consideration when developing the site. The biodiversity in El Oulfa pond could be jeopardized by significant water pollution. Indeed, the parameters of surface water monitored between 2015 and 2021 show concentrations that exceed the Moroccan thresholds relating to fish water quality. This suggests that for these parameters, the ecosystem does not provide conditions conducive to the maintenance of biodiversity. This pollution also poses challenges for residents who have expressed, during the open forum and interviews conducted in this study, the critical need for depollution and securing the pond before initiating any development. Building upon the study's findings, development strategies have been proposed to enhance the site and promote collective stewardship.

Introduction

In recent years, numerous reports have shown humanity's failure to tackle two of the major global crises: climate change and biodiversity loss (CBD, 2020 ; IPBES, 2019; WWF, 2020). The delicate balance between biodiversity and ecosystems is in jeopardy as a result of the increased industrialization, urbanization, and unsustainable practices mankind is facing (Dirzo et al., 2014; Kapitza et al., 2021). We cannot achieve biodiversity conservation without tackling climate change and vice versa. Thus, it is always recommended that protecting and restoring ecosystems is the only nature-based solution to reduce climate change and biodiversity loss and their interlinked consequences on the surrounding environment that underpins human wellbeing (Seddon et al., 2021).

Ponds are among the ecosystems severely impacted by these changes. However, due to their small size ($1m^2$ to 2–5 ha.), can be permanent or seasonal, man-made or natural (Richardson et al., 2022) and often the

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underappreciation of the benefits they provide, ponds are particularly vulnerable to anthropogenic stressors, including climate change, pollution, or habitat degradation (Hill et al., 2021; Epele et al., 2022). Small ponds and pond networks provide crucial ecosystem services - improving human well-being by providing aesthetic enjoyment and leisure, providing habitats for biodiversity, acting as carbon sinks, and mitigating climate change (Cuenca-Cambronero et al., 2023; Díaz et al., 2018; Hill et al., 2021; Walton et al., 2020).

Recently, scientific and nonscientific communities have significantly increased recognition of the importance of ponds and pondscapes to biodiversity and ecosystem services. Despite these benefits, current national and international environmental legislation and management strategies are almost exclusively focused on large waterbodies (Hill et al., 2018), with ponds being rarely monitored in a systematic manner because of the resource and logistical implications for protecting these abundant waterbodies. As evidence of the deterioration of natural ecosystems is growing, large-scale approaches with strong national and international collaboration are needed to face these global challenges.

Governments increasingly involve local communities and non-governmental organizations in managing natural resources (Puja et al., 2007). The ways in which different stakeholders are involved vary from being consulted to taking a central role in planning and monitoring and—infrequently—being given the legal right to manage resources. Ponds provide frequent opportunities for citizens to engage in conservation and habitat management activities, especially when linked to education or enjoyment of wildlife through dedicated trails (Willis & Samways, 2013). Given the inadequate funding levels for global biodiversity conservation (Waldron et al., 2013), there is increasing reliance on agencies such as environmental charities to act as intermediaries among government policymakers, stakeholders, and the public to realize the aspirations of conservation initiatives. This participation can be more effective if the community understands the value of its participation, what is required of it, and the necessity of working jointly with the government and other organizations (Akrout Yaiche, 2002; Dominguez-Rendo ´n et al., 2024; Layson and Xia, 2015; Zetlaoui-Leger, 2005).

In Morocco, the constitution ensures citizen participation in decision-making, and the political commitment to pursue this direction signifies a shift in the stance of public authorities regarding the role the population ought to assume (Seddiki, 2020). Nevertheless, in actual practice, citizen involvement is predominantly confined to "information" or "consultation," lacking significant influence on the decision-making process (Raki and Houdret, 2021).

This work is part of a partnership between a research association from Hassan II University, an association of agricultural development engineers from the city of Angers, and the delegated authority for liquid sanitation in Casablanca. It focuses on the development of the El Oulfa pond, located in Casablanca, which is suffering from advanced degradation, affecting the quality of life for residents. Several rehabilitation attempts have been made but have shown their limitations due to the lack of a thorough diagnosis and a participatory approach that could involve all stakeholders, particularly the local population. The goal is to suggest recommendations that meet the expectations of local communities and consider the improvement of the pond's water quality, the preservation of its biodiversity, and the development of its banks to make it a living space. Consequently, the methodology had to identify riparian needs and environmental issues related to the study area. We initially attempted to assess the lake's current state to better understand its rehabilitation. To achieve this, we mapped pollution sources and characterized water quality through physico-chemical and bacteriological analyses. Ornithological and floristic inventories were also conducted based on previous studies and on-site observations. The population's uses, perceptions and expectations were identified through an open forum, semi-structured interviews, and behavioural observations with individuals living and acting in the study area.

Materials and Methods

Presentation of the study area

The El Oulfa pond can be found in the southwestern part of Casablanca, within the Hay Hassani prefecture. Spanning 7 hectares, this body of water occupies the grounds of a former quarry, where water sources uncovered during excavation activities contribute to its supply (figure 1). On its western side, the pond is flanked by a cliff, standing several meters high, characterized by geological formations primarily composed of Acadian-age quartzites (Destombes and Jeannette, 1954).

Methodology

The approach taken in this study is interdisciplinary and consistent with the culture of environmental sciences. It combines qualitative and quantitative methods, synthesizing the results to formulate recommendations that aim to convert the pond into a residential area while safeguarding its long-term sustainability.

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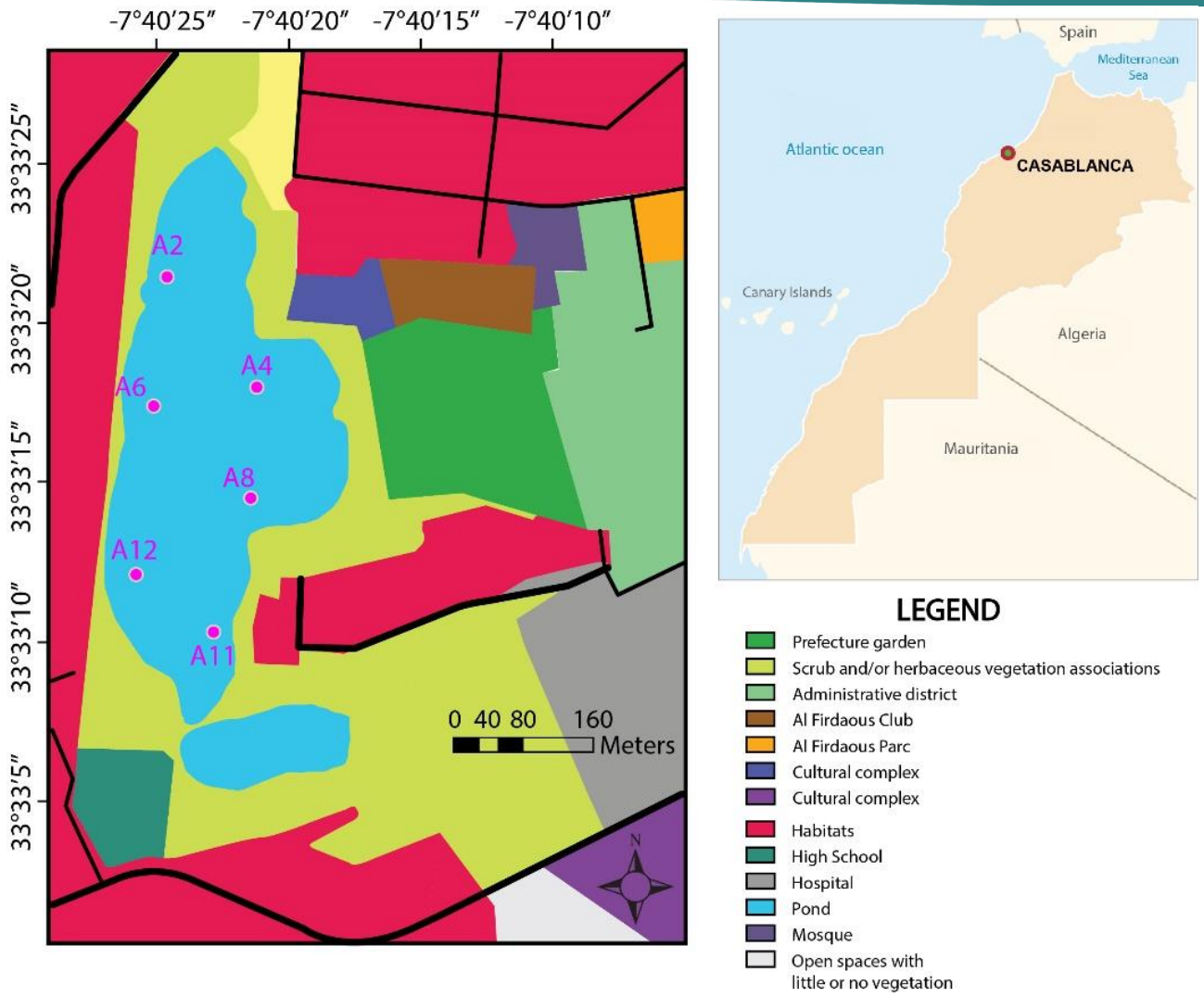

Figure 1. Study area and water quality sampling sites.

During the initial stage, our efforts focused on assessing the pond's water quality and creating an initial inventory of its biodiversity to enhance our understanding of its rehabilitation. In the subsequent phase, we aimed to identify the needs and expectations of the population through observations, interviews, and an open forum (figure 2).

The methodologies employed in this study encompass the application of the Environmental Delimitation Methodology to El Oulfa's urban wetland, followed by floristic and ornithological inventory methodologies. The goal was to identify floristic and ornithological species of interest present in the pond. Furthermore, a participatory approach was specifically applied, emphasizing consultation and diverse stakeholder involvement in project management. Lastly, the study incorporated a social component to integrate the opinions of residents and stakeholders related to the pond within the context of the maintenance and rehabilitation project.

A brief textual analysis was conducted using R Studio software to facilitate the presentation and interpretation of data from the Open Forum discussion reports (Version 2022.02.2).

Pond Water Quality

Water samples were collected from 6 sampling stations distributed alongside the pond, including areas where liquid and solid discharges were observed (figure 1), during different periods over 6 years (2016–2021). Water samples were collected in acid-washed 1L polyethylene bottles and immediately transported to the laboratory for further analysis. Four (4) indicators parameters, such as: total phosphorus (TP), ammoniacal nitrogen (NH^+_4-N), nitrate (NO_3) and biochemical oxygen demand (BOD_5), were analyzed in the laboratory using the same analytical techniques following the standard methods (Rodier et al., 2009). All analyses were duplicated, and the results were expressed as the mean. The obtained data are compared to the Moroccan quality standards for surface water quality (Official Bulletin, 2004) to assess the ecosystem's capacity to support biodiversity.

Ornithological inventories

The ornithological inventory was conducted during the month of May in the year 2022 using the Birdnet application (Kaye, 2022; Manzano-Robio et al., 2022) and following the recommended conditions by Sanz

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Perez et al. (2020). Ten listening points were selected after on-site observations to cover the entire area while positioning close to preferred nesting sites. Recordings of 20 minutes were made at sunrise, during the "morning chorus," and at sunset to identify crepuscular and nocturnal species as well. All species heard were inventoried, noting the number of occurrences and the plausibility of the results. The listening observations were supported by bibliographic research (Rihane and Hamoumi, 2018; El Hamoumi et al., 2022) on the recorded species as well as by visual observations. The International Union for Conservation of Nature (IUCN) global red list of threatened species was used to determine the threat level of the species present.

Floristic inventory

The floristic inventory by transects was chosen for this study due to its practicality and ease of implementation (Lazare, 2002; Rayaissé et al., 2009). This inventory took place during the dry season between May 3 and June 3, 2022. The transect was conducted from visible and passable paths at the physical limits of the pond's shores, moving from upstream to downstream. The observed plants were recorded progressively during the mission and characterized based on their origin and status using the species search tool of the INPN (Oulès and Solène., 2018). Additionally, they were characterized according to their indication of a wetland area, relying on the list of species listed in the French State Decree of June 24, 2008, specifying the criteria for the definition and delimitation of wetland areas.

Faculty of Sciences Aïn Chock, members of local associations, ornithology specialist associations, and the liquid sanitation manager were invited to this forum (50 participants). The chosen venue for the forum was the cultural complex in the neighbourhood where the lake is located. Resource persons were identified beforehand and equipped with computers to write real-time reports for each workshop.

Interviews

The chosen method is one of semi-structured interviews, characterized by "a set of imposed themes that must all be addressed, with open-ended questions, allowing the interviewee the freedom to respond, particularly in the order of responses" (Pin, 2023). The goal is to gather information regarding the residents' perception of the neighbourhood and the wetland, sharing their vision of the environment.

Since the open forum provided a significant amount of data on the expectations of the neighbourhood residents regarding the pond's rehabilitation, we opted to conduct interviews with only 9 individuals – presidents of associations actively involved in activities in the neighbouring areas, as they are in daily contact with the residents.

Result and Discussion

Water quality of the pond

The results of the parameters studied are represented in figure 3. BOD5 varied from 3.66mg/L (A12, 2017) and 44.3mg/L (A11 and A12, 2021). The TP range was

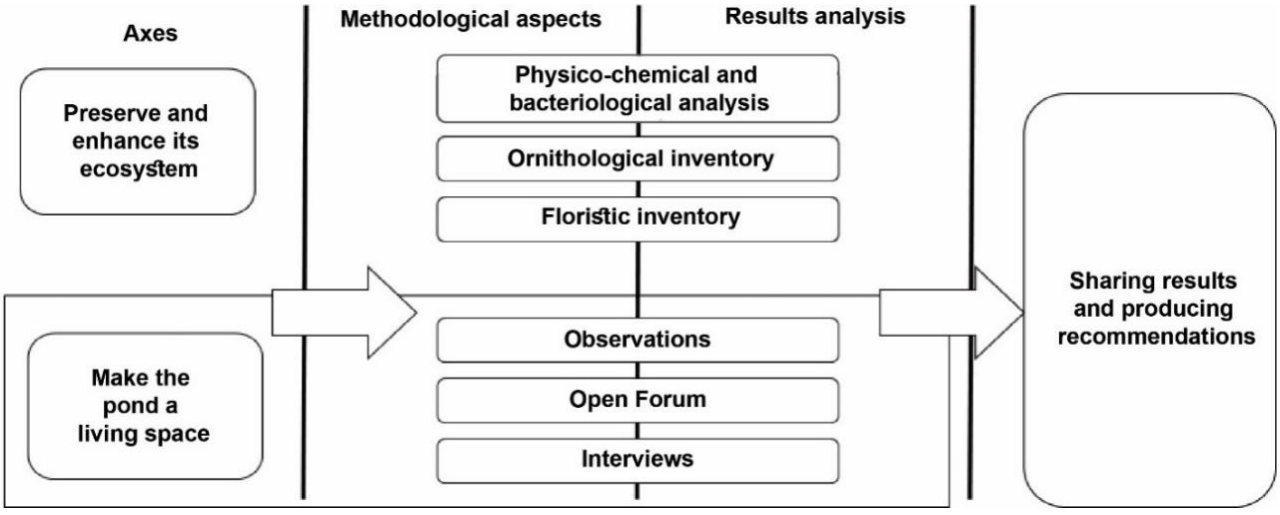

Figure 2. Methodology adopted for the production of recommendations.

Population Survey

Open Forum

The adopted methodology is based on adhering to the principles of the Open Forum (Owen, 2008), ensuring its acceptability and success. Residents from neighbourhoods around the pond, academics from the

1.04mg/L (A8, 2020) – 8.29mg/L (A11, 2021). The ammonium concentrations ranged from 0.05mg/L (A4, A8, A11 and A12, 2020) to 15mg/L (A6, 2021), while nitrates concentrations varied from 0.03mg/L (A2, 2018) to 15.4mg (A8, 2021). The four parameters had relatively higher concentrations in 2021 than in other years.

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The parameters monitored between 2015 and 2021 show concentrations that exceed the Moroccan thresholds relating to fish water quality (figure 3). This suggests that, for these parameters, the ecosystem does not provide conditions conducive to the growth and reproduction of aquatic organisms, thereby jeopardizing the maintenance of the fauna inhabiting the area. Elevated levels of biochemical oxygen demand (BOD_5) (Figure 3.a), total phosphorus (Figure 3.b), ammonium (Figure 3.c), and Nitrates (Figure 3.d) indicate contamination from wastewater (Chakri et al., 2019). The improvement in water quality noted in 2020 is attributed to restoration measures implemented by the sanitation delegate, involving the installation of an aeration system coupled with biological treatment (Nachchach et al., 2024). However, these measures have shown their limitations as total phosphorus concentrations continue to increase. In 2022, they exceeded 8 mg/L, placing the lake at the hyper-eutrophic level (Vollenweider, 1968).

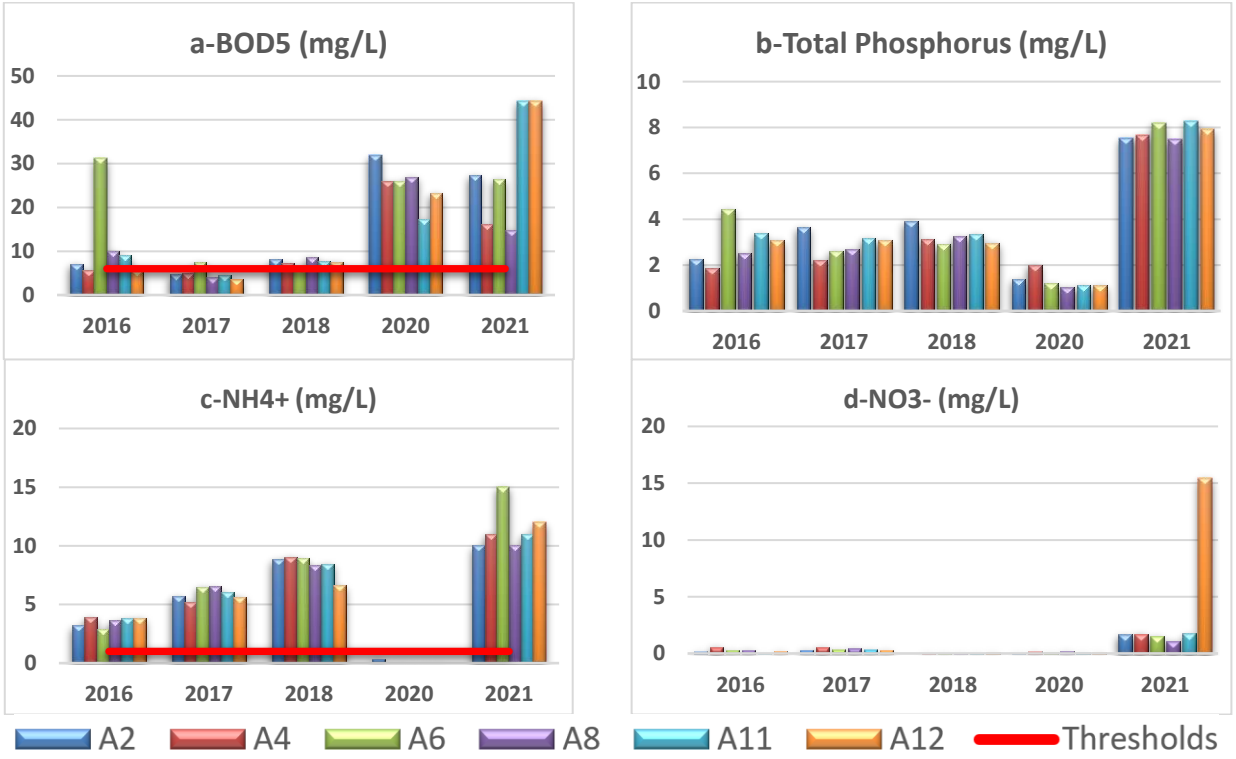

Figure 3. Temporal evolution of some water quality parameters of El Oulfa pond.

Ornithological inventory

This work has allowed the establishment of a non-exhaustive list of potentially present birds in the study area. We were able to identify 71 different species, which we classified into 4 categories based on their likelihood of presence around the El Oulfa pond (Table 1). The "Confirmed" category includes 12 species that we were able to identify either through visual confirmation or the relevance of the number of observations and their likelihood of recognition. This includes the cattle egret (Bubulcus ibis) and the glossy ibis (*Plegadis falcinellus*). The "Probable" category includes 10 species with a lower relevance of observations and recognition probability compared to the higher category but sufficient to consider their presence in the pond. However, no visual confirmation has occurred. This includes the swift and the sandpiper, for which the distribution range and preferred habitat coincide with the pond's ecosystem.

Close to 60% of the species whose presence around the pond is considered "confirmed" require a habitat in a wetland. This characteristic is essential to highlight in the development of this urban site, aiming to preserve biodiversity. No globally threatened species have been identified. However, some are classified as rare, endangered, or vulnerable in Morocco.

A slight loss of biodiversity is noted by comparing this inventory with the species listed by Belkattab et al., 2014, and observations made between 2016 and 2017 by Rihane and Hamoumi (2018). Some previously present species have now deserted the pond, such as the purple swamphen (Porphyrio), classified as endangered in Morocco.

Floristic inventory

Following the conducted transect, 123 different plant species were identified around the pond. Among these, 30.3% are native to the broader study area, meaning they originate from North Africa or the Mediterranean region. In comparison to previous studies, all seven species listed in the work of Belkhattab et al. (2014) were found in the inventory.

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No species classified as "rare" according to the IUCN were observed. However, two threatened plants were documented, according to the IUCN. Several invasive species, such as the Provence reed, edible ice plant, and common castor bean, were identified. 23% (35 plants) of the recorded plants are indicative of a Natural Area of Ecological Interest, Faunistic and Floristic (ZNIEFF) according to the INPN, 6.6% (10 plants) of the total plants identified in the area are indicative of a wetland, including species like *Arundo donax*, *Alternanthera philoxeroides*, *Typha* sp., *Silene* sp., or *Althaea officinalis*.

Table 1. Distribution of recorded ornithological species.

Category	Confirmed	Probable	To confirm	Excluded
Species Count	12	10	21	28
Species Requiring Wetland (in %)	60 %	55,5%	38%	32%

Observations of frequentation of the pond: a marginal space with varied uses

The observations of activities allowed the identification, on the one hand of important physical locations within the space (playgrounds, informal dumps, areas with a high presence of birds, etc.), as depicted in Figure 4a and on the other, the patterns of use and visitation of the space by individuals, represented in Figure 4b.

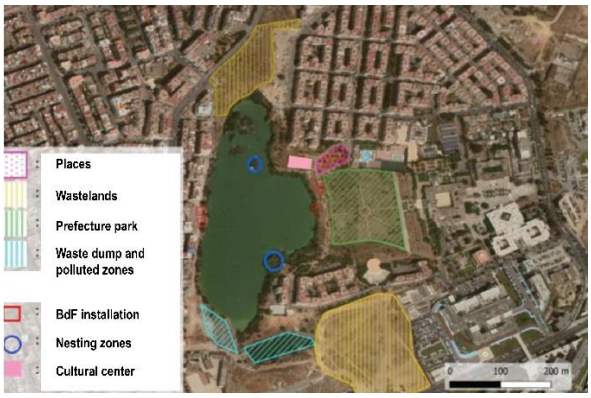

Figure 4. a. Notable locations on the site.

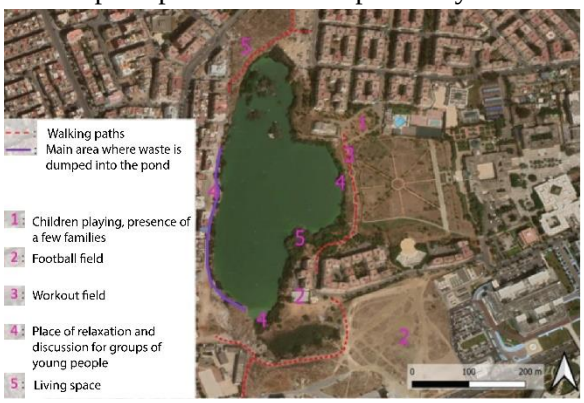

Figure 4.b. Attendance and use of space.

These results thus demonstrate that this area, despite being less developed, is frequented for various purposes (transit, recreation, sports, relaxation, waste disposal). While some of these uses, such as walks and recreational activities, are typical of urban green spaces (Long and Tonini, 2012), others, such as living areas and waste disposal sites, appear to be more associated with the undeveloped nature of this space.

Population survey

The concerns arising from the reports of the Open Forum discussions and semi-structured interviews (figure 5a and b) relate to the lack of awareness around the pond, insecurity due to deteriorated barriers and insufficient evening lighting, disposal of solid and liquid waste, the proliferation of mosquitoes, stray cats, snakes, and scorpions during the summer. The unpleasant odors resulting from the poor water quality of the pond and the absence of accessible and free sports facilities are also highlighted. However, it has been observed that there are numerous hopes for the rehabilitation of the area. In their interviews, some citizens even described the pond as a "lost gem" or a "golden nugget covered in mud." Besides representing a significant biodiversity resource, this space is also a real opportunity for the neighborhood.

Several groups have suggested enhancing security measures by installing barriers or surveillance cameras. Effective awareness campaigns emphasizing the need to preserve the surroundings of the pond could foster a sense of responsibility among residents, reducing waste disposal. The development of lucrative tourist activities could benefit the community and finance site maintenance. There is also a strong demand for the implementation of recreational activities for children and young people.

The perception of the pond by residents and stakeholders in the neighborhood is thus ambivalent, with a negative dimension linked to its degraded and hazardous nature and a positive dimension associated with the resource it represents as an ecosystem. The space's rehabilitation and development can potentially change the negative perception.

Conclusion and recommendations

The analysis of various study results has allowed the description of the current situation of the El Oulfa pond through multiple perspectives: it is both an undeveloped but frequented, used, and consequently perceived urban space and a degraded urban wetland providing ecosystem services that should be valued.

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The recommendations address the initial question: How can the El Oulfa pond site be transformed into a living space for residents while ensuring its sustainability? To answer this, action hypotheses (objectives) were formulated and guided our study axes:

#Axis 1: Transform the El Oulfa pond area into a living space.

#Axis 2: Preserve and enhance its ecosystem.

Our work confirmed these action hypotheses, emphasizing the importance of integrating these two objectives. This led us to consider three major types of actions:

#Rehabilitate and secure the space.

#Develop and enhance resources.

#Implement balanced management to ensure that the living space is also a conservation space.

health and well-being of residents. The challenge is to positively alter the perception that residents have of the pond, moving away from the notions of being "dirty," "abandoned," and "dangerous."

Figure 6 below summarizes all the proposed solutions for pond rehabilitation. Squares represent problems, and solutions are represented by circles. Arrows connect each suggested solutions to the identified problem(s). Some solutions address multiple problems.

Development and enhance resources.

All these recommendations concerning the development of the El Oulfa pond area are presented on the map below (Figure 7).

Any decision to modify the landscape must consider the following elements:

#Residents must retain the freedom to move around

Figure 5(a). Open Forum discussions and (b) semi-structured interviews.

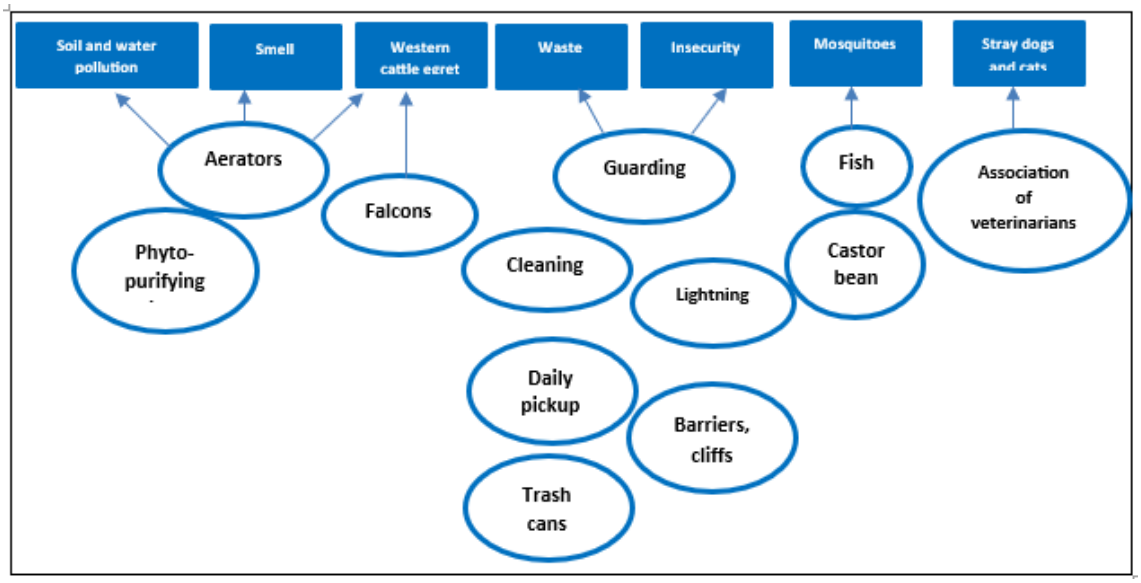

Figure 6. Solutions proposed for the rehabilitation of the pond.

Rehabilitate and secure the space

The recommendations were first concerned with the rehabilitation of the pond. The objective is to restore the balance of the ecosystem and prevent risks related to the

the pond and consider it as part of their living environment. They should be able to use their accustomed paths without restrictions.

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#Plant populations on which birds' nest must be preserved for the conservation and reproduction of the species.

#Rare and endangered plant species must be protected and should not be uprooted during developments.

Figure 7. Map of a development of the banks of El Oulfa pond.

Carrying out a balanced management to ensure that the living space is also a conservation space

All recommended developments cannot be sustainable without the inclusion and information of residents throughout the process of rehabilitating and developing the El Oulfa pond. Institutional stakeholders must be attentive to the expectations of local actors (residents, neighbourhood associations, researchers, etc.) and integrate them into future development projects. The integration of these stakeholders into the project, initiated during the open forum, should be maintained thereafter. This can be facilitated through other consultation workshops and by connecting various entities (neighbourhood associations, scientific research teams, institutions, etc.). Involving residents in the project will also reduce the risks of contestation and damage to the infrastructure and equipment provided by their re-appropriation of the space. Monitoring the ecosystem's balance is important to sustain the balance of the space and its management, raising awareness for better coexistence and developing connections between stakeholders. Regarding the implementation of the recommendations, rehabilitation and developments should be carried out simultaneously to initiate a virtuous circle of biodiversity protection (Gillot,2005).

Conflict of Interest Statement

This is to certify that there is no conflict of interest in this paper.

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