

Freshwater fish farming in tunisian reservoirs: zoo-sanitary registration status

Abstract

This work aims to investigate freshwater fish exploitation status in three Tunisian reservoirs: Siliana, Lahjar and Kasseb associated with the examination of progress in the zoo-sanitary registration. Three types of operators at these reservoirs were identified: a promoter, a fishery development group, and independent fishermen. The only operator who has all the required documents for the zoo-sanitary registration, is the promoter operating at Lahjar Reservoir.

The SWOT analysis applied to Siliana, Lahjar and Kasseb reservoirs allowed us to highlight the differences between the three modes of exploitation and to identify their strengths and weaknesses. Along with these findings, the analysis revealed factors that may directly or indirectly affect the reservoirs and made it possible to elaborate new perspectives which would help improve the inland fish farming sector in Tunisia.

Keywords: registration, zoo-sanitary, fish farming, exploitation, freshwater, Tunisia

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Abbreviations: DGSV, general Directorate of veterinary services; GDP, fishing development groups; ANPE, national agency for environmental protection; INSTM, national institute of marine sciences and technologies; APIA, agency for the promotion of agricultural investments; DGPA, general directorate of fishery and aquaculture; ISPAB, higher institute of fishery and aquaculture of bizerte; CTA, technical centre of aquaculture, TCA; IRESA, institution of agricultural research and higher education

Introduction

The experience of freshwater fish farming in Tunisian reservoirs was initiated in the 1960s by the National Fisheries Office. This began with the experimental stocking of reservoirs with fry of various fish species.¹⁻³ Currently, this activity involved a fishing effort composed of 230 boats and about 450 fishermen operating in 35 dams.^{4,5} Extensive fish farming, offers fishermen an opportunity to produce profitable fish at low prices that can be easily sold or consumed. Eventually, production of freshwater fish reservoirs increased from 843.5 tons in 2000 to over 1073.194 tons in 2020 harvesting mainly mullet, carp, pike perch, eel, catfish and tilapia.⁶⁻⁸ The observed growth rate of the introduced species into these reservoirs demonstrated a significant production potential. Aware of these and similar opportunities in freshwater fish farming, Tunisia put in place a strategy to develop its freshwater resources.⁹ However, despite several efforts, fisheries management of dams in the country still faces several technical and administrative problems.

Among the deployed efforts to enhance and develop the sector is the zoo-sanitary registration procedure in Tunisian reservoirs, which was set up by the General Directorate of Veterinary Services (DGSV).¹⁰ Zoo-sanitary registration is an administrative authorization, for the marketing of freshwater fish, issued by the competent authority for animal health. This authorization aims to monitor the introduction and spread of aquatic animal diseases and to enhance the valorization and marketing of freshwater fish farming in reservoirs. According to the memorandum n°200/576 governing the requirements for zoo-sanitary registrations of freshwater operations, dated March 6th, 2020,

this authorization is required from operators of freshwater reservoirs holding a fishery license¹⁰ and rearing and/or keeping aquatic animals in extensive systems. However, out of 34 freshwater reservoirs operated in inland fish farms in Tunisia, only Laabid Reservoir obtained a zoo-sanitary registration authorization in 2018.¹¹ In front of this situation, this study seeks to bring understanding of this procedure through a focused study on freshwater fish exploitation in three Tunisian reservoirs: Lahjar, Kasseb and Siliana and eventually guide the operators to gain the authorization. Indeed, this investigation not only pinpointed the underlying issues associated with the obtainment of the zoo-sanitary registration authorization, but also allowed us to identify the highlights and challenges of this activity and to propose corrective actions for sustainable exploitation.

Material and methods

Study areas

The studied reservoirs (Lahjar, Kasseb and Siliana) are exploited mainly to supply drinking water to the riparian areas and to irrigate the surrounding agricultural zones.^{6,9,12,13} These fishery resources are exploited by three types of operators: a private developer, a fishery development group and independent fishermen.^{14,15}

Lahjar Reservoir is a hill lake located in the governorate of Nabeul (36°54'18" N, 11°01'14" E) and it is used for irrigation. Fishery resources in this dam reservoir are exploited by the promoter.^{16,17} Kasseb Reservoir spreads about 20km west of the town of Beja (36°45'32" N, 9°0'20" E) and it is operated by independent fishermen.¹⁵⁻¹⁷ Siliana Reservoir is situated in the north of Siliana city (36°09'26" N, 9°20'55" E) and is used for irrigation. This dam is operated by a fishing development group composed of four fishermen (Figure 1).¹⁵⁻¹⁷

Data collection

Zoo-sanitary registration in these reservoirs requires a number of documents related to the exerted freshwater fish activity. In order to examine the status of the freshwater fisheries in the reservoirs of Lahjar, Kasseb and Siliana, we collected statistical data on production

(monthly by type of fishing and by species). These data were collected from organizations involved in this sector, notably CTA, INSTM, ISPAB, DGPA, DGSV and APIA.¹⁷ Other data were gathered during field visits through personal interview surveys in Lahjar, Kasseb and Rotengle by Rudd which were conducted on a monthly basis between March and September 2021.¹¹

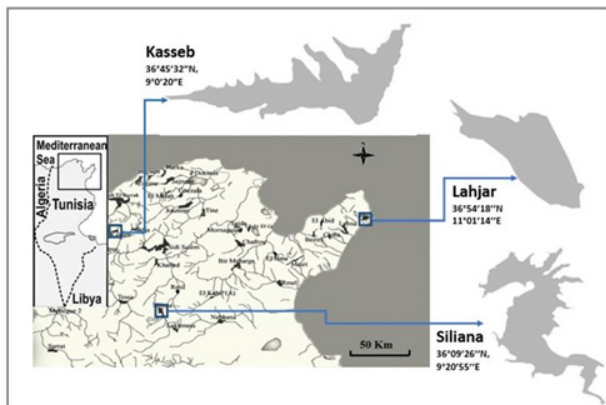


Figure 1 Study areas (Siliana, Lahjar, and Kasseb Dams).

It is worthy to note that the data collection process was fraught with difficulties with regards to mobility, and to the reluctance of some fishermen to cooperate and to provide valid information. Such problems have already been elucidated in previous studies conducted at Tunisian reservoirs by Mili et al.⁶ Mili et al.⁹ Losse et al.¹² Mtimet¹³ Mili¹⁴ and Elloumi¹⁸ Despite these challenges, though, the data collected helped us gain an insight into the status of the freshwater fisheries in these reservoirs.

Zoo-sanitary registration procedure

Zoo-sanitary registration requires a number of documents including the registration application form, other authorization certificates, such as the fishing license and ANPE authorization, which provide information on the nature of the fishing activities.¹¹ The zoo-sanitary registration application must be completed and signed by the operator of the reservoir. The list below includes all the required documents for the application.^{10,18}

- A copy of the freshwater reservoir operating license;
- A copy of the authorization from ANPE;
- A plan of the location of the exploitation (scale 1/1000 minimum) indicating the boundaries, the accesses and the surroundings of the exploitation as well as the fishing area;
- The number of people working on the farm and their qualification;
- Description of the used equipment and devices;
- Description of the reservoir activities including the type of cultivated species, the stocking schedule, annual schedule, production by species, list of suppliers of fry and/or larvae, the landing site with contact information, marketing of the product, neighboring activities (agricultural or other), etc;
- The recorded production as in the model of the follow-up sheets.

SWOT analysis

The investigated reservoirs are exploited by three different types of operators.^{6,9,18} The investigation was based on the information collected through the surveys, field visits and examination of the archives of the national organizations involved in the inland fish

farming sector in Tunisia (CTA, INSTM, ISPAB, DGPA, DGSV and APIA).^{9,14,18} The SWOT analysis sought to clarify the differences between the aforementioned three modes of exploitation and to indicate their strengths and weaknesses (Table 1). In addition, this analysis helped identify factors that may directly or indirectly affect fish farming activity in the reservoirs.

Table 1 Parameters used in the SWOT analysis

	Studied parameters
Internal factors	Characteristics of the reservoir: human resources, production, geographical location, fishing techniques, equipment and gear, etc.
External factors	External elements having an impact on the activity of the exploitation (pollution, climate, etc.); The environment of the operation (competitors, suppliers...)

Results and discussion

The results of this study showed that the freshwater fisheries in the reservoirs of Lahjar, Kasseb and Seliana are highly discrepant, mainly due to the mode of their exploitation.

Kasseb reservoir

At Kasseb Reservoir, the landing of the exploited fishery resource consists in mullet (*Chelon ramada* and *Mugil cephalus*), zander (*Sander lucioperca*), Barbell (*Barbus callensis*), silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio communis*).^{7,9,15} Fish production at this reservoir shows a seasonal variation and it was estimated at 15.99 tons in 2020. The most cultivated species is the mullet (38.08%), followed by barbel (31.64%) and zander (30.30%).⁸ These products are marketed directly (direct sale) and indirectly through resellers.^{6,9,12-14} They are sold at the wholesale market of Tunis and the local market of Beja (Figure 2).

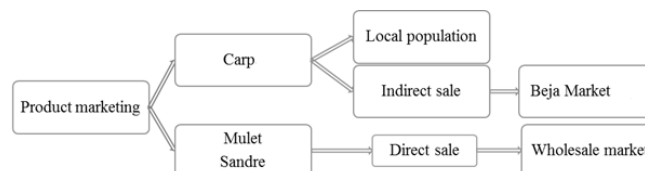


Figure 2 Value chain at Kasseb reservoir.

The harvested fish in this reservoir is rarely kept in freezers except in case of production shortage. It is transported, just after harvest, by means of a refrigerated truck, which keeps its freshness and ensures good quality. This method impacts positively the selling prices.

Siliana reservoir

In Siliana Reservoir, the main ichthyic exploited resources are mullet (*Chelon ramada* and *Mugil cephalus*), pikeperch (*Sander lucioperca*), common carp (*Cyprenus carpio communis*), barbel (*Luciobarbus callensis*) and rudd (*Scandinus erythrophthalmus*) with an annual production which was estimated at 13.02 tons in 2020.^{7,9,14,15} The most harvested species is the common carp which accounts for 36.47% of the harvest volume, followed by pikeperch (26.49%), mullet (19.35%) and barbel (17.66%).⁸ The sale of these products is achieved through an intermediary. Fish is first taken to a storage room in Siliana where it is conserved with ice coverage. Then, it is transported to the wholesale market of Tunis in a refrigerated van (Figure 3).

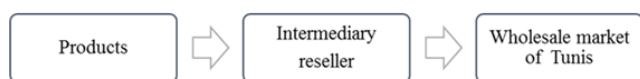


Figure 3 Value chain at Siliana reservoir.

Lahjar reservoir

At Lahjar Reservoir, we recorded 10 species belonging to 5 families during the landings.^{7,9,15} The Mugilidae, represented by *Chelon ramada* and *Mugil cephalus*; the Cyprinidae family including the *Cyprinus carpio communis*, *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis*, *Scardinius erythrophthalmus* and *Rutilus rubilio*. The Pikeperch (*Sander lucioperca*), the Nile Tilapia (*Oreochromis niloticus*), the eel (*Anguilla anguilla*), and the sea bass (*Dicentrarchus labrax*) also feature among the cultivated species.^{14,19,20}

Fish production in Lahjar Reservoir was estimated at 6.04 tons in 2020 with an important seasonal variability.^{9,15} The most harvested species is the mullet (50.05%), followed by tilapia (38.49%), eel (4.57%), common carp (3.86%) and zander (3.01%).⁸ After fish is caught, it is sorted and placed in boxes with ice. Next, it is stored in cold storage spaces. Then, it is transported in an insulated van directly to the wholesale market in Tunis, hotels and restaurants. Additionally, there is high demand for this fish by local consumers (Figure 4).

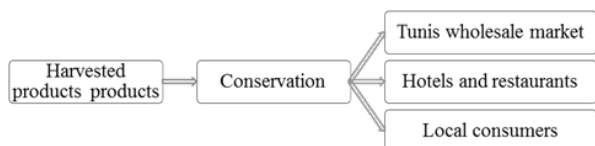


Figure 4 Value chain at Lahjar reservoir.

Workforce

At Siliana Reservoir, we counted an active workforce composed of eight fishermen. While, only three fishermen work at Kasseb exploitation. Lahjar Reservoir Farm, on the other hand, is distinguished by a diversified workforce of 6 people: an administrative agent, a driver, a commercial agent, a guard and two fishermen.

Used equipment and gear

Equipment and gear at Kasseb Reservoir include a non-motorized boat (length 5.92m) made of resin- coated wood, trammel nets and combined nets (mesh size 45mm, 45mm and 60mm) with drops varying between 200 and 600 meshes. The technical characteristics of these gears are comparable to those identified by Mili et al.⁶ in 2015 during the census conducted in 2011. The packaging and conservation equipment is composed of 30 fish boxes and an isothermal cooler. A private refrigerated truck is rented each time the production is higher than normal and requires liquidation in market. These results are akin to those reported by Mtimet¹³

The fishing fleet at Siliana Reservoir encompasses four non-motorized fishing boats (length 5m and 5.5m and 4.20m) made of resin- coated wood. The most deployed fishing gears are gillnets (mesh size 40, 55, 60 and 80 with a drop of 100 meshes) and trammel nets (mesh size 40mm). This has also previously been described in other studies: Mili et al.⁶ Mili et al.⁹ Mtimet¹³ & Mili¹⁴ For packaging and conservation, the fishery development group has a scale and 20 fish boxes. The products are placed in the crates and conserved with ice. Then, they are transported in a private refrigerated truck which is rented at each sale operation.

At Lahjar Reservoir, a motorized wooden boat armored with resin is used. The used fishing gears are mainly gillnets (mesh size 70mm), trammel nets (internal mesh size 45/50/60mm), pots and longlines. With regards to packaging and conservation, the operator has a cold room, an isothermal cooler, a scale and 50 fish boxes. For transport, an isothermal truck is deployed. Regarding the rearing structure, three cages are used in this reservoir. These are made of woven polyamide (mesh size 6mm) with 5m-length, 5m-width and 1.5m-height, and they are placed at 3m-depth. The used equipment are similar to those inventoried during the freshwater fisheries diagnosis conducted by ISPAB and CTA researchers in 2015.^{6,14}

Evaluations of Zoo-sanitary registration

Obtaining the zoo-sanitary registration for a freshwater fishing body depends on several factors. These include the compliance with the requirements, the commitment of the person in charge and the presence of the appropriate conditions ensuring the conservation of the products and the protection of the consumers. The zoo-sanitary registration is a very important step in the development of the Tunisian inland aquaculture sector and the sanitary safety of the farmed products coming from freshwater reservoirs.

Zoo-sanitary registration files include all the specificities and detailed information on the conducted operations in each reservoir. Table 2, summarizes the type of activity in every reservoir and shows the dates of the applications for the zoo-sanitary registration. The zoo-sanitary files were classified based on the information related to the fishing activities as well as the qualification of the personnel. The conformity of the gear and equipment to the required sanitary conditions was also verified.

Table 2 Schedule of Zoo-sanitary registration requests

Name of the farm	Type of operator	Date
Lahjar Reservoir	Promoter	2/9/2021
Siliana Reservoir	Fishery Development Group	19/09/2021
Kasseb Reservoir	Fisherman	20/09/2021

The comparison of the zoo-sanitary registration files (Table 3) revealed a great variability in the process, progress and in the degree of compliance of the operators with the requirements. The examined files had some deficiencies, such as unproved documents either due to the reluctance of the operators or because of administrative difficulties. Only the operator of Lahjar Reservoir adheres to the zoo-sanitary requirements and has a complete file ready for the zoo-sanitary registration authorization.

Table 3 Identification of the required documents for registration (+: available; -: not available)

Required documents	Lahjar Reservoir	Kasseb Reservoir	Siliana Reservoir
Application for registration	+	+	+
Fishing authorization	+	+	+
Authorization from ANPE	+	-	-
Map of the geographical location	-	-	-
Number and qualification of Personnel	+	+	+
Description of the equipment	+	+	+
Presentation and description of the activity	+	+	+
Production record	+	-	-

The three aforementioned modes of exploitation which were identified have some differences, such as the qualification of personnel and the type of gear and equipment used. In fact, this is the case for the majority of freshwater fish farms in Tunisian reservoirs.^{6,12-15}

It was also noted that the compliance with the zoo-sanitary registration procedure in freshwater reservoirs is influenced by the type of operators. At Lahjar Reservoir, the promoter holds a university degree and he perfectly understands the importance of the reinforcement of this procedure. On the other hand, at Kasseb and Siliana Reservoirs, we have identified lack of fishermen's involvement and negligence of the requirements. The documents presented by the operators in these reservoirs reflect the challenges encountered in the implementation of the zoo-sanitary registration in reservoirs.

At Kasseb Reservoir, the production register, which is one of the required documents for the zoo-sanitary registration was not provided.¹⁰ This dam is operated with a fishing permit and only one operator is usually working at this dam (no grouping of fishermen). Presumably, this operator will be excluded from the classification process as the zoo-sanitary registration requirements are only for private operators of freshwater bodies with a fixed fishery license and fishery development groups.^{10,21}

Besides, operators of freshwater bodies holding a fishing license are exempt from environmental impact assessment and are therefore not required to have an ANPE license.

Similarly, at Siliana Reservoir the production register was not presented. In addition, the conservation conditions of the harvest do not follow the guidelines on food safety for human consumption.²² Due to the unavailability of the manager, the fishery development group was inactive when the survey was conducted. Besides, the fishermen's lack of awareness and the difficulty in dealing with the operators pose a real problem and result in non-compliance with the zoo-sanitary registration process. Besides, the lacks of funding and financial constraints are the major handicap for the development of this activity. The current status (lack of traceability measures, etc.) will naturally delay the obtainment of the freshwater fish zoo-sanitary registration in this reservoir. The operators (fishermen) in this reservoir are also exempted from the environmental impact study.

At Lahjar Reservoir, we noted only one anomaly in relation with the requirements of the zoo-sanitary registration procedure: *Tilapia* was cultivated in cages in an intensive system. Apart from this, the promoter of this reservoir meets all the requirements to obtain an authorization from the ANPE.

SWOT analysis

Detailed data were collected at the level of each reservoir and analyzed (Table 4). The results of the SWOT analysis facilitated the classification of the three exploitation modes and the development of a sustainable strategy for the inland fish farming sector in Tunisia.

Table 4 SWOT analysis made for the three modes of exploitation in Tunisian reservoirs

	Exploitation by fishermen: Kasseb Reservoir	Exploitation by a fishery development group: Siliana Reservoir	Exploitation by a promoter: Lahjar Reservoir
Strengths	<ul style="list-style-type: none"> Fishing authorization renewed; Experience in the field of inland fishing; Additional income through sea fishing activity; Direct sale of fresh products; Absence of urbanization and industrial activities around Reservoir. 	<ul style="list-style-type: none"> Existence of fishery development group; Large quantities of stocked fry; Existence of additional source of income for fishermen (agriculture and construction); Operators' experience in inland fisheries. 	<ul style="list-style-type: none"> Manager's grade level; Strong will of the operator to obtain the zoo-sanitary registration; Availability of freezing materials and equipment; Availability of a qualified local workforce; Preservation of products; Mastered fishing technique; Intensive cage farming system.
Opportunities	<ul style="list-style-type: none"> Existence of a potential international market; Low competition; Possibility of setting up ecolabels and certifications; Participation in national and international fairs and exhibitions; Possibility of developing ecotourism. 	<ul style="list-style-type: none"> Existence of a potential international market ; Participation in national and international fairs and exhibitions; Low competition for fish products; Possibility of setting up an ecolabel and certification; Possibility of development of ecotourism. 	<ul style="list-style-type: none"> Existence of a potential international market with little competition; Possibility of development of ecotourism; Possibility of setting up ecolabels and certifications; Participation in national and international fairs and exhibitions.
Weaknesses	<ul style="list-style-type: none"> Lack of production records; Unavailability of the operator in summer; Low income from fishing; Seasonality of the production; Agricultural activities around reservoir; Extensive breeding system; Use of the reservoir by the National Water Distribution Utility (SONEDE) as a source of drinking water. 	<ul style="list-style-type: none"> Non-functional Fisheries Development Grouping; Poor preservation of the caught products; Low production; Use of non-regulatory net mesh; Lack of funding and investment; Difficulty in communicating with fishermen; Inappropriate marketing channel; Poor hygiene practices; Lack of production records. 	<ul style="list-style-type: none"> Lack of specific space for product storage; Agricultural and urban exploitation of the areas bordering reservoir.

Table Continued...

	Exploitation by fishermen: Kasseb Reservoir	Exploitation by a fishery development group: Siliana Reservoir	Exploitation by a promoter: Lahjar Reservoir
Threats	<ul style="list-style-type: none"> • Consumer Behavior; • Risk of drought; • Risk of depletion of natural stocks of Mugilidae fry; • Risk of developing pathologies; • Agricultural fertilizer pollution; • Theft of fishing gear and production. 	<ul style="list-style-type: none"> • Risk of siltation of the Reservoir; • Low water supply and risk of dryness of the Reservoir; • Storm water Pollution; • Risk of spreading pathologies; • Unstable consumer behavior; • Risk of depletion of natural stocks of fry. 	<ul style="list-style-type: none"> • Growing urbanization and pollution risk; • Lack of water supply and risk of drought; • Massive presence of freshwater turtles causing damage to fish and fishing gear; • Risk of fish diseases; • Fishing equipment theft; • Risk of chemical pollution caused by the surrounding agricultural activity; • Unpredictable consumer behavior.

The conducted SWOT analyses indicated great potential for inland fish farming in Tunisia thanks to the omnipresence of various strengths and opportunities compared to the identified weaknesses and threats in these reservoirs. On those grounds, we put forward the following recommendations:

- Generalizing the zoo-sanitary registration procedure for all private persons or legal entities exploiting reservoirs in order to produce quality freshwater fish and enhance its marketing;
- Setting up an upgrading program for fishermen which would allow them to acquire knowledge in the field of sea products' conservation as well as the pathologies of aquatic organisms;
- Raising fishermen's awareness of the importance of the zoo-sanitary registration procedure and encouraging them to comply with its requirements;
- Monitoring of the production records by the competent authorities.

Conclusion

The results of the investigations on zoo-sanitary registration showed certain discrepancies in the level of commitment and compliance with the procedure between the different operators, such as the provision of the required documents. In addition, a great variability in the progress of the files' submission was noted among the different modes of operation (Promoter, Fishery Development Group or Independent Fishermen).

The examined documents indicated that the obtainment of the zoo-sanitary registration for Kasseb and Siliana Reservoirs is not possible at present because of the unavailability of the required documents, such as the production register. In addition, it was revealed that fish caught at Siliana Reservoir is poorly conserved and may therefore present health hazards for consumers. However, for Lahjar Reservoir, the file has all the required documents and the exploitation can therefore obtain the registration. Nevertheless, the rearing of Tilapia in an intensive way poses difficulties for this process.

The conducted SWOT analyses in the three reservoirs allowed to highlight the difference between the modes of exploitation and to elaborate new perspectives of development of the inland fish farming sector in Tunisia. The encouragement of ecotourism in Siliana and Kasseb Reservoirs can represent an additional source of income for fishermen and, at the same time, reduce the pressure on these fishery resources. Obtaining ecolabels and certifications would guarantee the quality of the marketed products and help gain the consumers' trust. The participation in fairs and exhibitions should also aid to conquer new national and international markets.

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Conflicts of interest

The authors declare no conflict of interest.

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