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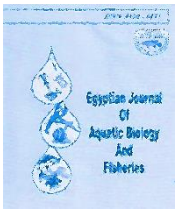

Analyzing Ownership Models and Their Effects on Aquaculture Productivity in Egypt

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ABSTRACT

This research provided a comprehensive analysis of the impact of different ownership models on aquaculture productivity in Egypt. It delved into the trends in the fish farming land area changes from 2011 to 2020 and investigated how ownership models influence aquaculture productivity. This study relied on secondary data, which underwent rigorous analysis using analysis of variance (ANOVA) to discern variations between ownership models. Additionally, Tukey's HSD Test was applied to identify specific differences. The findings are significant, highlighting substantial disparities in farm productivity in Egypt based on ownership models. Private-owned farms emerge as the most productive, followed by temporary and rental farms, while government-owned farms exhibit the lowest productivity, accounting for a mere 1% of total production. However, these governmental farms occupy 14% of the total farm area. The study underscored the importance of supporting private sector involvement and enhancing the productivity of government-owned farms, especially larger projects. These insights are invaluable for policymakers seeking to promote sustainable aquaculture development in Egypt.

INTRODUCTION

Fish constitute approximately 38% of an individual's animal protein consumption in Egypt **(Nasr-Allah *et al.*, 2020)**. Aquaculture effectively addresses the challenge of providing sufficient fish supply to the growing population, serving as a solution to bridge the gap between fish demand and limited natural fishery production. In 2021, Egypt achieved a total fish production of 2,001,959 tonnes, including 425,770 tonnes from natural fisheries and 1,576,189 tonnes from aquaculture, accounting for a significant 78% of the overall fish production **(FAO, 2023)**. This underscores the crucial role of aquaculture in enhancing fish availability, food security, and meeting protein requirements in Egypt.

One of the key challenges that hinders the expansion of aquaculture in Egypt is the limited availability of water and land resources. The law prohibits the use of agricultural land for fish farming, but temporary land utilization is permitted to remove salt for subsequent plant production. Moreover, the aquaculture sector faces competition with tourism for land use **(El-Gayar, 2003; Rothuis *et al.*, 2013; Sadek, 2013)**.

Several studies have highlighted the pivotal role of land ownership in influencing decisions related to the adoption of aquaculture technology **(Kumar *et al.*, 2018)**. The limited availability of land has emerged as a significant factor that

impedes the uptake of advanced aquacultural practices **(NCAEPR, 2003)**. Consequently, this reinforces the findings of **Mitra *et al.* (2022)**, emphasizing the importance of considering various ownership models and their profound impact on agricultural outcomes

Aquaculture areas in Egypt are mainly concentrated in the delta region, particularly around the northern lakes' peripheries. These lands became available due to the construction of the High Dam in the 1960s, rendering them unsuitable for fishing and traditional agriculture, thus making them suitable for fish farming **(Radwan, 2008; Sadek, 2013; El-Sayed, 2015)**. Egypt's fish farming landscape comprises various ownership patterns, encompassing government-owned and private farms with rental, ownership, and temporary arrangements. However, despite the importance of land in aquaculture, comprehensive studies on ownership patterns' impact on productivity are lacking, hindering informed development plans for expanding aquaculture. While, the optimal ownership model isn't specified. According to **Feidi (2018)**, government initiatives such as Birkat Ghalioun and East Suez Canal projects underline their commitment to expanding major projects.

The aim of this research was to comprehensively examine the implications of various ownership models on the productivity of aquaculture in Egypt. It focused on analyzing the trends in the alteration of fish farming lands between 2007 and 2021. Furthermore, it delved into the influence of land tenure systems on aquaculture productivity, providing insights into the productivity differences, and putting forth recommendations for guiding policymakers and planners to effectively utilize fish farming lands. These efforts are integral to fostering the sustainable development of aquaculture in Egypt.

MATERIALS AND METHODS

Data sources

The study relies on data sources such as the General Authority for Fish Wealth Development (GAFRD), currently known as the Lakes and Fish Resources Protection and Development Agency (LFRPDA). These sources provide information related to farm area and production in the context of aquaculture, The data cover the period from 2011 to 2020. In addition, this study relied on published research and studies.

Data analysis

The dataset was analyzed using both descriptive analysis and quantitative analysis, including the utilization of the SPSS software for conducting ANOVA analysis and Tukey's HSD Test. The research methodology followed a comprehensive approach, leveraging existing data sets to explore the trends and implications highlighted in the research objectives.

RESULTS

1. Contribution of different sources in aquaculture production

The data presented in Fig. (1) illustrate the production sources in Egypt's aquaculture sector, where private farms accounted for 86% of the production, while governmental farms contributed only 1%. Cage culture represented 12% of the production, and the production from rice-fish culture, intensive culture, and the in-pond raceway system are not of significant importance. This means that the land used in aquaculture, both in private and governmental farms, contributed to approximately 87% of the total fish farming production in 2020.

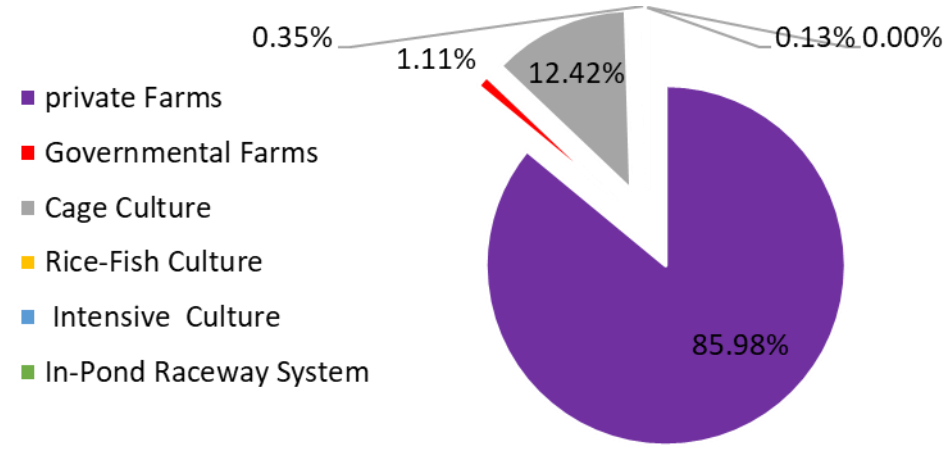

Fig. 1. Egypt's aquaculture production in 2020 **(GAFRD, 2022)**

2. Trends in aquaculture area by ownership models

Fig. (2) illustrates the distribution of fish farms by ownership type in hectares. The data show that the total area of fish farms did not experience significant growth during this period. Governmental fish farms, on the other hand, observed an increase in their area, ranging from 5,341 hectares in 2015 to 17,568 hectares in 2020. Owned farms showed fluctuating areas, rent farms remained relatively stable, while temporary farms exhibited a decreasing trend in terms of area.

In addition, government-owned farms represented about 14% of the total fish farming area in 2020. These farms include both old and new projects (referred to as large or national projects), which encompass the Suez Canal Project, Ghalioun Project, Al-Fayrouz Project, and Al-Diba farm, with areas of 3150, 1680, 6672 and 86 ha, respectively **(GAFRD, 2022)**.

These trends suggest potential shifts in ownership and management practices within the aquaculture industry. Governments appear to be expanding their presence in fish farming, while temporary farms might be on a declining trajectory at a faster rate.

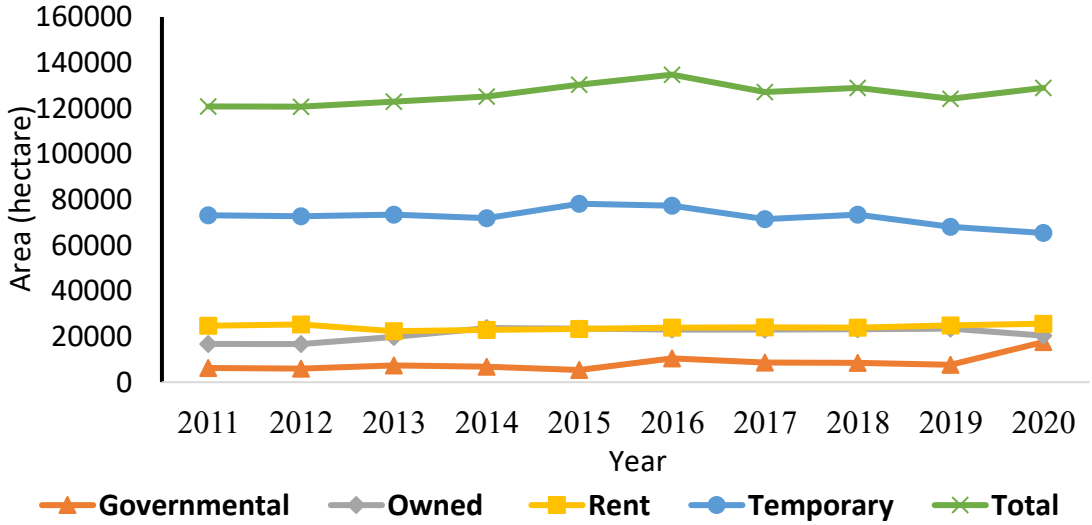

Fig. 2. Fish farming area by ownership models from 2001-2020 **(GAFRD, 2022)**

3. Productivity patterns in fish farms by ownership models

Fig. (3) shows the mean production values (tonnes/ha) for aquaculture farms across different ownership models over a span of ten years (2011-2020). The ownership models include governmental, owned, rent, and temporary farms.

Governmental farms consistently had the lowest mean production throughout the entire period, ranging from 1.1 to 2.4 tonnes. Owned farms consistently showed the highest mean production, ranging from 8.1 to 13.3 tonnes. They consistently outperformed the other ownership models in terms of production. Rent farms had intermediate mean production levels, ranging from 4.3 to 10.3 tonnes. Temporary farms also had intermediate mean production levels, ranging from 6.3 to 12.6 tonnes.

Overall, these findings suggest that the ownership model plays a crucial role in determining the production levels in aquaculture farms, with owned farms consistently exhibiting higher mean production compared to other ownership models.

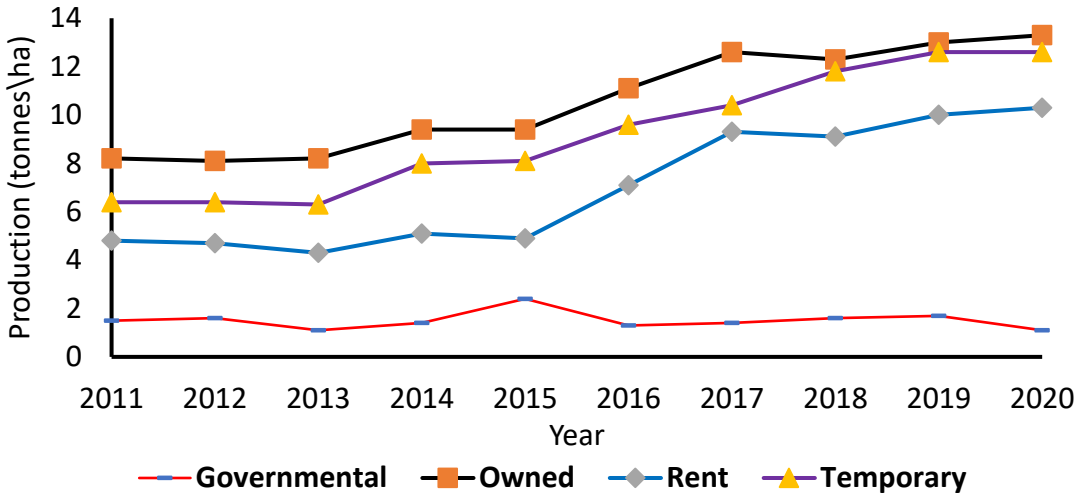

Fig. 3. Productivity of fish farms in Egypt by ownership models from 2011-2020 **(GAFRD, 2022)**

4. Government farms and the new large-scale aquaculture projects

In Fig. (4), data presented display the fish production of major farms, including Al-Fayrouz, Ghalioun, Suez Canal, and Al-Diba, measured in tonnes per hectare for the year 2020. In addition, the data included the average production of these farms collectively and the average production of older government-owned farms.

Al-Fayrouz farm produced 0.2 tonnes/ ha, Ghalioun farm recorded 2.0 tonnes/ha, the Suez Canal farm had a production of 0.3 tonnes/ ha, and Al-Diba farm yielded 1.4 tonnes/ ha. On average, these farms collectively produced 0.4 tonnes/ ha, while the average production of the older government-owned farms was significantly higher at 2.8 tonnes/ ha.

These data highlight that the overall productivity of fish farms and large aquaculture projects is comparatively lower when compared to older government-owned farms. It's worth noting that, even the older government-owned farms exhibit lower productivity when compared to privately owned farms, especially those owned by individuals.

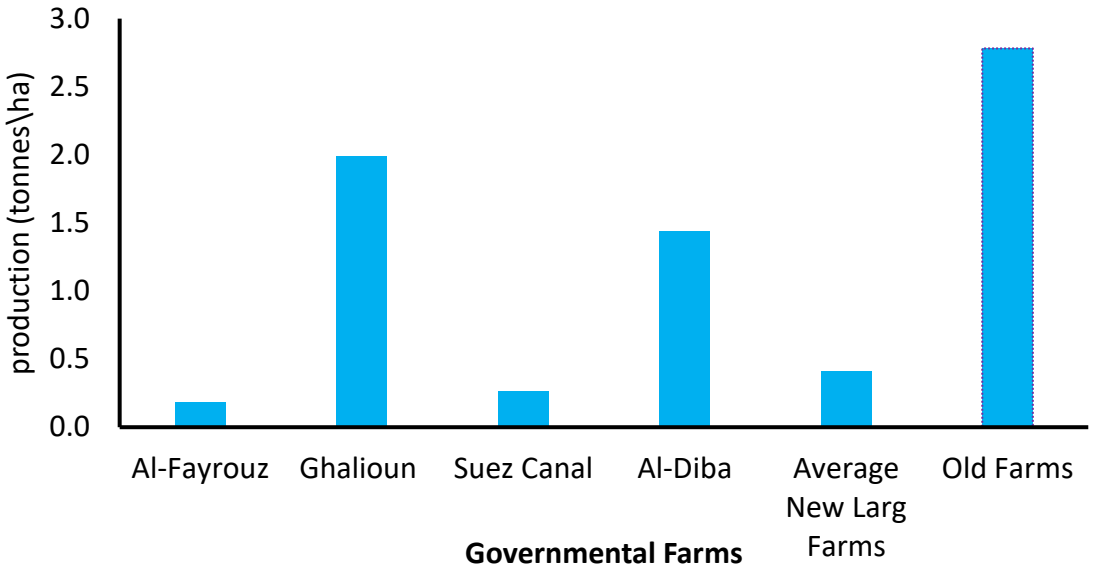

Fig. 4. Productivity of governmental farms in Egypt in 2020 **(GAFRD, 2022)**

5. Analysis variance for production based on ownership models

The ANOVA results reveal a statistically significant difference in mean production among the ownership types of aquaculture farms (F = 36.876, $P < 0.001$). This finding indicates that the ownership type has a significant impact on the production levels within aquaculture farms.

Further examination of the mean production values shows that aquaculture farms under governmental ownership have the lowest mean production (M = 1.51) with a relatively low standard deviation (SD = 0.37). On the other hand, farms under ownership type "owned " exhibit the highest mean production (M = 10.56), with a moderate standard deviation (SD = 2.13). Farms under "Rent" owned have a mean production value of 6.96 (SD = 2.47), while those categorized as "Temporary" ownership have a mean production value of 9.22 (SD = 2.54).

Table 1. ANOVA results for mean production variation among ownership types in aquaculture farms

Ownership model	**Mean**	**Std. deviation**	**F**	***P*-value**
Governmental	1.51	0.37	36.876	0.000
Owned	10.56	2.13		
Rent	6.96	2.47		
Temporary	9.22	2.54		

The results from the Tukey's HSD test reveal statistically significant differences in mean production among the various ownership models in aquaculture farms. Table (2) presents the mean differences, standard errors, and *P*-values for the pair-wise comparisons.

In the comparison between owned farms and governmental farms, a substantial mean difference of 9.05 (SE = 0.93) was observed, indicating significantly higher mean production in owned farms compared to governmental farms ($P< 0.001$). Similarly, in the comparison between owned farms and rent farms, there was a significant mean difference of 3.60 (SE= 0.93), indicating higher mean production in owned farms compared to rent farms ($P= 0.002$). However, when comparing owned

farms to temporary farms, the mean difference was relatively small at 1.34 (SE = 0.93), and the *P*-value was not statistically significant (*P* = 0.482). This suggests that there is no significant difference in mean production between owned farms and temporary farms.

Table 2. Tukey's HSD test for mean production differences among ownership models in aquaculture farms

Comparison	Mean difference (I-J)	Standard error	*P*-value
Owned - Governmental	9.05	0.93	0.000
Owned - Rent	3.60	0.93	0.002
Owned - Temporary	1.34	0.93	0.482

DISCUSSION

The results of this study show that there is a significant variation in farm productivity in Egypt depending on the ownership models. It was noticed that the most productive owned pattern is private owned, followed by temporary and then rental ownership, with government-owned farms being the least productive.

The reason for this difference can be attributed to the fact that privately owned farms have more stability in land tenure, enabling some of them to access credit, which is not available to other ownership patterns like rental and temporary ownership **(El-Gayar, 2003; Macfadyen *et al.*, 2011; Rothuis *et al.*, 2013; El-Sayed *et al.*, 2022; Rossignoli *et al.*, 2023)**. Additionally, the higher productivity of temporary farms, despite removal orders, may be because these lands are used for fish farming until they are desalinated **(Sadek, 2013)**, making them more fertile with lower salinity, creating an ideal environment for tilapia, the main species in the Egyptian farms **(GAFRD, 2022)**. Moreover, not paying licensing fees may make this pattern more profitable.

In general, these results align with those of **Dey *et al.* (2005)** who mentioned that, owner-operated farms adopt improved techniques in shrimp farms in Thailand, while tenants adopt extensive aquaculture in India. Short-term lease contracts may significantly hinder the adoption of technologies, even when they are seen as having future benefits **(Blackman, 1999)**.

The lower productivity of rented farms compared to private and temporary farms may be due to the fact that these farms are located at the end of the irrigation system and may have experienced land fragmentation, resulting in smaller land sizes. Furthermore, the state leases them for short periods and periodically re-evaluates rental values, significantly increasing the rent. Additionally, according to **Kumar *et al.* (2018)**, the short tenure period reduces incentives for technology adoption. It is known that the General Authority for Fish Wealth Development leases land for very short periods, typically ranging from 3 to 5 years **(Macfadyen *et al.*, 2011; Rothuis *et al.*, 2013)**.

The lower productivity of old government farms may be traced back to reduced financial allocations, government bureaucracy, poor management, and employees' unwillingness to bear financial responsibility. As for new government farms, their lower production may have risen from the lack of sound feasibility studies, lack of specialized management, and bureaucratic routine. This significant decrease in aquaculture farm productivity occurs despite the availability of several factors (large size, project integration, and financing opportunities) that allow these projects to use technologies that enhance productivity **(Feidi, 2018)**. Numerous studies have

postulated that larger farms are more technically efficient and capable of adopting technologies that increase productivity **(Nhan *et al.*, 2007; Bosma *et al.*, 2012; Asche *et al.*, 2013; Kumar, 2015; Salazar *et al.*, 2018)**.

CONCLUSION AND RECOMMENDATIONS

The research provided valuable insights into aquaculture ownership models and their impact in Egypt. It analyzed fish farming land trends from 2011 to 2020, focusing on land tenure's influence on productivity. Private farms dominated, contributing 86% of total production, while governmental farms contributed only 1%. Despite this, governmental farms represented 14% of the total fish farm area in 2020. Overall, fish farm area showed limited growth, but governmental farms expanded, indicating changing management practices. Private farms had fluctuating land areas, while rented farms remained stable, and temporary farms decreased. owned farms consistently had the highest production levels, outperforming others, while governmental farms had the lowest production. ANOVA results confirmed significant differences in production among ownership types, emphasizing ownership's impact. Policymakers should support private sector participation due to its dominance in aquaculture. Furthermore, enhancing governmental farm productivity is essential (particularly large projects). This research serves as a valuable resource for promoting sustainable aquaculture development, emphasizing the importance of addressing ownership models for improved productivity.

Based on the findings of the research several recommendations can be made to guide policymakers and planners towards effectively utilizing fish farming lands and fostering the sustainable development of aquaculture in Egypt:

1. Promote privately owned farms: that privately owned farms consistently exhibit higher mean production compared to other ownership models. encouraging private ownership and investment in aquaculture can enhance productivity.
2. Review government-owned farms: given that government-owned farms had consistently lower mean production, it is advisable to assess their efficiency and consider potential improvements or alternative ownership models.
3. Support rental ownership farms: rental ownership farms had intermediate mean production levels. Policymakers could explore ways to support these farms through incentives or assistance programs to further boost their productivity and extending the lease period to 25 years and finding solutions to prevent space fragmentation.
4. Enhance land tenure systems: since land tenure systems were found to influence aquaculture productivity, efforts should be made to improve and streamline these systems to benefit fish farmers.
5. Research and data collection: continuously monitor and collect data on aquaculture productivity, ownership models, and land use trends to make informed decisions and adapt policies accordingly.
6. Capacity building: invest in training and capacity building programs for fish farmers to improve their practices and increase overall productivity.
7. Investment in modernization: encourage the adoption of modern aquaculture techniques and technologies to enhance efficiency and productivity across all ownership models.

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