

Socio-economic impact of the saltwater intrusion in the Shatt al-Arab River on fish farmers in Al-Mashab marshes, Southern Iraq

Arafat R. Ahmed* , Jihad M. Al-Zewar

Marine Science Centre, University of Basrah, Iraq

*corresponding author e-mail: aquanutrition1@gmail.com

ABSTRACT

The salinity of the Shatt al-Arab River is determined by the volume of freshwater entering the river from tributaries and on the tidal forces from the Arabian Gulf. The implementation of hydrological projects by upstream countries has led to a reduction in the freshwater discharges reaching the Shatt al-Arab. The decrease in freshwater volume in the Shatt al-Arab has made space for saltwater from the Arabian Gulf to intrude 150 km upstream from the river mouth. Saltwater intrusion (SWI) in the Shatt al-Arab is harmful fish farmers in Al-Mashab marshes, north of Basrah, southern Iraq. The SWI in 2018 was the most severe on record, resulting in the mass mortality of farmed fish in Al-Mashab marshes. As a result of the mass mortality of fish, farmers lost the main source of their income, which led to serious and complicated problems at the socioeconomic level. These problems may finally lead to social and political unrest in the case of absence of governmental planning and solutions.

KEY WORDS: Saltwater intrusion, fish farming, socioeconomic impact, Shatt al-Arab, Iraq.

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1. Introduction

The Euphrates and Tigris Rivers originate in the mountains of eastern Turkey and take separate paths from Turkey through Syria until they meet in the province of Al-Basrah, southern Iraq to form the Shatt al-Arab River, which empties into the Arabian Gulf. Several tributaries join the Shatt al-Arab during its course, most importantly the Karkheh and the Karun Rivers, both of which originate in the Zagros Mountains in Iran and discharge into the Shatt al-Arab (UN-ESCWA and BGR, 2013). The Shatt al-Arab has a length of 195 km and an average width of 500 m with a depth that ranges from 8-15 m (Al-Ramadhan and Pastour, 1987). The Shatt al-Arab is a tidal river, in which the tidal flux comes from the north of the Arabian Gulf and the dominant tide is a semi-diurnal type (Al-Ramadhan and Pastour, 1987).

Gradually, the economic, social and cultural activities that depended on the Shatt al-Arab including the agriculture and aquaculture industries collapsed due to deteriorating of the environment, primarily the rapidly declining quality and quantity of water in the Shatt al-Arab (Abdullah et al., 2015; 2018). The collapse of the Shatt al-Arab river system is the result of the regional riparian countries (i.e. Turkey, Syria, Iran, and Iraq) establishing large-scale dams and other water infrastructure projects in the Euphrates, Tigris, Karkheh and Karun basins over the last decades (Patrow, 2001; Price, 2018), with the result of significantly decreasing or altogether ending water discharges into the Shatt al-Arab from its tributaries (Brandimarte et al., 2015).

The reduction in water volume following in the Shatt al-Arab river lead to decrease its currents velocity, so the saltwater from the Arabian Gulf intrude into the Shatt al-Arab waterway. Saltwater

intrusion has caused severe salinization in the Shatt al-Arab basin, further destroying the ecosystem and disrupting economic activities in Basrah (Abdullah et al., 2015).

In recent years, several studies have included assessing water quality of Shatt al-Arab (Al-Tawash et al., 2013; Moyel, 2014; Moyel and Hussain; 2015), identifying sources of the salinity (Brandimarte et al., 2014; Abdullah et al, 2015) and examining the effect of salinity on fish diversity in the river (Mohamed and Abood, 2017). However, no studies have evaluated the impact of saltwater intrusion on fish farming operations and the socioeconomic status of fish culturists in Basrah. This study aims to address those two issues by focusing specifically on the exceptionally high saltwater intrusion in Shatt al-Arab in the summer of 2018.

2. Methods

2.1. Study Area

The Al-Mashab village is located within the boundaries of al-Hartha region (N 30 ° 41'35 "E 47 ° 44'20"), about 60 km from the confluence point of the Tigris and Euphrates rivers and 135 km from the Arabian Gulf (Figure 1). This area is locally known as the Al-Mashab marshes. It is a part of al-Hammar marshes, northwest of Basrah province. The Garmat Ali River—a branch of the Shatt al-Arab is the only source of freshwater for the study area. Water level in this section of the marshes rises and falls with the tide twice a day. The livelihoods of the people in the Al-Mashab village are dependent on small scale agriculture, animal husbandry, fishing and earthen-pond aquaculture.

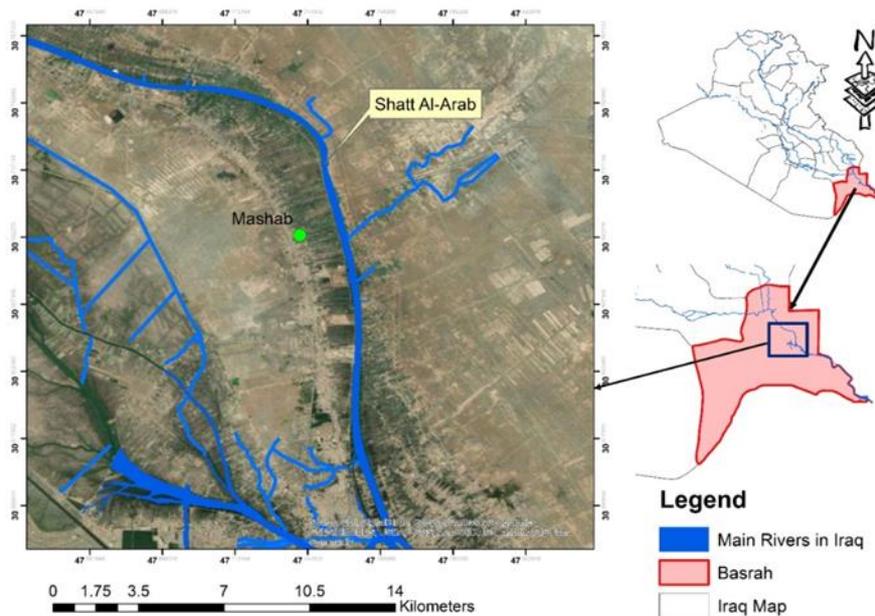


Fig 1. The location of Al-Mashab marshes, south of Iraq

2.2. Data Collection

Various data collection methods were used in this study. The main method was through the questionnaire shown in table 1. The questionnaire was given to 80 farmers in the village. Data was also derived through direct communication and group discussion with the farmers from the visited farms in addition to review of official unpublished reports by the Center for Rehabilitation of Marshes and Wetland (CRMW), in Al-Basrah governorate.

Table 1. The questionnaire form that used to collect the information from fish farmers

1. Form number
2. Farm location (GPS)
3. Total area of land used for ponds
4. Number of ponds per farm
5. Number of fish per pond
6. Type of cultured fish
7. Initial weight of cultured fish
8. Buying cost per fish
9. Source of feed
10. Type of feed
11. Feed price (\$ US/ton)
12. Number of workers and their salaries
13. Culture starting date
14. Date of the mass mortality of fish due to the saltwater intrusion
15. Your strategy to cope with the salinity problem
16. Others

Eighty farms for common carp (*Cyprinus carpio*) were included in the current study. The population of 80 farmers was interviewed and questionnaires were filled by the researchers with assistance of the tribe leader. In order to collect the information, a minimum of 10 visits was organized.

The CRMW provided salinity readings from the Al-Mashab station, which were collected every week from January-December 2018. Measurements of water discharge to the Shatt al-Arab from Qal’at Saleh regulatory gate in Maysan province were also obtained from the CRMW. The study estimated the economic losses for each farm separately based on the expense of fish purchased at the beginning of the culture season, the cost of the consumed feed before the saltwater intrusion event, and the salaries of workers who run the farms for 6 months (from March to September 2018). Microsoft Excel 2010 was used to calculate the results in table 2 and 3.

3. Results

Measurements of water salinity and water discharges reaching the Shatt al-Arab are presented in Figures 2 and 3 respectively. The lowest level of salinity was 2.5 g/l, recorded in May, and the highest salinity was 15.97 g/l in September.

The highest monthly rate of water discharges reaching the Shatt al-Arab during the study period (January – December 2018) was 64.7 m³/ S in August and fell to the lowest level of 28.3 m³/ S in November.

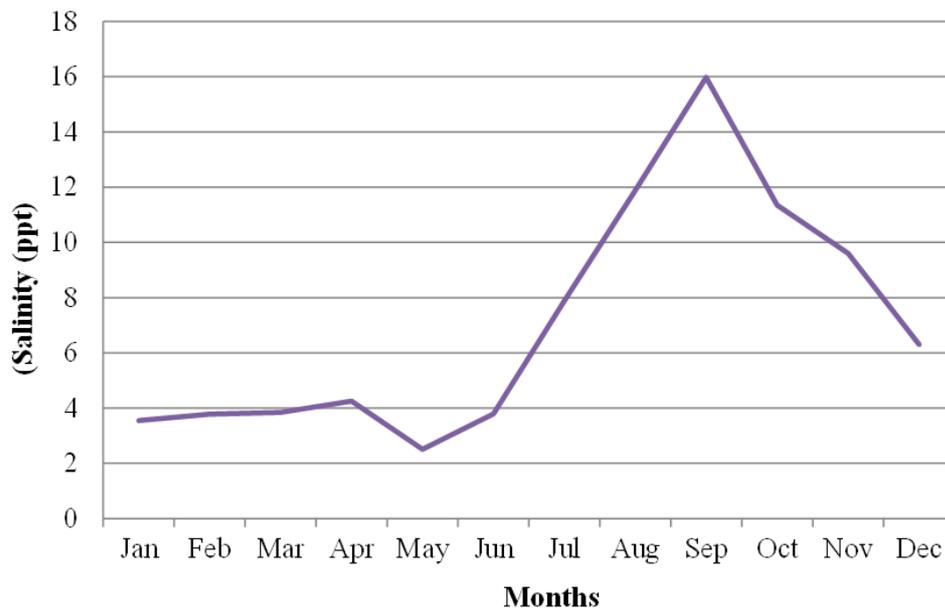


Figure 2. The salinity of the Shatt al-Arab water (ppt) during the study period (provided from CRMW).

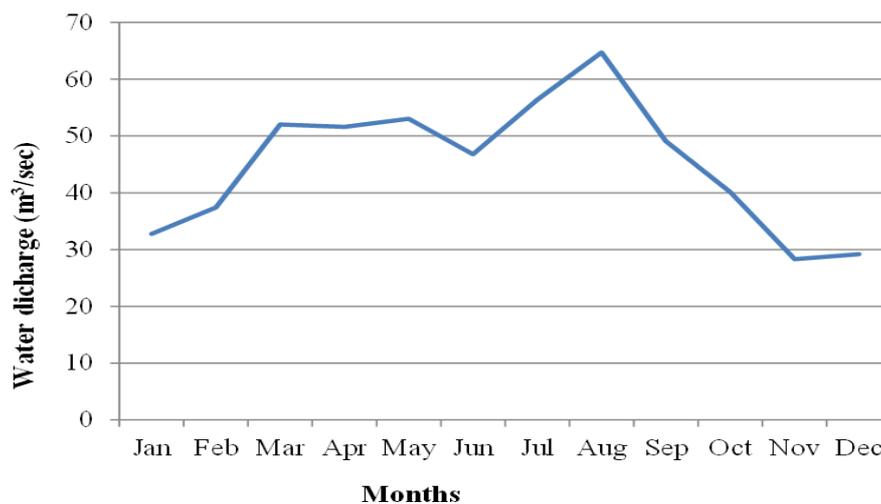


Figure 3. The water discharge releasing to the Shatt al-Arab River from Qal’at Saleh regulatory gate in Maysan province (provide from CRMW)

The initial weight of the farmed fish, total number, and the purchasing price with the cost of the feed consumed in 6 months (from March to September) are presented in table 2.

Table 2. The initial weight of the farmed fish, total number, and the purchasing price with the cost of the feed consumed in 6 months.

Initial weight of farmed fish (g)	Total number of farmed fish	Purchasing cost per individual fish (\$US)	Total cost of farmed fish (\$US)	Mean of feed consumed per individual fish (kg) for 6 months	Cost of feed (\$US per Kg)	Total cost of the consumed feed (\$US)
2-5	589,000	0.031	1.825.9	2.0	0.5	589,000
10-25	517,050	0.167	86.347.35	2.5	0.5	646,312.5
80-150	128,500	0.52	66.820	3.0	0.5	192,750
Total	1,234,550		154,993.25			1,428,062

Note: We used the information gathered by table 1 (the questionnaire form) for all fish farms to produce the results presented in Table 2 and 3.

Common carp (*Cyprinus carpio*) is the main species being cultured in the study area. Fish is fed a locally made sinking pellets (purchasing cost about \$500 US per ton). Residents of the Al-Mashab marshes have a total of 80 earthen-ponds fish farms, which cover a total area of 17.2 km².

Table 3. Represents more details related to fish farms (number of farms, area, number of ponds, average number of fish in m³, and number of workers).

Category	Farm area (m ²)	Number of farms	Number of ponds in each farm	The average area of each pond (m ²)	The average number of fish in m ³			Number of workers
					2-5 (g)	10- 25 (g)	80-150 (g)	
1	2500 -10000	20	1	3500	0.44	0.66	0.36	22
2	12500 - 20000	20	2	5000	0.47	0.45	0.36	21
3	22500- 40000	27	3	5000	0.68	0.63	0.38	53
4	42500- 80000	10	5	5000	0.49	0.96	0.55	20
5	82500 and more	3	7	7000	0.44	---	0.40	9
	Total	80						125

The total number of workers who receive salaries from the farms owners in the Al-Mashab village is 125 persons. The salary of each worker or guard is about \$ 460 US monthly and the total paid salaries were \$57.500 US. The results suggested that the farmers had no strategy to cope with the salinity problem. The saltwater intrusion crisis resulted in

total loss of \$1,640,555US (included the cost of fish and feed as presented in table 2 in addition to the total paid salaries) across the 80 fish farms.

4. Discussion

The inland distance of SWI was 150 km upstream from the river mouth (CRMW, 2018; personal

communication and unpublished report). Previous study of SWI in the region found that seawater flowing upstream from the Arabian Gulf in the Shatt al-Arab can reach the confluence point of the Tigris and Euphrates in Garmat Ali (135) km inland and may extend further depending on the volume of water discharges reaching the Shatt al-Arab from its tributaries (Brandimarte et al., 2015). In addition, the quality of water in the Shatt al-Arab deteriorated not only due to high salinity, but also as a result of the direct discharge of domestic, agriculture, and industrial waste into Shatt al-Arab and its tributaries by farms upstream and in Al-Basrah province (Abdullah et al., 2015). Furthermore, Iraq is facing extreme negative impacts of the climate change, such as rising temperatures and sea level rise (Adamo, 2018), which significantly impact the agriculture and fisheries sectors in direct or indirect manner (IPCC, 2012).

The fish culture season begins in March every year and the harvest time starts in November. Unfortunately, the 2018 SWI occurred during the summer months and before the harvest season, killing nearly all of the fish in the fish ponds included in this study. A laboratory study in 2011 indicated that carp survival in salinity levels exceeding 6 g/l requires significant changes in the kidney and gill functions that are responsible for osmotic regulation (Salati et al., 2011). The same study indicated that fish can tolerate an increase in salinity up to 12 g/l, but only in a gradual manner, giving their kidneys and gills time to change their function. It is possible that the mass mortality of farmed fish was due to the rapid increase and extreme fluctuation in water salinity of the Shatt al-Arab, which disrupted the carp's osmoregulation process without sufficient time for the fish to adjust to the new conditions. The other reason for the mass mortality could be that the high salinity of the water reduced the oxygen consumption and elevated the concentration of the total ions in the plasma (Maceina et al., 1979).

As a result of the mass mortality of fish, the al-Mashab Village farmers lost the main source of their income, which led to serious socioeconomic problems for the whole community. One complicating factor is the contract many farmers sign with private companies. The company provides advance fish and feed in exchange for the guarantee

that the farmer will pay back these supplies in installments during the harvest season. The widespread death of fish before harvest due to the 2018 SWI left many farmers deeply indebted.

The United Nations of the Environment Program report (UNEP, 2007) indicates a close relationship between environmental changes and human well-being. Subsistence farming and fishing communities are often the most at risk for livelihood disruption from environmental shocks (Karfakis et al., 2012). This relationship is evident in the case of the Shatt al-Arab basin, where the recently high salinity in soil and water reduces soil fertility and productivity, leads to scarcity of freshwater, causes erosion of equipment and damages infrastructure. All of these rapid changes jeopardize the livelihoods of local communities, many of whom are already impoverished and struggling to sustain themselves.

Some fish farmers tried to minimize the losses by not pumping new water from the Shatt al-Arab to the ponds (to avoid the salty water) so they could sell the crop and recover even part of the capital, but they failed because the consumers declined to buy the locally produced fish during the crisis because they were unsure if that fish is suitable for human consumption or not.

Subsequently, some community members gave up on their aquaculture enterprises and left the village to search for economic opportunities in urban areas. This is consistent with other studies that have identified changes in local ecosystems as a key cause of human migration (Wood, 2001; Matutinovic, 2006). The migration from the rural areas to urban centers due to the environmental changes will add more pressure on the city of Al-Basrah, which already suffers from a shortage of basic services such as electricity, healthcare, improved water and infrastructure, and has high levels of unemployment (Adamo et al., 2018). In the Basrah city center, most farmers became taxi drivers or construction workers to cover the daily requirements of their families and begin competing with the city's population for jobs.

The other consequence of migration for rural communities like the al-Mashab Village is the disintegration of the social relations. It has been widely documented that rural-to-urban migration due to changing economic and environmental conditions results in the severing of widespread kinship relations

and networks of support for individuals, and can lead to the loss of cultural traditions, local knowledge, and unique farming practices (Padoch et al, 2008; Nguyen et al, 2012).

As saltwater intrusion will likely become even more severe in coming years, SWI in the study area will likely continue to exacerbate poverty and food insecurity and drive migration from the al-Mashab Village to the Basrah city center. These problems may finally lead to social unrest in the case of the absence of future governmental planning and solutions (Adamo et al., 2018).

The water problem in the south of Iraq is a serious issue that is expected to worsen in the future because of population growth, increased dam construction upstream, poor management of the available water resources and climate change (Al-Furaiji et al., 2016). Therefore, it is essential that communities and political leaders in the region adopt integrated strategies to reduce the risk of the environmental catastrophe and to develop comprehensive plans to reduce the social, environmental and economic impacts of saltwater intrusion. One of the possible solutions to prevent the saline water of the Arabian Gulf from migrating upstream in the Shatt al-Arab is to construct a mechanical barrier with specific features as suggested by the Marine Science Center, the University of Basrah (Shatt al-Arab; the future of Basrah, unpublished study). Mechanical barriers such as dams and gates may be effective in blocking saline waters in rivers impacted by saltwater intrusion (White and Kaplan, 2017).

Confronting climatic and environmental changes requires judicious management of available water resources through the wastewater recycling and the adoption of water harvesting projects (Mirsha, 2017). It is necessary to reconsider the environmental and economic feasibility of the traditional farming methods in the province, which drain huge amounts of water, and to find alternative sources of Shatt al-Arab water such as groundwater.

The Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) pointed out that the poor are more affected by natural disasters and environmental changes because lack of financial resources weakens their ability to survive and recover from crises or adapt to rapidly changing conditions.

Therefore, it is necessary to find alternative employment opportunities outside the aquaculture sector in order to reduce the impacts of extreme weather events on the rural community. Furthermore, it is imperative to establish community support funds that will supply food and other key resources to poor communities in times of crises, particularly to secure the lives of children and women. To ensure community security and to avoid internal conflicts, it is necessary to include the disaster risk management within the country's development plan and to build specialized expertise in disaster risk management, environmental change, and water resources management (UNISDR, 2015). The public awareness program is necessary so that all the people appreciate the serious problem they are facing (Al-Ansari and Adamo, 2018).

The global climate changes threaten most people and their human rights (Levy et al, 2015). Therefore, more studies are needed to understand the effect of the environmental changes on the socio-economic status of fish farmers that can help planning to enhance farmers' incomes and protect their human rights while minimizing negative environmental impacts.

5. Conclusions

Both the reductions of freshwater discharges to the Shatt al-Arab from tributaries and the increasing extent of saltwater intrusion into the river is expected to continue. Therefore, it is necessary to find alternative sources of water for communities that historically relied on the Shatt al-Arab and to adopt modern farming methods. To ensure community stability, an integrated plan must be adopted to reduce the impact of environmental changes on the society, especially the poorest and most dependent on the elements of the environment in obtaining their livelihoods.

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