Impact of Climate Change on Fisheries and Aquaculture Activities in Southern Iraq

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Abstract

The impacts on aquaculture and fisheries sectors from climate change in the southern part of Iraq will likely to be both positive and negative arising from direct and indirect impacts on natural resources. The main elements of climate change that could potentially impact fisheries and aquaculture activities in Iraq are temperature, rain patterns, shortage of freshwater, circulation, upwelling, sea level rise and sea water intrusion in the estuarine areas. Impacts on aquaculture production, aquaculture dependent livelihoods and indirect influences through availability of feed ingredients are discussed. Global warming is likely to be small on aquaculture practices. It may be positive by enhancing growth rates of cultured stocks or negative through impact on water availability, weather patterns, stratification and eutrophication in lentic waters. Based on current practices of fish culture in Iraq, that is predominantly based on species feeding low in the food chain, the greater availability of phytoplankton and zooplankton through eutrophication could possibly enhance production. The predicted water stress is thought to result in decreasing water availability in major rivers which can affect that used for aquaculture. There is a need for 11,500 cum/m3 in extensive fish culture and 30,100 cum water / ton fish in intensive fish production. Non consumptive uses of water in aquaculture, such as cage culture and the use of small lentic waters for culture systems based on naturally produced feed within the water system are being encouraged. The predicted reduced water availability in Tigris and Euphrates river system and Shatt Al-Arab Estuary has to be considered in conjunction with saline water intrusion in the rivers and adjoining wetlands. Sea level rise and consequent increased salt water intrusion in Shatt Al-Arab estuary imposes adaptations to the related impacts by operations that culture species with high salinity tolerance.

The study also discussed the effect of climate changes on the inland freshwater fisheries and marine fisheries in addition to the adaptive physiological mechanisms that accompanied such changes.

Keywords: Climate, Shatt Al-Arab, Aquaculture, Iraq

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Introduction

The main elements of climate change that might potentially impact aquaculture production and aquaculture-dependent livelihoods can be categorized as direct and indirect. The direct impacts of climate change on aquaculture include changes in temperature changes in the availability of freshwater, changes in sea level and increased frequencies of extreme events (such as flooding and storm surges). However, indirect effects include:

1. Economic impacts, e.g. costs and availability of feed.
2. Stress due to increased temperature and oxygen demands.
3. Uncertain supplies of freshwater.
4. Increased frequency of diseases and toxic events.
5. Uncertain supplies of fishmeal from capture fisheries.

Impact of temperature rise

Global warming and a consequent increase in water temperature could impact negatively aquaculture in temperate zones because such increases could exceed the optimal temperature range of organisms currently cultured. Such impacts may be balanced with positive impacts that might occur as a result of climate change, such as enhanced growth and production in tropical and subtropical zones. However, positive impacts are unlikely to occur without some potential negative impacts arising from other climatic change elements (e.g. increased eutrophication in inland waters). Furthermore, it is likely that diseases affecting aquaculture will increase both in incidence and impact. Indirect impacts on aquaculture could be extending to influence the availability of fishmeal and fish oil (Handisyde *et al*., 2006).

Water stress

Projected water stresses brought about by climate change could have major impacts on aquaculture in tropical regions, The predicted stress is thought to result in decreasing water availability in major rivers The amount of water used in food production varies enormously between different sectors. There is a need for 11,500 cum/m3 in extensive fish culture and 30,100 cum water / ton fish in intensive fish production (Zimmer and Renault, 2003).

In general, reduction of aquaculture water use could be achieved as pointed out by De Silva (2003) Verdegem *et al.* (2006) through:

a. Selection of feed ingredients that need little water to be produced.
b. Enhancement of within aquaculture-system feed production through periphyton based technologies.
c. Integration of water with agriculture.
d. Non consumptive uses of water in aquaculture, such as cage culture.
e. The use of small lentic waters for culture-based fisheries (CBF) based on naturally produced feed within the water system. This will make such water bodies relatively unsuitable for aquaculture purposes because a minimum period of six months of water retention is needed

for most fish to attain marketable size.

f. The use of recirculation systems. Energy costs of maintaining recirculation systems are rather high (De Ionno *et al*., 2006) and even if the operations are financially rewarding, they would contribute to greenhouse gas emissions, the primary causative factor for climate change, far more than other traditional aquaculture activities.

Sea water intrusion

The predicted reduced water availability in major river systems in the deltaic regions of Asia, where major aquaculture activities exist, has to be considered in conjunction with saline water intrusion arising from sea level rise (Hughes *et al*., 2003) and the expected changes in precipitation or monsoon patterns (Goswami *et al*., 2006). The impact level depends upon:

1. Degree of seawater intrusion in the rivers and adjoining wetlands.
2. Assessment of agriculture activities that is likely to be lost as a result of seawater intrusion.
3. Gross change of habitats, spawning migration, seed availability for cage culture.

Impact of sea level rise

Sea level rise and consequent increased salt water intrusion in the deltaic areas of the tropics where there is considerable aquaculture production is likely to occur. Adaptations to related impacts will involve the movement inland of some operations that culture species with limited saline tolerance. On the whole aquaculture is less energy costly and could contribute to carbon sequestration more than other terrestrial farming systems. Climate change is likely to bring about significant changes particularly with respect to salinity and temperatures in brackish water habitats and will therefore influence aquaculture production in such environments.

Positive and negative impacts

The impacts on aquaculture from climate change, as in the fisheries sector, will likely to be both positive and negative arising from direct and indirect impacts on natural resources required for aquaculture; the major issues being water, land, seed, feed and energy. Climate change impacts as a result of global warming are likely to be small on aquaculture practices taking place in such systems and if at all positive, brought about by enhanced growth rates of cultured stocks. On the other hand, climate change will impact on water availability, weather patterns such as extreme rain events, and exacerbate eutrophication and stratification in static (lentic) waters. However, based on current practices, particularly with regard to inland finfish aquaculture that is predominantly based on species feeding low in the food chain, the greater availability of phytoplankton and zooplankton through eutrophication could possibly enhance production.

List of positive impacts of climate change on aquaculture include:

1. Increased food conversion efficiencies and growth rates in warmer waters.
2. Increased food supplies are needed for aquaculture activities to realise benefits from increased temperatures.
3. Increased length of the growing season.
4. Increased primary production would provide more food for filter-feeding invertebrates.

The negative impacts, on the other hand, include:

1. Problems with non-native species invasions.
2. Declining oxygen concentrations.
3. Possible increase in blooms of harmful algae.
4. Local conditions in traditional rearing areas may become unsuitable for many traditional species; temperature stress will affect physiological processes such as oxygen demands and food requirements. Freshwater aquaculture activities will compete with changes in availability of freshwater due to agricultural, industrial, domestic and riverine requirements, as well as changes in precipitation regimes.
5. Increases in precipitation could also cause problems such as flooding.
6. Sea level rise also has the potential to flood coastal land areas, mangrove and sea grass regions which may supply seed stock for aquaculture species.

Impacts on aquaculture in southern Iraq

The aquatic ecosystem of Southern Iraq comprises of vast area of wetlands locally called Marshes. They include Huwaizah marsh, Central marshes and Hammar marsh. It includes the Shatt Al-Arab estuary which flows into the Gulf (Fig. 1).

Figure 1: The aquatic ecoststem of southern Iraq.

The predicted water stress is thought to result in decreasing water availability in major rivers which can affect that used for aquaculture. There is a need for 11,500 cum/m3 in extensive fish culture and 30,100 cum water / ton fish in intensive fish production. Non consumptive uses of water in aquaculture, such as cage culture and the use of small lentic waters for culture systems based on naturally produced feed within the water system are being encouraged.

In Iraq shortage of water was noticeable during recent years as seen from the data of Table 1. The predicted reduced water availability in Tigris and Euphrates river system and Shatt Al-Arab Estuary has to be considered in conjunction with saline water intrusion in the rivers and adjoining wetlands. Sea level rise and consequent increased salt water intrusion in Shatt Al-Arab estuary imposes adaptations to the related impacts by rearing species with high salinity tolerance.

Table 1: Annual discharge of Tigris & Euphrates and their branches.

Annual Discharge	**Billion m3**
Tigris at Feish-Khabour	20.90
Upper Zabat Eski-Kalak	14.30
Lower ZabU/S Dokan	7.10
Adhaimat Enjana	0.70
DialaU/S Derbendikhan Dam	5.86
Euphrates At Hussaiba (1976-1989)	27.40
Euphrates At Hussaiba (1989-1994)	12.20
Euphrates At Hussaiba (1994-2003)	19.15

In Basra region only 7% of the fish farms are working, 93% are not producing fish due to shortage of water, increased water salinity due to intrusion of seawater and deterioration of water quality (Fig. 2). Some of the currently producing fish farms replaced stenohaline freshwater fish with oligohaline species which can tolerate certain degree of salinity such as carp and mullet or even seawater species (Al-Mukhtar *et al*., 2005). Water salinity of some of the farms in Abo-Alkhasib area at the lower reaches of Shatt Al-Arab River reached 15-20 g/L (Ghazi, 2012). Such level of salinity could be lethal for the sensitive species and even growth inhibitor for the more resistance species. This will definitely reflect on low fish production and less economically feasible aquaculture projects.

Impact on fisheries production

The following fisheries as most responsive to climatic variables as suggested by Sharp (2003) includes:

1. Fisheries in small lakes and rivers with high temperature and precipitation changes.
2. Fisheries of large lakes and rivers.
3. Fisheries in estuaries impacted by sea level rise or decreased river flow.

Figure 2: Impacts of salinity increase on freshwater fish farms in Basra City.

The less impacted are marine fisheries which is affected by human interventions. Synergistic interactions occurred between current stressors, including fishing and ecosystem resilience, and the abilities of marine and aquatic organisms to adapt and evolve according to climatic changes. Roessig *et al*. (2004) called for increased research on the physiology and ecology of marine and estuarine fishes, particularly in the tropics. Effects of climate change on fresh water systems will occur through increased water temperature, decreased oxygen levels and the increased toxicity of pollutants. In addition, it was concluded that altered hydrological regimes and increased groundwater temperatures would impact on fish communities in lotic systems. In lentic systems eutrophication could be exacerbated and stratification becomes more pronounced with a consequent impact on food webs and habitat availability and quality.

Direct impact

1. Global warming 1.1 C – 3 C during the century.
2. Sea level rise IPCC 10-100 cm from, thermal 10-43 and melting ice 23 cm.
3. Ocean productivity and circulation patterns.
4. Monsoons and extreme climatic events (Floods, rain, storminess).
5. Water stress and freshwater availability.
6. Hydrological regimes in inland waters (Eutrification, stratification, quality, food web).

Species adaptation

Organisms have specific ranges of environmental conditions to which they are adapted and within which they perform optimally. Physiological performance, often related to tissue metabolic oxygen demands, may degrade and cause stress at conditions (e.g. temperatures) which may be considerably below lethal limits. Increasing temperatures will have negative impacts on the physiology of fish because of limited oxygen transport to tissues at higher temperatures. This physiological constraint is likely to cause significant limitations for aquaculture. These constraints on physiology will result in changes in distributions of both freshwater and marine species, and likely cause changes in abundance as recruitment processes are impacted.

Changes in the timing of life history events such as short life span and rapid turnover of small pelagic fish species are expected. Impact the recruitment success and therefore, the abundances of many marine and aquatic populations. These impacts are also likely to be most acute at the extremes of species' ranges and for shorter-lived species. Changes in abundance will alter the composition of marine and freshwater communities, with possible consequences for the structure and productivity of these ecosystems (Table 2). In lentic systems eutrophication and stratification become more pronounced with a consequent impact on food webs and habitat availability and quality.

Increasing vertical stratification is predicted for many areas, and is expected to reduce vertical mixing and decrease productivity (intermediate confidence). It will drive changes in species composition. Most models show decreasing primary production with changes of phytoplankton composition to smaller forms, although with high regional variability.

Table 2: Relationship between water temperature and salinity with ecological indices of fish in Shatt Al-Basrah canal.

Month	W. Temp.	Salintiy (ppt)	Species No.	Individuals No.	Richness (D)	Diversity (H)	Evenness (J)
July 2008	31.5	47.5	14	296	2.28	1.67	0.63
August	28.5	47.4	11	56	2.48	2.04	0.85
September	30.5	46.3	22	230	3.86	2.21	0.72
October	27	45.6	19	295	3.17	1.97	0.67
November	25	35.4	14	97	2.84	2.11	0.80
December			0	0	0	0	0
February 2009	15	12.3	7	32	1.73	1.42	0.73
March	18	5.5	10	85	2.03	1.82	0.79
April	20.5	7.6	19	173	3.21	2.11	0.72
May	23	12.2	14	175	2.52	1.94	0.74
June	24.5	15.3	11	173	1.94	1.71	0.71
Total			**35**	**1712**	**2.61**	**1.90**	**0.74**

Freshwater fisheries

Fisheries in small lakes and rivers with high temperature and precipitation changes are most responsive to climatic variables than those of large lakes and rivers. Regarding freshwater systems, there are specific concerns over changes in timing, intensity and duration of floods, to which many fish species are adapted in terms of migration, spawning and transport of spawning products as a result of climate change. It is important to develop management systems capable of addressing the needs for fresh water by fish and land-based food production systems in the context of climate change, particularly in developing countries.

Combined effects of changes such as salinity, temperature, nutrients, and primary production cascade up the food web to influence prey availability and habitat conditions for fish. Water temperature showed a positive correlation with the number of species and the total catch of fish species in the marshy area. While, salinity showed a negative correlation with the number of species and total catch of fish individuals (Fig. 3). This could be explained that the marshes are inhabited by fresh water species and increase of salinity will eliminate them.

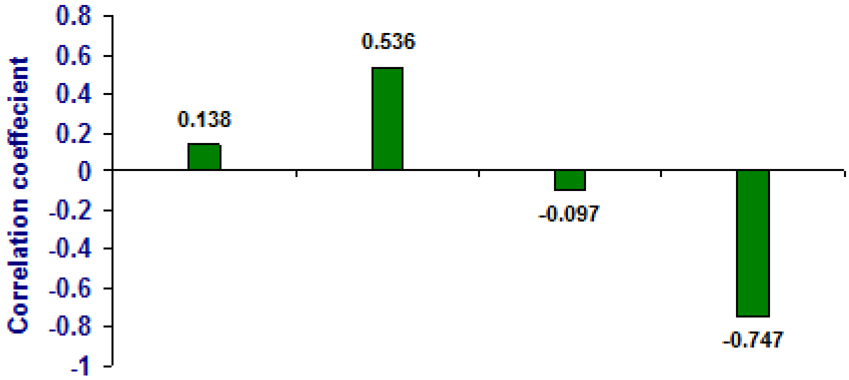

Figure 3: Correlation coefficients of temperature and salinity with the total catch in the inland marshes of Southern Iraq (Salman *et al*., 2009).

Although fishing is the main economic practice for the marshes, fishing effort and fishery production are at their lowest rates due to decline in fish stocks and overfishing activities. Draining of the marsh and shortage of water caused serious damages to the spawning grounds of many fish species and decline in number of spawners (Salman *et al*., 2009). Abundance and species diversity of riverine fishes are particularly sensitive to these disturbances, since lower dry season water levels reduce the number of individuals able to spawn successfully and many fish species are adapted to spawn in synchrony with the flood pulse to enable their eggs and larvae to be transported to nursery areas on floodplains. Accordingly recruitment rates have reduced in the marsh especially for the commercial species which were subjected to overfishing by pesticides, electric shock and explosives. Occurance of marine species penetrating from the Gulf and Estuary due to increased salinity levels.

Marine fisheries

Fisheries in estuaries impacted by sea level rise or decreased river flow are more impacted than marine fisheries, which is mainly affected by human interventions rather than climate changes. Effects of climate change on aquatic ecosystems will occur through increased water temperature, decreased oxygen levels and the increased toxicity of pollutants**.** Greatest impacts are likely to occur on coastal species and subtidal nursery areas. Temperate endemic and tropical species as well as coastal and demersal species are the most affected rather than pelagic and deep-sea species. Ocean warming has caused increased vertical stratification, strengthening of coastal currents, increasing ocean acidification, sea level rise and altered storm and rainfall regimes.

Warming and increasing stratification will alter plankton community composition, alter their distributions and change the timing of their bloom dynamics so that transfers to higher trophic levels may be impaired. Benthic and demersal fishes will shift their distributions southward and may decline in abundance. The abilities of marine and aquatic organisms to adapt and evolve according to climatic changes needs more research on the physiology and ecology of freshwater, marine and estuarine fishes.

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