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RESEARCH BASED BOOK CHAPTER

CLIMATE CHANGE AND ENVIRONMENTAL EFFECT ON PRODUCTION OF PALLA (TENUALOSA ILISHA) FROM INDUS RIVER

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Abstract

It is reported that the production of Palla is greatly impacted by changes in water temperature. Moreover, changes in water temperature can affect pH and DO (dissolved oxygen) levels, two crucial factors in breeding. Different research studies have recommended that, for optimal migratory and pre-breeding congregation of Palla fish, salinity should be kept 0.1 ppm and also the depth of water ought to be above 10 m. To determine the relationship between climate change variables such salinity, temperature, dissolved oxygen, and the fish supply, there aren't any time series data or prior studies available. Further investigation into these issues is highly encouraged. For Pakistan to have better sustainable management options, greater research on the socio-ecological aspects of Palla fisheries management is also essential.

Keywords
Indus River, Tenualosa ilisha, Climate Change, Environment, Aquaculture

1. Introduction

Since 1988, based on solid scientific data has been regularly publishing informs on climate change and its political and economic ramifications IPCC (The Intergovernmental Panel on Climate Change). Since the middle of the nineteenth century, the average surface temperature of the Earth has grown by more than 0.8 °C, and it is currently increasing at a rate of more than 0.1 °C every decade [1]. Even though data dependability and degree of accuracy differ between continents, heat waves are increasingly often lately [2]. The rising concentration of GHGs in the atmospheric including carbon dioxide (CO2), methane (CH4), and nitrogen dioxide (NO2) is thought to be the main cause of this warming. GHGs are in charge of sustaining life on Earth by acting as a heat blanket surrounding the planet [3].

2. Just how Poverty and Climate Change are Relate in Fisheries and Aquaculture?

Limited aquaculture and fishing are especially in danger to climate change. Both their geographic location and their economic predicament make them vulnerable. Communities that depend on fishing and fish farming are particularly vulnerable to extreme weather caused cyclones, sea level rise, hurricanes, ocean acidification, floods, and coastal erosion by effect of climate change. Frequent flooding prevents millions of residents of low-lying coastal & floodplain areas from leaving their homes. As described through this whole volume, the effects of climate change are having a negative influence on both natural systems and human, including organization, fish populations, natural resources, species and ecosystems. These effects also decrease resilience. So, climate change poses a risk to people's health, happiness, and means of subsistence.

3. Fish Consumption and Trade by the Impacts of Climate Change

With the distribution of climate change several species predicted to alter as a result of fluctuating conditions is anticipated to have an impact on the accessibility and exchange of items from aquatic industry. The accessibility of fish supplies, particularly for small-scale fishermen, the fishing methods used, and consequently the dietary habits of the surrounding people, plus the behaviors of producers, exporters, and consumers, may all be impacted by these species' transitions. International fisheries agreements and governance may also come under strain from changes in the distribution of fish resources. The patterns of trade can also be affected, which could have an effect on the food security of nations that depend more on the export for tax and foreign exchange profits of fish and fish products. These shifts can also have an impact on consumption, either positively or negatively, by increasing or decreasing the availability of local customers' preferred species on home markets. For the peoples which dependent on fishing and aquaculture, in living on fish as food, the effects on consumption are anticipated to be more severe [4] and especially for people who reside close to climate-sensitive places like low-lying coastal regions and water-stressed areas. When specific species affected by climate change are used for export or consumption, the implications could be worse, especially if there is no help provided by focused strategies on adaptation to climate change and variability. The aquatic resources availability and the worldwide supply, as well as the price of the items, infrastructure, and services needed for the production, processing, and distribution of aquatic foods, are all projected to change as a result of climate change (Table 1). By 2050, it is predicted that the impact of anticipated food output will increase food price when changing in temperature and precipitation on worldwide [5]. While never climate change associated to scenario in 2050, the highest emission scenario examined in the Intergovernmental Panel on Climate Change's (IPCC) fifth assessment report is predicted to increase food prices by two percent to 35 percent [6]. This may also apply to fish prices, particularly if there is a decrease in supply on local markets or as a result of shocks brought on by unanticipated catastrophic events. The demand for and consumption of these goods may decline as a result of higher fish prices, which might have a significant negative effect on food safety and malnutrition, especially between the maximum disadvantaged families. Higher prices could decrease demand in nations that depend on imports for their consumption, especially among less well-off customers.

4. Food and Fish Demand

Income, prices, and historical trends in food mix preferences all affect per capita food intake. In the previous fifty years and to saturate at amount to those predicted by Alexandratos et al. [7], who forecasts were based on comparable expectations about growth in economy and human population, that looks to be, to a little lower 3500 kcal/individual/24hrs in 2012 [8]. Given their higher per capita economic growth, middle- and low-income world countries per capita calorie utilization is anticipated to increase until 2030 at a faster rate than high-income countries', and to reach levels similar to those predicted by Alexandratos et al. [7], who predicted that their calorie consumption would extent closely 3000 kcal/individual/24hrs by 2050. Between 2012 and 2050, it is anticipated that global annual per capita edible fish consumption will somewhat decline, but at a relatively modest rate of 0.5 percent per year (from 21 kg/individual in 2012 to 18 kg/individual in 2050). Nonetheless, significant variations are anticipated between places and according to the era, as illustrated in. According to projections, the per capita food fish demand in high-income nations between 2012 and 2030 will decrease by 0.6 % annually. This outcome is consistent with the animal evolution product utilize and the persistence of historical food mix preferences. According to FAO [8], there is already a dietary trend towards consuming more fruit and vegetables and fewer animal-based products.

5. Pakistan Significance of the Fisheries Sector and Its Role in Economic

Around two-thirds of Pakistan's 135 million people are reliant on agriculture, both either directly or through indirect means, as the nation is mostly an agricultural one [9]. Fisheries, a segment of agriculture, is important to Pakistan's national economy & helps ensure the nation's food and nutritional security [10]. It employs 1.0 percent of the nation's labour force and contributes around 1.0 percent to the total GDP, which is comparable to about 4.0 percent of the GDP of the agriculture sector [11]. 600,000 people work in ancillary sectors in addition to the approximately 400,000 fishermen who are employed directly by the fishing sector [12]. They rely on fishing for a living with their families [13]. According to Daudpota et al. [14], the estimated annual fisheries production is 0.6MMT (Million metric tonnes), with 37% of it occurring inland and 63% in the sea. Pakistan's aquaculture benefits from irrigation because roughly 75% of the nation's fish ponds are supplied with water by irrigation canals [15]. The fisheries industry expanded by 4.2% from 2006 to 2007. (Jarwar 2008). A total of 62.30 thousand metric tonnes (MT) were produced by Pakistani fisheries in 2013, of which 14.81 thousand MT were produced through aquaculture and 47.49 thousand MT were obtained by capture [16]. In Pakistan, shrimp fishing is a significant source of fish. With its export, this fishery resource has been extremely important in generating income. In 1950, the total shrimp production was only 2900 t. According to data provided in 2015, over 18981 t of various varieties of shrimp were caught in Pakistan, indicating that this quantity has multiplied greatly. Sadly, recent figures show that overexploitation is causing this fishery resource's capture productivity to decline [17]. In contrast, shrimp aquaculture production is increasing, from 1988 (40 t) to 2015 (119 t), albeit at a relatively slow rate compared to capture production. Shrimp fisheries exports from Pakistan are growing and reached 21155 t (75519000 USD) in 2015. Yet, the market's makeup has evolved since then [18]. The largest new export market for Pakistani shrimp aquaculture is China. China receives over 75% of the items made from shrimp. This fishery resource has enormous export potential, which can be further expanded by increasing production and putting in place trade-promoting regulations [19]. The protection and export of fisheries and aquaculture products are governed by many regulations and laws in Pakistan. The Fisheries Act of 1897, the Fisheries Development Board, and the Marine Fisheries Department are a few of these. The first comprehensive fishing strategy for Pakistan was introduced in 2007. Our policies must encourage flexibility, such as diversifying access to fisheries and finding new sources of income. Better resources should be made available, such improved fisheries technology and capability.

6. Climate changes Effect in Pakistan fisheries

In addition to being a significant source of food and revenue for the nation, fishing provides a means of subsistence for Pakistan's coastal residents [20]. The most affordable and valuable source of animal protein for humans is fish [21]. In addition to numerous other concurrent pressures like overfishing, habitat degradation, pollution, the introduction of new species, etc., climate change poses serious dangers to fisheries [22]. 90% of Pakistan's top fish exporter's breeding grounds and residents depend on mangrove forests for food and fuel [23]. First off, smaller amount fish is producing for local utilization because of some species of fishes going to decline. Second, fishermen who are impotent to along with follow fish due to political borders and economic causes will be significantly stuck by the movement of various species of fish to water bodies with the best climatic situations [24]. Finally, limited fish capturing for distribute in many developing nations and the fisheries supply majority, fish productivity will be in decline and also decline fish export incomes, which would limit the capability to import fish and make worse country food shortages [25]. The aquaculture and fisheries industries are confronted with a number of obstacles and challenges, both internal (from within the industry) and external (from other land- and water-use sectors competition, pollution, and habitat degradation). Internal obstacles and challenges include overexploitation of resources, discrimination in access to resources, and poor management [26]. Since overfishing and environmental degradation are already a problem in many fisheries throughout the world due to poor management and inadequate governance, it is estimated that 30 percent of stocks are now overexploited and 57.4 percent are fully exploited [27, 28]. Unplanned aquaculture development has seriously harmed freshwater and marine ecosystems, caused disease outbreaks, and raised concerns about human health [29]. The broad effects of climate change on ecosystems, society, and economies provide a compounding danger to the sustainability of fisheries and aquaculture in addition to these already pressing issues [30].

Table 1 World trends in fisheries and aquaculture

Average	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2015	2016
Million tonnes								
Total production	26.8	49.0	66.4	85.9	110.7	134.3	158.5	170.9
Capture fisheries	25.6	47.0	62.9	77.8	88.9	90.8	90.7	90.9
Inland water	2.6	3.8	4.9	5.7	7.1	9.3	11.1	11.6
Marine water	23.0	43.2	58.0	72.1	81.9	81.6	79.5	79.3
Aquaculture	1.1	1.9	3.5	8.1	21.8	43.5	67.8	80.0
Inland water	0.6	0.9	1.7	4.6	12.6	25.7	43.0	51.4
Marine water	0.6	1.0	1.8	3.5	9.2	17.7	24.9	28.7
Share trade as a percentage of total production	….	…..	…..	30%	36%	38%	37%	35%
Per capita food fish consumption	8.1	9.9	11.5	12.5	14.3	16.8	19.3	20.3
From capture	7.7	9.3	10.7	10.9	10.5	10.1	9.8	10.8
From aquaculture	0.4	0.6	0.9	1.6	3.8	6.7	9.5	9.6

Absence of aquatic mammals (whales and seals) and aquatic plants [31]

7. Impact of Climate Change of Palla fishery in Indus River Pakistan

One of Pakistan's most commercially significant trans - border migratory fish species, the Palla fish (Tenualosa ilisha), accounts for 5–10% of the world's reported catch (Figure 1)

[32]. The migratory Palla fish begins its spawning voyage from the sea to the upstream area, and the young Palla (also known as Palli locally) grazes on rivers and floodplains for 5–6 months before beginning its back migration to the sea. According to Morrill et al. [33] and Lagler et al. [34], a number of physicochemical factors, including physical ones (bottom materials, water depth, current and tide, turbidity, temperature, and light intensity) and chemical ones (salinity, alkalinity, dissolved gases, odor, tastes, and pollutants), may affect the migratory movements of fish. For instance, when Palla fish eggs are placed in freshwater, they hatch within 23–26 hours at a temperature of around 23 °C [35]. Thus, the production of Palla is greatly impacted by changes in water temperature. Moreover, changes in water temperature can affect pH and DO (dissolved oxygen) levels, two crucial factors in breeding. According to a study by Ahsan et al. [32], for optimal migratory and pre-breeding congregation of Palla fish, salinity should be kept 0.1 ppm and also the depth of water ought to be above 10 m. To determine the relationship between climate change variables such salinity, temperature, dissolved oxygen, and the fish supply, there aren't any time series data or prior studies available. Further investigation into these issues is highly encouraged. For Pakistan to have better sustainable management options, greater research on the socio-ecological aspects of Palla fisheries management is also essential.

Figure 1 Palla fish (Tenualosa ilisha) capturing in aquaculture pond

8. Sindh Barrages

The Indus River's irrigation system consists of about 107,000 watercourses, 19 barrages and headworks, 12 link canals, and 43 commands (Figure 2). Years ago, the barrages were built, mostly for irrigation but also to manage floodwaters. The Pakistan irrigation network, world's largest single unified irrigation network, with the 9,923 km in length and a command area of more than 3.05 million ha, is nourished by the barrages of Pakistan. It was thought that the Guddu barrage in the Sindh province needed to be repaired. There are two further barrages located downstream of the Guddu barrage, located at Sukkur and Kotri. When viewed in the situation of the cumulative effects of all barrages, construction consequences of barrage rehabilitation may be large and long-term in character, despite the fact that they are typically ephemeral in nature if they are assessed separately. Before building large-scale infrastructure, it is appropriate to conduct a cumulative impact assessment (CIA). Unfortunately, because environmental rules and regulations were nonexistent when these barrages were built more than 60 years ago, their overall impacts were not investigated before construction. A reexamine of collective calculations is required throughout their recovery efforts due to recent changes in the nation's environmental laws and regulations [36]. Since the introduction of the Environmental Law in 1997, more comprehensive laws have also been adopted in Pakistan. The necessity for undertaking for the projects an environmental impact assessment is relatively new in Pakistan [37]. The Sindh Irrigation Department therefore started a collective result calculation in larger ESIA study for the anticipated restoration operations. The CIA's goal was to assess the overall effects of I the rehabilitation of the Indus River's barrages, (ii) water diversion, (iii) the Indus River division of caused by barrages, and (iv) developments that have occurred both upstream and downstream of the Indus River and other activities.

9. Palla Migration

To comprehend its movement patterns, no in-depth research on Palla was done in Pakistan. According to Bhuiyan and Talbot [38], the migration of palla from the sea to the river generally begins in January and lasts until July. Nevertheless, it seems that there are two peak migration phases, one from January to February and the other from April to July. Before the Sukkur Barrage was built in 1932, the Palla was said to traverse more than 1,000 miles up to Multan [39]. Since Sukkur Barrage lacks any fish routes, migration of palla was restricted to it once it was built [40]. Fish passes were built into the barrages (Kotri and

Guddu), built in 1956 to 1962, to support migration of palla. The migration of Palla in Kotri Barrage's was not correctly constructed and enable to fishes can pass. As a result, after 1956, migration of palla was limited to Jamshoro at Kotri Barrage and travel only 300 Km from the Arabian Sea. Due to this impediment, the Palla fish former spawning grounds were cut off by two-thirds [38]. In the Guddu Barrage, two fish ladders with a combined length of 85 m (downstream length is 50 m and upstream length is 35 m), 1.5 m depth and 3 m width have been built in the outside jetties of each support pocket, namely after gates number 7 showing in Figure 3 and 61 gate showing Figure 4. Lock chamber wall and the left bank ladder are built. A screw gate that is 0.6 m (2 ft) wide is used to control the upstream fish ladder. Throughout the entire length, there are cross-partitions in ladders that create a sequence of baffle steps. Two access gates, in the left wall and the ladder ends, are located on the downstream side of the right-side ladder. Both gates are in bad shape. Vertical baffle walls have been cast into the side of the chute on the right-side ladder. There is a single gated opening in the left sidewall on the ladder's upstream side. This gate is in good shape and was replaced in April 2011. The downstream end of the left side fish ladder also features two sluice entry gates, but the baffles inside the chute are horizontal rather than vertical. There is one sluice gate on the right side of the chute wall at the upstream end and two sluice gates on the left. Fish are drawn to turbulence of fish ladders at the downstream end so they can move upstream. To produce this turbulence, the fall at the downstream end of the ladders is kept above 0.6 m. The remaining fall is dispersed up to the fish pass so that it never exceeds 0.6 meters at any regulation point. Fish ladders are made to function at the minimal winter pond level required by Barrage. Fish can easily swim rather than jump when the water flow is controlled by altering the gate opening and a minimum water depth of 0.5 m is maintained in the steps. Similar in size to those in Guddu Barrage, Kotri Barrage has two fish ladders that are situated on each of the partition walls. The Sukkur Barrage lacks fish ladders.

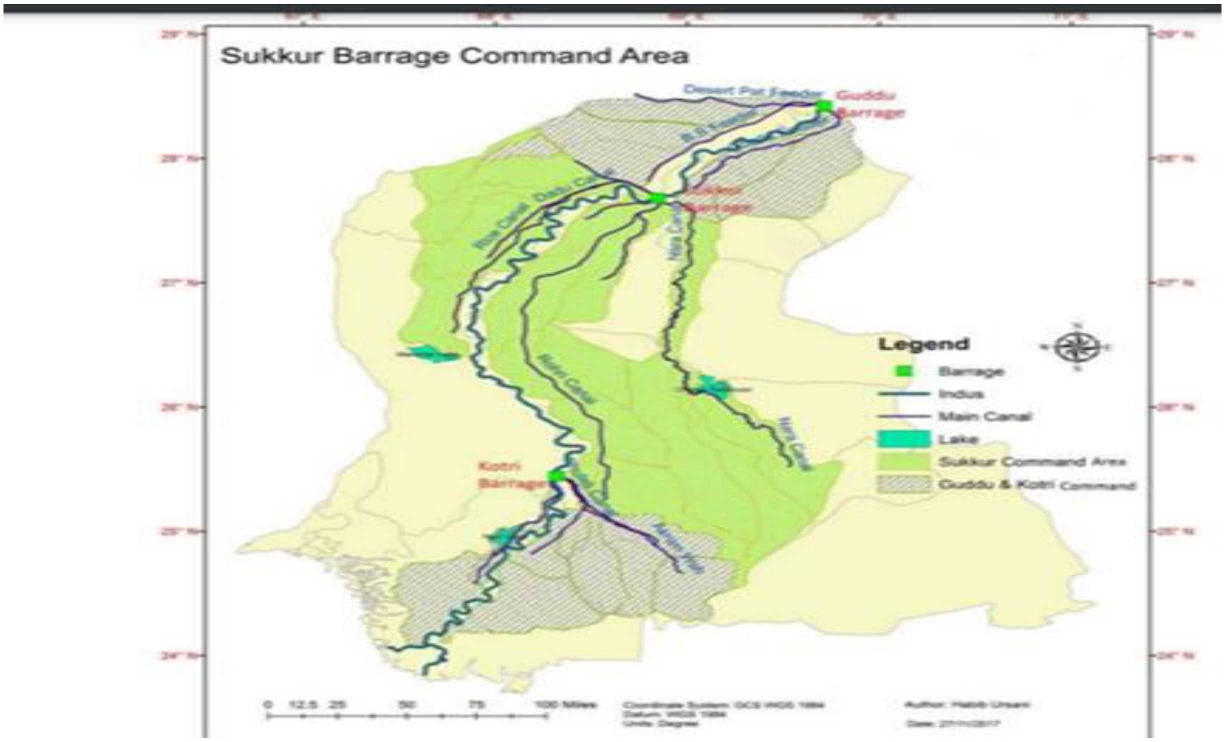

Figure 2 This map show Indus River canal and barrages system

Upstream end ***Downstream end***

Figure 3 Right side fish ladder at Guddu Barrage (Gate 7)

Figure 4 Left side fish ladder at Guddu Barrage (Gate 61)

Figure 5 Palla fish (Tenualosa ilisha) captured in hanging Basket made by iron wires at Kotri Barrage, Jamshoro Sindh

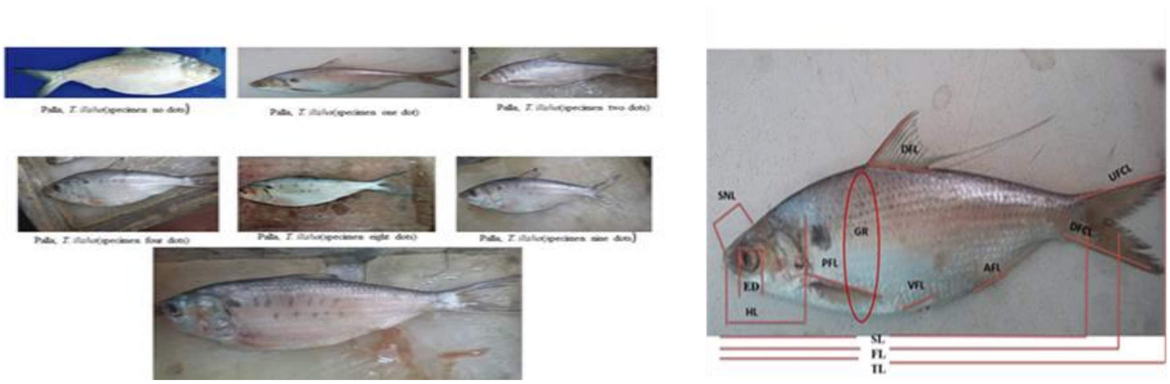

Figure 6 Photographs of Palla (T. ilisha) collected from Indus River, Sindh-Pakistan and Showing thirteen morphometric characters

Table 2 Morphometric analysis of (T. ilisha)

Sr. No	WT (g)	TL (cm)	FL (cm)	SL (cm)	HL (cm)	HH (cm)	SnL (cm)	ED (cm)
One dot specimens								
1	150	20.9	18.4	17.5	4.9	3.5	0.9	1.1
2	200	24.5	18.2	16.9	4.2	4.5	0.9	1.2
3	200	25.6	16	15.1	4.3	4.2	0.9	0.9
4	220	26	13.2	12.6	3.7	3.1	0.7	0.8
5	360	29.3	14.5	13.9	4.2	3.8	0.8	0.8
6	410	30.2	13.3	12.9	3.9	3.7	0.7	0.9
7	360	31.5	14.3	13.6	4	3.8	0.9	0.8
Mean	271.4285714	26.85714286	15.41428571	14.64285714	4.171428571	3.8	0.828571429	0.928571429
Two dot specimens								
8	350	32	15.2	14.8	4.5	3.6	1	1.1
9	390	32.7	14.3	13.2	3.9	3.1	0.8	0.8
Mean	370	32.35	14.75	14	4.2	3.35	0.9	0.95
Four dot specimens								
10	500	36.5	17.3	16.3	5	5.3	1.2	1.1
11	590	37.5	16.8	15.1	4.5	4.8	1	1
12	50	36.5	16.4	14.9	4.1	4.2	1	1
Mean	380	36.83333333	16.83333	15.43333	4.533333	4.766667	1.066667	1.033333
Eight dot specimens								
13	243	20.2	16.9	14.9	5.2	5.3	1	1.1
14	230	19.4	16.6	14.7	5	5.1	1	1.1
15	139.2	19.3	16.4	14.4	4.8	4.9	1	1
16	265	24.1	16.1	14.2	4.4	4.6	1	0.9
17	416.3	27.5	15.8	14	4.1	4.5	1	0.8
Mean	258.7	22.1	16.36	14.44	4.7	4.88	1	0.98
Nine dot specimens								
18	686	34.5	16.5	15.7	5.1	5.1	1.2	1
19	775.5	37.1	16.2	15.3	5	5	1	1
20	860	41.5	15.9	15.1	4.9	4.7	0.9	0.8
Mean	773.8333333	37.7	16.2	15.36667	5	4.933333	1.033333	0.933333
Twelve dot specimens								
21	887	43.3	17.6	16.7	5	4.9	1.4	1.1
22	950	44	17.1	16.3	4.9	4.8	1.2	1

Mean	918.5	43.65	17.35	16.5	4.95	4.85	1.3	1.05
No dot specimens								
23	970	45.3	16.8	15.6	5.1	4.8	1.1	1
24	1170.2	46.9	15.6	15	4.1	4	0.8	1
25	1260	47.8	13.9	13.4	4	3.7	0.6	0.8
Mean	1133.4	46.66666667	15.43333	14.66667	4.4	4.166667	0.833333	0.933333

*WT represents weight gain; TL (total length); FL (fork length); SL (standard length); HL (Head Length); HH (head height); SnL (Snout Length); ED (Eye diameter)

Table 3 Length-Weight relationship of Hilsa shad (T. ilisha)

Sex (Male & Female)	Male	Female
N	13	12
L min-max (cm)	20.9-38	14.2-47.8
W min-max (g)	740-150	1260-50
A	0.07230942	0.109462
B	2.480301413	2.46932
SE (b)	0.391599728	0.391599728
CI (b)	0.26216903	0.26216903
r^2	0.891903205	0.910437854
P	0.005326472	0.005326472
t-test sig	-3.543401943 Negative	-3.543401943 Negative
K (Fulton's condition factor)	1.245334342	1.459104178

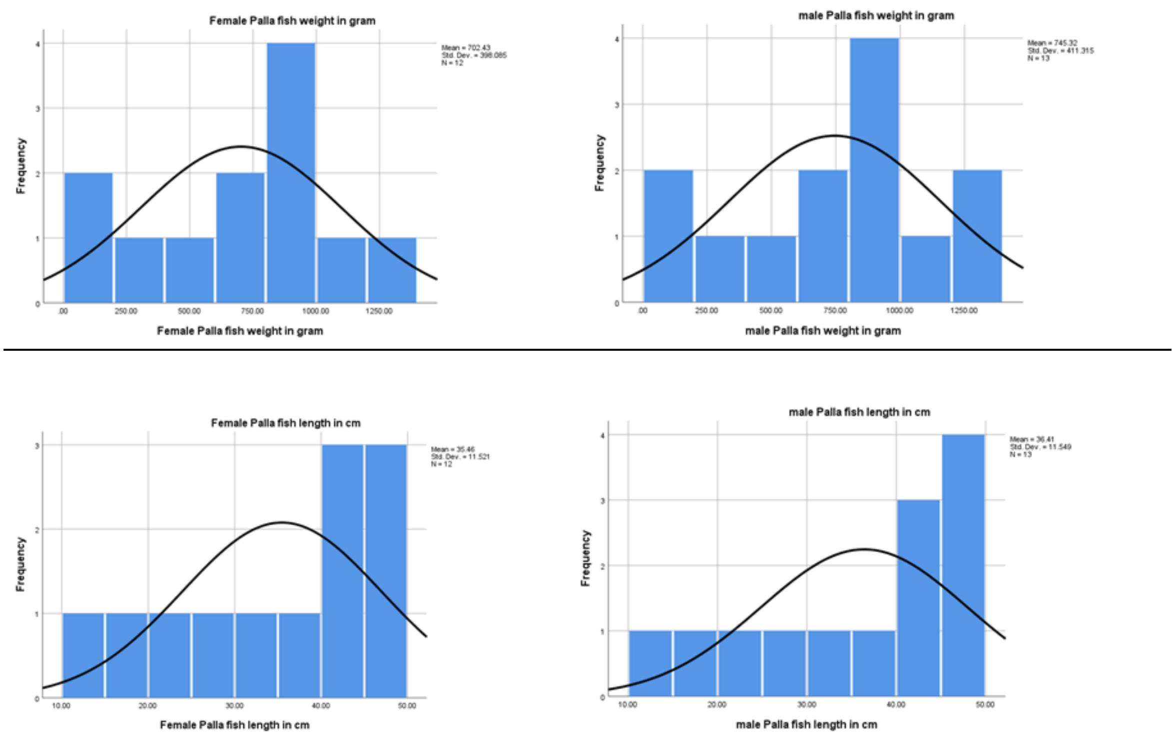

Figure7 Weight and Length Histogram of Male and Female of T. ilisha

Morphological characteristics and Length-Weight relationship of Hilsa Shad (Tenualosa ilisha) from the Down Stream Kotri Barrage Indus River, Pakistan are examined. Total 25 specimens (T. ilisha) were collected from August 2019 to September 2020 and T. ilisha body presents multiple dots. The dots were varying in some range; like some sample of T. ilisha have no dots in their body and others were present 1 to 12 range of dots in their body. The color of these dots is in black and first time reported in Pakistan. The morphometric characters, body length and weight were found different but meristic are similar. The maximum and minimum weight and length were noted as 254±0.7g and 31±0.6g, 21.1±0.9cm and 15.5±0.8cm, respectively. Only three specimens were found without dots present in their body followed by four dots and nine dots, however, only two specimens categorized as two dots and twelve dots, five specimens with eight dots and seven specimens with single dot. The growth of fish was found higher in one-dot specimens followed by four, eight and twelve dot specimens. Results also revealed that almost all specimens exhibited an isometric growth and the Length-weight relationship was significant with r2 ≥0.910 while no statistical (P>0.05) difference was found between female (A) and male fish (B). The Hilsa (T. ilisha) is a migratory fish from sea to river for breeding and spawning purpose but, unfortunately illegal fishing, local demand, environmental change and habitat destruction cause Hilsa fish to decline continuously in the Indus River of Pakistan. Therefore, it is recommended that stock assessment with genomic studies of Hilsa Shad will be taken to distinguish the actual number of species present in the Indus River of Pakistan.

Author Contributions

Analysis design, P.K.L.; performing the experiment, D.A., review and editing, M.Y.L.

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Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The date is available from the corresponding author (Dr. Punhal Khan Lashari).

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