

Research article

Studies on the Use of Aquatic Food in Pakistan

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ghulamabbas@uok.edu.pk**Abstract**

The natural resources of Pakistan, such as the Arabian Sea, the Indus Delta, dams, lakes, and mountain streams, present a variety of marine and inland fisheries potentials. These resources support numerous species with dietary and economic value. Fish and other aquatic food are major sources of protein for native people and animal populations worldwide. Fish accounts for 7% of the protein in diet and 17% in animal protein. Fish production in Pakistan rose from 214,231 metric tonnes in 1973 to 733,025 metric tonnes in 2021 at a rate of 4.9% per annum. During the same period, the amount of fish used for human consumption went from 99,368 metric tonnes to 500,866, at an annual rate of 9.7%. Fish export had increased at rate of 18.6% from 24,623 metric tonnes in 1980 to 217,030 metric tonnes in 2021. The export values reached 496 million US\$ in 2022-23. In 2021, fish imports totalled 5,770 metric tonnes. Fish for human consumption in aquatic food chains are typically sold in canned, frozen, cured, or fresh forms. Fresh marketing, freezing, and canning all require special equipment, which involves high capital costs. However, curing is a simple, low-cost preservation process that doesn't involve much in the way of material or capital expenditures. Frozen fishery products are dominant with 85%, followed by live (7%), dried (6%) and chilled (2%). Fish is also processed into meal before being added to animal feed; the bulk of processed fishmeal is used for chicken feed. 16% of the total fish production was converted to fishmeal production. With 25 currently in operation in Karachi and 30 in Gwadar, the country's fish processing facilities are somewhat old and equipped with outdated machinery. Particularly for rural populations, fisheries resources offer sustainable development, employment opportunities, and financial rewards. Additionally, it has been noted that export statistics for fisheries are not adequately reported, which is necessary for them to be comparable to those of other countries. The study also provides sources for fisheries statistics.

Key words: Aquatic food, usage, processing methods, export commodities.

1. Introduction

Pakistan is blessed with a wide range of natural resources, including the Arabian Sea in the south, the vast Indus delta in the southeast, big dams, natural lakes, and mountain streams in the north. These natural resources offer a vast array of marine and inland fisheries potential, supporting a large range of species with nutritional and commercial importance. The fish resources are a source of revenue for the marine

provinces of Sindh and Balochistan as well as a source of sustenance for the coastal people. Fish and shrimp are processed into chilled/ fresh, frozen, cured, and canned products. Additionally, by-catch from shrimp trawling, offal from other fisheries, and small pelagic fish are also used to generate fish meal. Nearly all of the fishery's frozen, cured, and canned goods are exported, while the majority of the processed fish meal is used in the country to make chicken feed [7].

The country's processing facilities have antiquated machinery and are extremely ancient (40 years on average). 25 of these plants are currently operating in Karachi, while 30 brand-new plants have been built in Gwadar. Compared to Karachi, these plants are smaller in size and have a lower processing capacity. Approximately 84% of the catch is suitable for human consumption annually, of which 58.1% is sold as fresh, 19.2% as frozen, 16.2% as fishermen's subsistence, and 6.4% as dried and salted product. It is reported that 14.5% of the entire production is reduced to fish meal [1]. Tuna, queenfish, sea catfish, sharks, and rays/skates are among the fish that are processed into dried, salted items. Sharks are typically sliced or filleted, while small fish are typically salted and dried whole, while large-size fishes are typically gutted and cut into butterfly shapes.

For the majority of the population, fish serves as a cheap and valuable source of protein, and it also serves as a helpful source of foreign exchange gains. Fish stocks provide chances for sustainable development and the exploitation of various edible fish species, resulting in job opportunities and economic gains, particularly for rural populations. The nation's fishing industry is quite minor, accounting for only 0.32% of the national GDP and 1.39% of agriculture GDP [2], as compared to 0.8% of the nation's GDP and 3.7% of the GDP from agriculture, and less than 1% of jobs are supported by it [3]. Fish is consumed at 1.8 kilograms per person annually [3]. China, Thailand, Malaysia, the Middle East, Sri Lanka, and Japan, etc. are major importers of fish and fishery preparation from Pakistan [2].

The International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) were used to study the fishery data of Pakistan in a number of categories [4]. The latter, however, was examined by species groups [5]. A research study was conducted to: (i) assess the stock, production, and future prospects of rays and skates in Pakistani coastal waters; (ii) assess the dry-salted fisheries and suggest value-added ray and skates products; An assessment of the various fish processing methods employed in the country and their success in terms of export potential for the

years 1972-2010 had also been examined in that study [6].

People and researchers have the impression that fishery statistics are erratic and dubious. There is a perception among people and researchers that fisheries statistics are scattered and questionable. In the current study, shortcomings in the data quality have been discovered and discussed, along with a review of fisheries statistics, including fish production, fish processing by different categories, and fish exports from 1973 to 2021. Additionally, sources for fishery statistics are listed, and each source has its own procedures for ensuring the accuracy of the data.

2. Material and Method

The following sources have been used to compile data on the fish production and export of various fisheries products:

- i) The Handbook of Fisheries Statistics of Pakistan, which is based on a calendar-year basis, was used from 1973 to 2009; after that, it was taken from the Marine Fisheries Department, Karachi. It offers statistics on fish production (by provinces and industry), fish disposal by category, registered and operational fishing vessels, processing of fish, and fishery products by category, including frozen, cured, chilled, live products, canned, and fishmeal production. The names of the fisheries exporters by fish processing categories, as well as the wholesale prices, are also given [7].
- ii) The Pakistan Bureau of Statistics also provides information on fish production data from 2000-01 to the present; however, this data is based on a financial year basis (from July to June) [8]. <https://www.pbs.gov.pk/trade-tables>
- iii) Information on fish production and exports on a fiscal year is also provided in the Economic Survey of Pakistan's Agriculture Chapter [2]. <https://www.finance.gov.pk>
- iv) The Trade Development Authority also publishes data on a fiscal-year basis on export commodities, including fish and fishery products [9]. <https://tdap.gov.pk/trade-statistics/>
- v) The FAO Fishery Country Profile of Pakistan offers data on the overall amount of fish produced, as well as information on aquaculture, capture fisheries, exports of fish, and imports of fish on calendar-year basis [10]. <https://www.fao.org/fishery/en/facp/pak?lang=en>

For the benefit of governments, universities, research institutions, and businesses, the United Nations Comtrade database compiles comprehensive yearly and monthly trade statistics by product and trading partner. Over 200 countries are represented in the United Nations Statistics Division, which accounts for more than 99% of global trade in products [11]. <https://comtradeplus.un.org/>

3. Results

3.1. Fish production

Fish production from 1973 to 2021 by provinces and zones (marine and inland) is depicted in Figure 1A. The total fish production in the Pakistan increased significantly, reaching a total of 737,025 tonnes. The growth rate varied from 4.34% to 13.15%. The marine sector produced 196,614 tonnes in 1973, which increased to 426,025 tonnes in 2021. The growth rate ranges from 2.04% to 5.88%. The inland sector produced 17,617 tonnes in 1973, which increased to 307,000 tonnes in 2021. The growth rate varied from 23.28% between 1973 and 1980 to 27.31% between 2020 and 2021

The fish production trend in the maritime sector is also shown in Figure 1A. The province of Sindh saw a rise in fish production from 158,892 tonnes in 1973 to 230,314 tonnes in 2021. The range of the growth rate was minus 2.85% to 4.85%. The growth rate was at its lowest from 2001 to 2010 and at its highest point from 1981 to 1990. The province of Balochistan produced 37,722 tonnes of fish in 1973. From then on, the amount of fish produced increased significantly, reaching 195,711 tonnes in 2021. Growth rates ranged from a minimum of minus 0.18% from 2001 to 2010 to a maximum of 10% from 2020 to 2021. Fish production from the EEZ started in 1982 with 2,314 tonnes and had a varying trajectory until 2009, when it ultimately stopped completely in 2010. In 1993, the maximum production was 30,677 tonnes, with a minimum of 78 tonnes produced in 2009.

Figure 1B shows data on fish exports and production from 2000–01 (July–June) to 2022–23 that was provided by the Trade Development Authority. According to that data, fish production has been rising steadily from 468,000 tonnes since 2000-01, and in 2022-23 it reached 817,000 tonnes. The

growth rate ranged from a minimum of 0.55% in 2020–21 to a maximum of 4.32% in 2000-01 to 2000–09. The production of marine fish rose from 316,000 tonnes in 2000-01 to 509,000 tonnes in 2022-23. The growth rate ranged from a minimum of 0.58% in 2020-21 to 2022-23, to a maximum of 3.61% in 2000-01 to 2009-10. Inland fish production rose from 152,000 to 308,000 tonnes during the same time frame. From 2020–21 to 2022–23, the smallest growth rate was 0.50%, while from 2000–01 to 2009–10, the maximum growth rate was 5.79%. Figure 1B also displays the overall value of fish and fisheries product exports. The total export of fish and fisheries products rose from 82,045 tonnes in 2000–01 to 214,367 tonnes in 2022–2023. The export value grew at a variable growth rate, from 6.81% to 7.93%, from 135 million US dollars in 2000–01 to 496 million US dollars in 2022–23.

The FAO Fishery Country Profile of Pakistan provides data on Pakistan's fish production, capture fisheries, aquaculture, exports and imports from 1980 to 2021 (Figure 1C). The total fish production in 1980 was 238,097 tonnes, which increased to 660,586 tonnes in 2021. The growth rate varies from minus 0.26% to 8.62%. The fish production from capture fisheries (marine and inland waters) was 232,897 tonnes in 1980 which increased to 496,059 tonnes in 2021. The growth rate decreased to 3.19% from 1991 to 2000, -2.39% from 2001-2010, 0.82% from 2011-2020, and 0.66% from 2020 to 2021. Aquaculture production also increased steadily from 5,200 tonnes in 1980 to 164,527 tonnes in 2021, with a growth rate of 8.46% from 1980 to 1990; and peaked growth rate of 102.22% from 2001 to 2010 was recorded.

Figure 1C also shows the export and import of fishery products from 1980 to 2021. Fish export in 1980 was 24,623 tonnes and reached to 217,030 tonnes in 2021. The highest growth rate was 8.0% from 1980 to 1990, 8.66% from 1991 to 2000, and 8.25% from 2020 to 2021. Imports increased from 108 tonnes in 1980 to 5,770 tonnes in 2021. The growth rate varied from 11.70% from 1980 to 1990, to 26.47% from 2020 to 2021.

3.2. Disposition of fish

Figure 1D displays the amount of fish produced for human consumption and utilized in fishmeal production between 1973

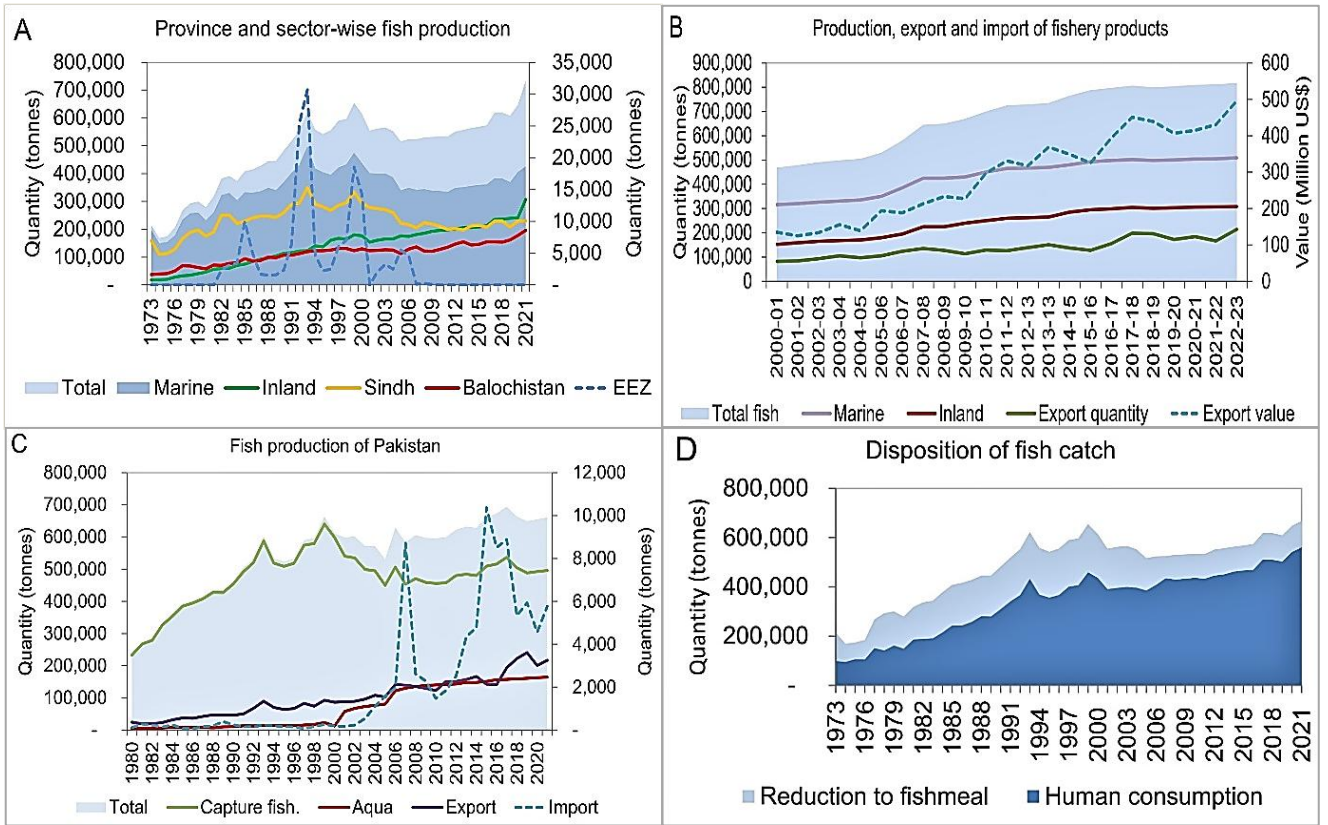


Figure 1. (A) Province and sector wise fish production [7], (B) Production and export of fish and fishery products [9], (C) Fish production of Pakistan [10], (D) Disposition of fish production [7].

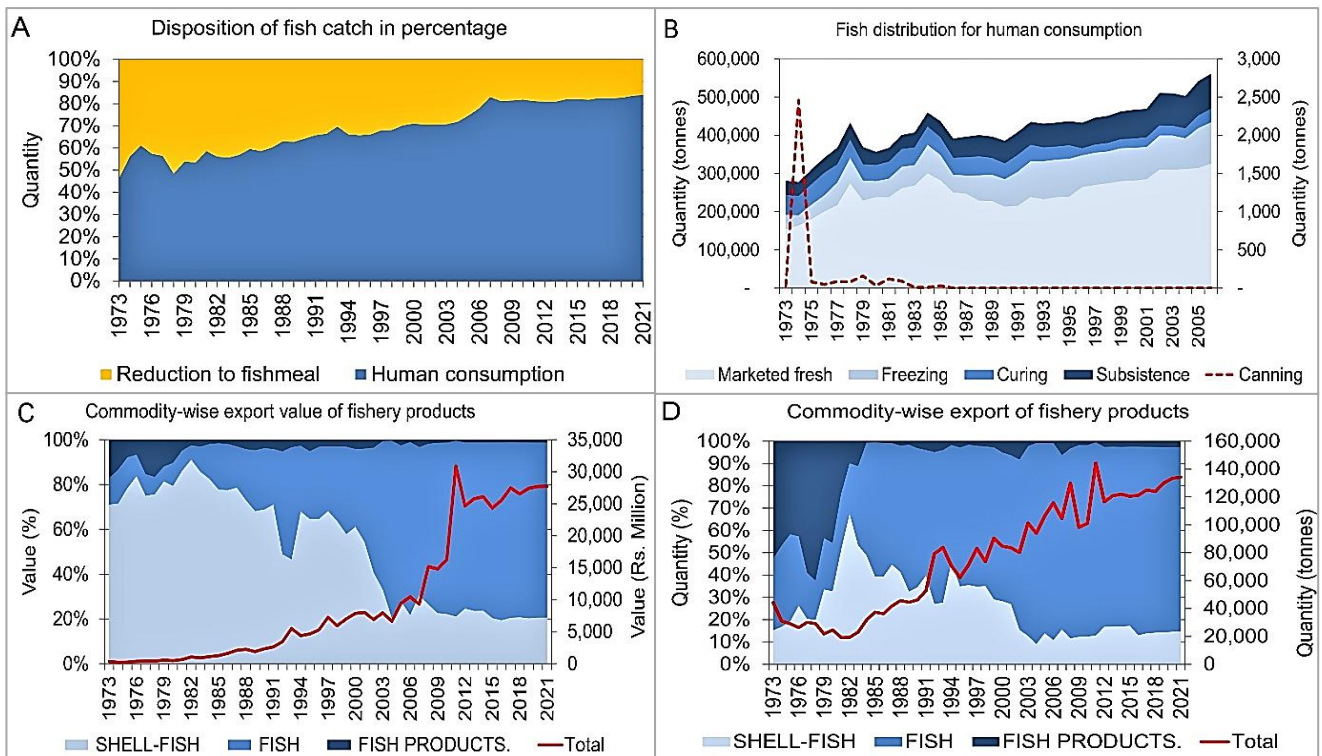


Figure 2. (A) Disposition nominal fish catch in percentage [7] (B) Fish distribution for human consumption [7] (C) Commodity-wise export of fishery products [7] (D) Exports value of fish and fishery products [7].

and 2021. Fish used for human consumption increased from 99,368 tonnes to 560,866 tonnes between 1973 and 2021, with an annual growth rate of 9.7%. Fishmeal production declined from 114,863 tonnes in 1973 to 106,988 tonnes in 2021, with a maximum growth rate of 3.31% between 1981 and 1990. Fish consumption rose to 84% in 2021 from 49% in 1973 (Figure 2A). The percentage of fish used to produce fishmeal dropped from 46.5% to 16% from 1973 to 2021.

There were several uses for the fish produced for human consumption, including subsistence, canning, freezing, curing, and fresh fish marketing (Figure 2B). The fish utilization for subsistence was 1,559 tonnes in 1973 which increased to 91,123 tonnes in 2021. The marketed fresh increased from 42,704 tonnes in 1973 to 325,814 tonnes in 2021. Fish used for freezing amounted to 10,384 tonnes in 1973 which climbed to 107,966 in 2021. The amount of fish used for canning in 1973 was 9,021 tonnes which dropped to 30 tonnes in 2000, no fish was utilized for canning since 2001 to 2021. The amount of fish used for curing rose from 35,701 tonnes in 1973 to 35,963 tonnes in 2021.

3.3. Export of fish and fishery products

In Figure 2C, the total export of fish and fisheries products is displayed from 1973 to 2021. The total export increased from 44,276 tonnes to 134,261 tonnes in 2021. The growth ranged from a negative 5.5% during the period from 1973 to 1980 to a maximum of 8.7% from 1981 to 1990. The contribution of fish rose from 14,159 tonnes in 1973 to 110,843 tonnes in 2021. The minimum growth rate was minus 6.5% from 1973 to 1980 and a maximum of 44.1% from 1981 to 1990. The contribution of shellfish rose from 6,759 tonnes in 1973 to 19,716 tonnes in 2021. The growth rate was 2.4% from 1973 to 1980, a maximum of 9.7% from 1981 to 1990, and thereafter it dropped to 1.1% from 2020 to 2021. The export of fish products decreased from 23,358 tonnes in 1973 to 3,702 tonnes in 2021. The growth rate was 52.8% in 1973, dropped to minus 8.7% from 1981 to 1990, and reached a maximum of 19.8% from 1991 to 2000.

The value of the exports by commodity from 1973 to 2021 is shown in Figure 2D. The export value of fish, shellfish, and

fish products increased from Rs. 350 million in 1973 to Rs. 27,728 million in 2021. The growth rate was 5.2% from 1973 to 1980, 37.2% from 1981 to 1990, and then it dropped to 0.1% from 2020 to 2021. The contribution of fish was Rs. 41 million in 1973, which increased to Rs. 21,663 million in 2021. The growth rate was 7.3% from 1973 to 1980, 31% from 1981 to 1990, and then dropped to 0.2% from 2020 to 2021. Contributions from shellfish climbed from Rs. 249 million in 1973 to Rs. 5,717 million in 2021. From 1973 to 1980, the growth rate was 7.3%; from 1981 to 1990, it was 31%; from 1991 to 2000, it was 19.9%; from 2001 to 2010, it was 2.5%; from 2011 to 2020, it was 5.8%; and from 2020 to 2021, it was 0.2%. The fish products contributed Rs. 60 million in 1973 and increased to Rs. 348 million in 2021. The growth rate ranged from minus 1.9% during the period from 1973 to 1980 to 26.7% from 1991 to 2000.

3.4. Processing fishery products

The fish and shellfish harvested in the country have been processed for a number of purposes, including marketing, as fresh, freezing, canning, curing, reduction to meal, oil extraction, and other uses. The country consumed all inland fish caught. The amounts of fish processed in different products from 1973 to 2021 are displayed in Figure 3A. Between 1973 and 2021, the amount of fresh or chilled fish rose from 14 tonnes to 8,188 tonnes. The growth rate fluctuated from a minimum of minus 0.55% to a maximum of 964.3% between 1973 and 1980. The amount of dried fisheries products increased from 14,412 tonnes in 1973 to 17,281 tonnes in 2021. Between 1973 and 1980, the growth rate was minus 10.23%, and between 1981 and 1990, it reached a maximum of 65.49%. The amount of frozen products climbed from 5.013 tonnes in 1973 to 102,018 tonnes in 2021. Its growth rate varied from as low as 0.61% between 2020 and 2021 to as high as 16.44 between 1981 and 1990. The amount of live fisheries products climbed from 2 tonnes in 1973 to 3,072 tonnes in 2021. The growth rate varied from a minimum of minus 1.4% from 2011 to 2020 to a maximum of 326.7% from 1981 to 1990.

Figure 3B displays the value of fishery products exported by commodity. Since 1973, there has been a notable increase in

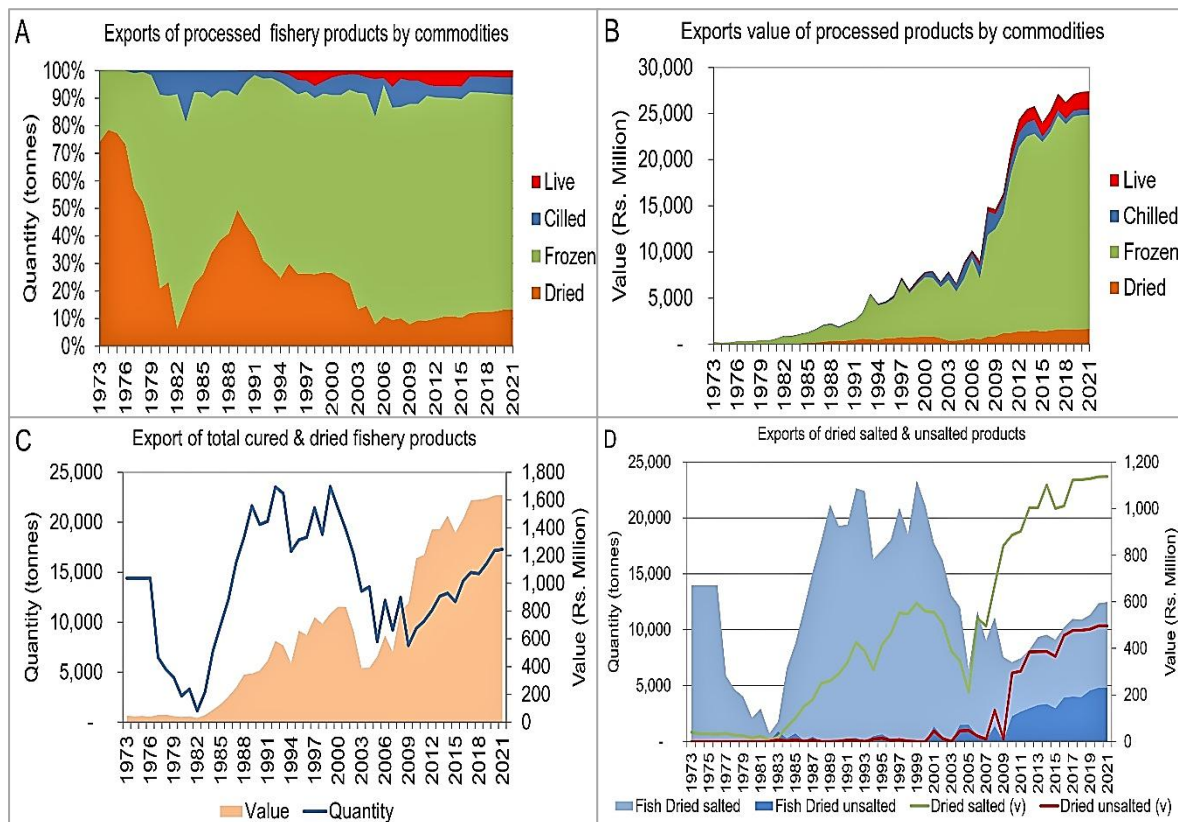


Figure 3. (A) Export of processed fishery products by commodity [7], (B) Exports value of fishery products by commodity [7], (C) Exports of cured and dried fishery products [7]. (D) Export of dried salted and un-salted fish products [7].

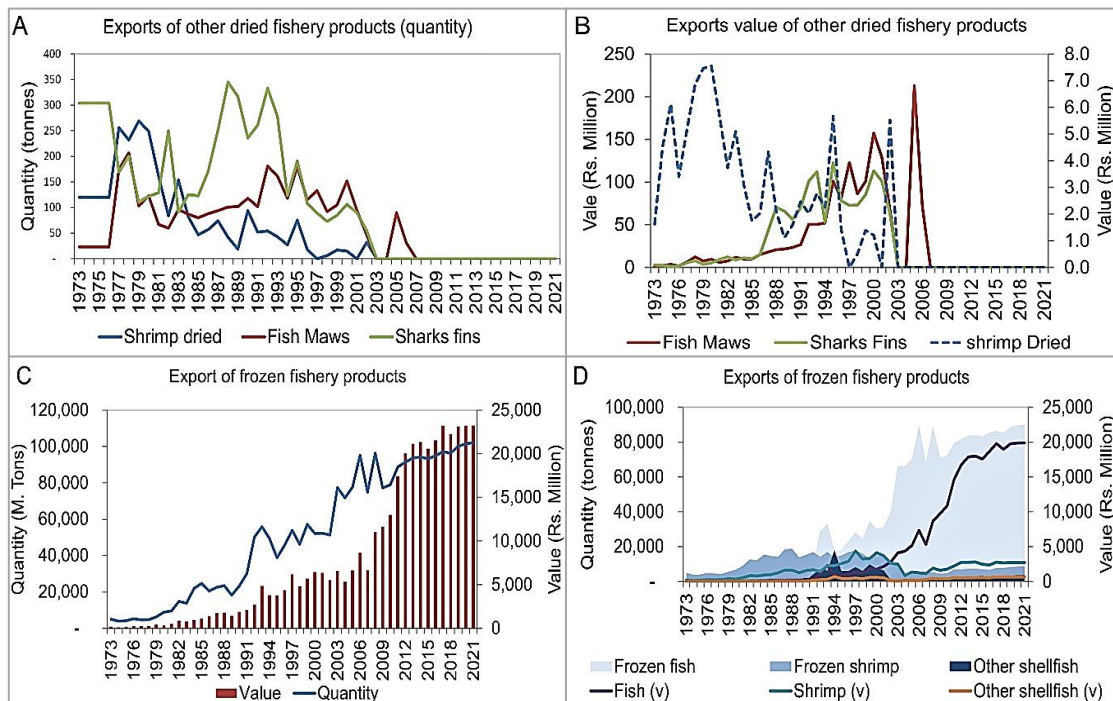


Figure 4. (A) Exports of other dried fishery products [7], (B) Exports value of other dried fish fishery products [7], (C) Exports of frozen fishery products [7], (D) Frozen fisheries commodities export value.

the export value of chilled or fresh finfish products. Between 1973 and 2010, it went from Rs. 0.1 million to Rs. 1,710 million, and then it decreased to Rs. 633 million in 2021. During the years 2011 to 2020, the growth rate was notably high 964.29%, and then it gradually decreased to minus 0.55%. In 1973, the value of dried fisheries products was Rs. 45 million; by 2021, it was Rs. 1,634 million. Between 1973 and 1980, the growth rate varied from negative 2.12% to a maximum of 90.17% between 1981 and 1990. Frozen products contributed Rs. 191 million in 1973 and Rs. 23,215 million in 2021. The growth rate fluctuated from a minimum of 0.0.7% during the period from 2020 to 2021, to a maximum of 43.28% from 1981 to 1990. In 1973, live fishery products contributed Rs. 0.01 million, and by 2021, that amount had increased to Rs. 1,898 million. The growth rate ranged from 0.09% during the period from 200 to 2021 to a maximum of 479.72% from 1981 and 1990.

3.5. Cured and dried fishery products

Figure 3C shows the exports of cured and dried fishery products from 1973 to 2021. The exports were 14,412 tonnes in 1973, and increased to 17,281 tonnes in 2021. The growth rate ranged from 0.68% from 2020 to 2021 and maximum of 65.5% from 1981 to 1990. The export value was Rs. 44.84 million in 1973, and reached to Rs. 1,633.10 million in 2021. The growth rate varied from minus 2.12% from 1973 to 1980 and 90.17% from 1981 to 1990.

Figure 3D depicts the export performance of the cured fisheries product, which includes dried salted fish and dry unsalted fish products. Exports of dried salted fish increased from 13, 965 tonnes in 1973 to 21,104 tonnes in 2000. In 2021, it fell to 12,475 tonnes. From 1973 to 1980, the growth rate was minus 10.6%, and from 1981 to 1990, it was 80.72%. Fishery products that have been dried and unsalted were not exported at all between 1973 and 1978. Its export was 4 tonnes in 1979 and increased to 4,806 tonnes in 2021. From 1979 to 1980, the growth rate was negative 75%, and from 1981 to 1990, it reached a maximum of 480%.

The export value of dried salted and un-salted fish products is also shown in Figure 3D, with dried salted fish contributing

Rs. 39.2 million in 1973, which increased to Rs. 1,137.6 million in 2021. The growth rate ranged from minus 7.79% between 1973 to 1980 to a maximum of 186.8% between 1981 to 1990. Dried, un-salted product contributions increased from Rs. 0.6 million in 1979, to Rs. 496.74 million in 2021, The growth rate ranged from 71.19% in 1979 to 554.12% from 1981 to 1990.

The export of other dry fisheries products include fish maws, dried shrimps, and dried shark fins, as shown in Figure 4A. The exports of dried shrimp ranged from 120 tonnes in 1973 and decreased to 32 tonnes in 2002, there was no export from 2003 to 2021. The growth rate ranged between minus 6.22% from 1981 to 1990 and a maximum of 113.33% from 200 to 2002. The export of dried fish maws were 23 tonnes in 1973, rose to 152 tonnes in 2000, then dropped to 31 tonnes in 2006. From 2007 until 2021, no export was made. From 1973 to 1980, the growth rate was minus 54.35%, and from 1991 to 2000, it reached a maximum of 2.9%. Exports of dry shark fins were 304 tonnes in 1973, dropped to 55 tonnes in 2002, and then stopped altogether in 2021. From 1973 to 1980, the growth rate was 7.48%, reaching a maximum of 24.1% between 2001 and 2002

Figure 4B shows the export value of other dried fishery products. The dried shrimp had an export value of Rs. 1.62 million in 1973, Rs. 5.52% in 2002. Between 1973 and 1980, the growth rate amounted to 45.68%, while between from 2001 to 2002, it decreased by minus 29%. Dried fish maws had an export value of Rs. 1.01 million in 1973, rising to Rs. 157 million in 2000 before falling to Rs. 71.10 million in 2006. Between 1973 and 1980, the growth rate varied from 106% to a negative 9.14% between 2001 and 2006. Dried shark fins had an export value of Rs. 2.98 million in 1973, rising to Rs. 113.10 million in 2000 before falling to Rs. 63.02 million in 2002. Between 1981 and 1990, the growth rate amounted to 95.46%, and between 2001 and 2002, it was negative 11%.

3.6. Frozen fishery products

Among the frozen seafood exports are frozen lobster, frozen crab, frozen shrimps, frozen fish and frozen mollusks (Figure 4C). Between 1973 and 2021, the total amount of frozen

fisheries products exported rose from 5,013 tonnes to 102,018 tonnes. From 1981 to 1990, the growth rate was 16.44%; from 2020 to 2021, it decreased to 0.61%. Frozen seafood products had an increase in export value from Rs. 191 million in 1973 to Rs. 23,215 million in 2021. From 1981 to 1990, the growth rate varied between 43.28% and from 2020 to 2021, it was 0.1%.

The exports of frozen fisheries commodities are displayed in Figure 4D. The amount of frozen fish was exported rose from 180 tonnes in 1973 to 89,956 tonnes in 2021. Growth rate was 132.85% from 1973 to 1980 and dropped to 0.56% from 2020 to 2021. Exports of frozen shrimp ranged from 4,775 tonnes in 1973 to 15,255 tonnes in 1990 and 8,499 tonnes in 2021. Between 1981 and 1990, the growth rate ranged to 12.7%, and between 2001 and 2010, it decreased to minus 6.86%. The amount of other frozen shellfish exported rose from 58 tonnes in 1973 to 3,553 tonnes in 2021. In 1980, the exports dropped to 13 tonnes. The maximum growth rate was 353.85% from 1981 to 1990, while the minimum growth rate was a negative 9.67% from 1973 to 1980.

Figure 4D also showed the frozen fisheries commodities export value. Frozen fish was valued at Rs. 1.87 million in 1973 and increased to Rs. 19,872 million in 2021. From 1973 to 1980, the growth rate was 132.2%, and from 2020 to 2021, it was at least 0.03%. The value of frozen shrimp climbed from Rs. 186 million in 1973 to Rs. 2,696 million in 2021. Between 2020 and 2021, the growth rate was at its lowest of 0.22% and at its maximum of 566% between 1981 and 1990. The value of other frozen shellfish climbed from Rs. 3.0 million in 1973 to Rs. 646 million in 2020 to 2021. From 1973 to 1980, the minimum growth rate was negative 5.85%, while from 1981 to 1990, the maximum growth rate was 239.54%.

3.7. Chilled or fresh fishery products

Finfish is the primary component in these products, along with fresh shrimps, lobster, crab, and molluscs. According to Figure 5A, the total amount of fresh or chilled fishery products exported rose from 14 tonnes in 1973 to 8,578 tonnes in 2010 and 8,188 tonnes in 2021. From 1973 through

1980, the growth rate was 964.3%; from 2011 to 2020, it was 0.55%. The maximum amount was 14,105 tonnes in 2005, while minimum of 2 tonnes in 1975

The value of fresh or chilled fishery products exported in 1973 was about Rs. 0.1 million, and by 2021, it had increased to Rs. 632.7 million (Figure 5A). From 1973 to 1980, the rate of growth was 2,250.3%, however, from 2011-2020, it was negative 6.32%. Rs. 0.1 million was the minimum amount in 1973, while Rs. 1,710 million was the largest value in 2010.

In Figure 5B, the fresh or chilled fisheries products are exported commodity-wise. There appears to have been a rise in the export of chilled or fresh finfish products from 14 tonnes in 1973 to 3,606 tonnes in 2021. Between 1973 and 1980, the growth was 2,250%, while between 2020 and 2021, it was 0.44%. The maximum amount was 12,591 tonnes in 2005, and 2 tonnes was the minimum in 1975. Due to no exports from 1973 to 1978, fresh prawn exports climbed from 0.5 tonnes in 1979 to 110.4 tonnes in 2021. Between 1981 and 1990, the growth rate was minus 10.71%, and between 1991 and 2000, it was 128.36%. A minimum of one tonne was exported in 1986, while the greatest shipment of 3,586 tonnes occurred in 2021. Up until 2004, there were no exports of fresh lobster. Lobster exports rose from 101 tonnes in 2004 to 901 tonnes in 2021. Between 2004 and 2010, the growth rate was 73.25%, and between 2020 and 2021, it was 0.32%. There was a minimum of 101 tonnes in 2004 and a maximum of 901 tonnes in 2021.

The commodity-wise export value of fresh or chilled fisheries products is displayed in Figure 5C. Fresh or chilled finfish had an export value of Rs. 0.08 million in 1973 and Rs. 156.32 million in 2021. Between 1973 and 1980, the growth rate was 2,250.3%, while between 2020 and 2021, it was 0.44%. 2008 saw a maximum value of Rs. 1,411.5 million, while 1975 saw a minimum value of Rs. 0.08 million. Between 1979 and 2021, the value of shrimps exported was Rs. 0.5 million and Rs. 110.4 million, respectively. For the years 1981 to 1990 and 2001 to 2010, the growth rate was respectively negative 10.71% and 1,967.5%. In 2014, the value reached its height of Rs. 1,034; in 1979, it reached its lowest of Rs. 0.5 million. Lobsters were valued at Rs. 36.9 million in 2004 and Rs. 316.6

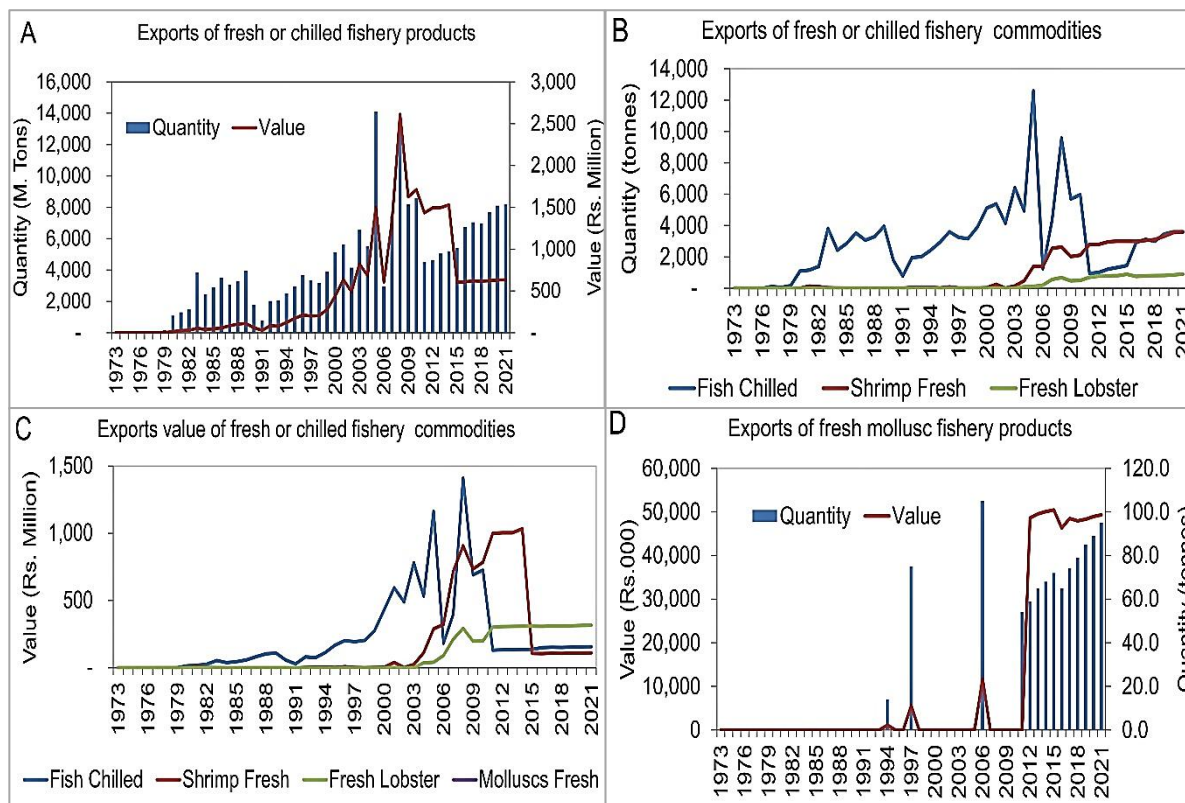


Figure 5. (A) Exports of fresh or chilled fishery products [7], (B) Export of fresh or chilled fishery products [7], (C) Exports value of fresh/ chilled fishery products [7], (D) Export of fresh mollusc’s fishery products [7].

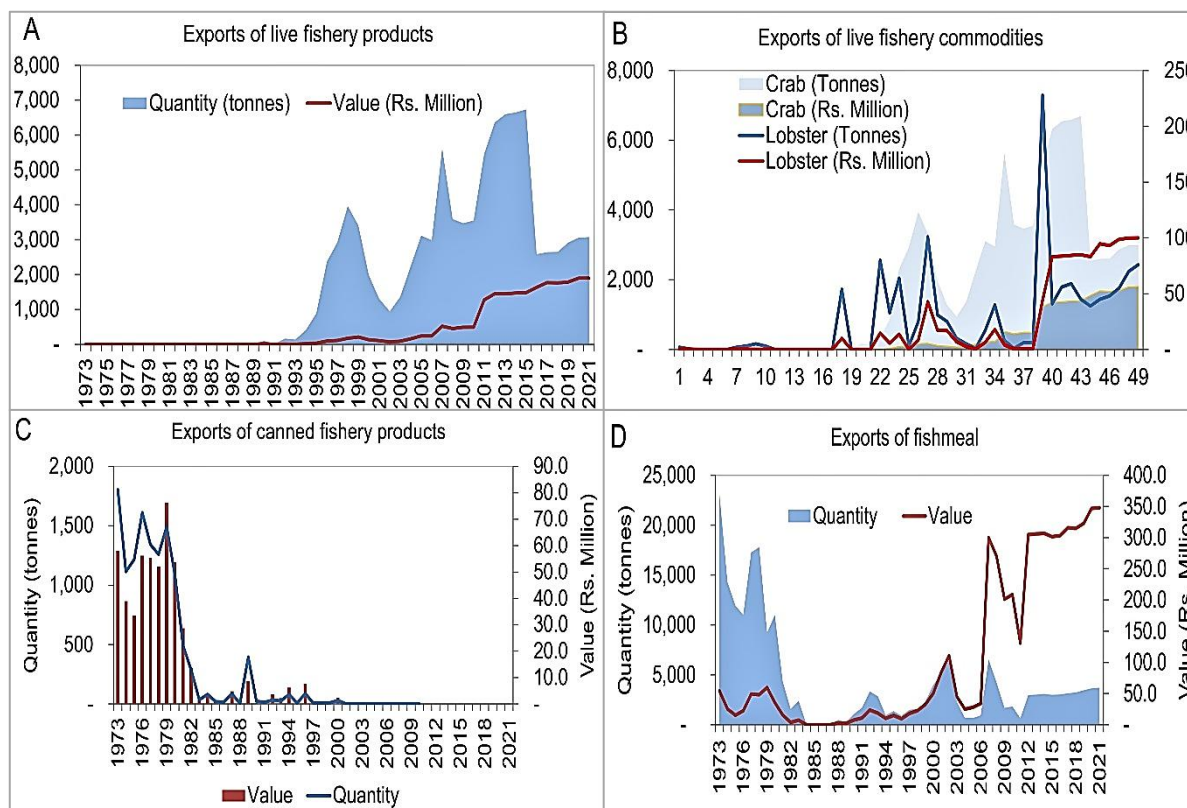


Figure 6. (A) Exports of live fishery products [7], (B) Exports of live fishery product commodities [7], (C) Exports of canned fishery products [7], (D) Exports and value of fishmeal [7].

million in 2021. From 2004 to 2010, the growth rate was 73.25%, while between 2020 and 2021, it was 0.32%. The highest export value in 2021 was Rs. 316.6, while the lowest was Rs. 36.9 in 2004.

Figure 5D shows the growth of the fresh molluscs export, which began in 2005 with one tonne and reached 95 tonnes in 2021. From 2012 to 2020, the growth rate was 6.36%, and from 2020 to 2021, it was 6.74%. The lowest amount of 59 tonnes in 2012 and the highest quantity of 95 tonnes in 2021 were reached. Mollusc exports were valued at Rs. 0.05 million in 2005 and Rs. 49.4 million in 2021. From 2012 to 2020 and from 2020 to 2021, the growth rate was 0.08% and 0.82%, respectively. The value ranged from a minimum of Rs. 0.05 million in 2005 to a maximum of Rs. 50.5 million in 2015.

3.8. Live fishery products

Figure 6A shows the exports of live fisheries goods, such as live mud crab (*Scylla serrata*) and lobster (*Panulirus polyphagus*). It appears that its exports rose from 2 tonnes in 1973 to 3,072 tonnes in 2021. Between 1981 and 1990, the growth rate was 326.67%, and between 2011 and 2020, it was minus 1.40%. A minimum of one tonne was exported in 1974, while the maximum was 6,748 tonnes in 2015. Exports of live fisheries climbed from Rs. 0.12 million in 1973 to Rs. 1,898 million in 2021. Between 1981 and 1990, the growth rate was 479.72%, and between 2020 and 2021, it was 0.09%. The value of Rs. 1,898 million reached its highest in 2021 and its minimum in 1989 was Rs. 0.01 million.

Figure 6B displays the commodities exports of live fisheries products. In 1973, there were two tonnes of live lobster exported; by 2021, that amount had risen to 76 tonnes after a fluctuating pattern. From 1994 to 2000, the growth rate was negative 8.75%, and from 2011 to 2020, it was 106.67%. In 2011, the maximum export was 228 tonnes, and in 1974, 2004, and 2008, the minimum was 1 tonne. A single tonne of live crab was exported in 1974, and from 1975 until 1988, there was no export. Once more, its exports began in 1989 with 2 tonnes and reached 2,996 tonnes in 2021. Between 1991 and 2000, the growth rate was 406.17%, while between 2011 and 2020, it was - 1.58%. Exports included a minimum of 1 tonne

in 1974 and a maximum of 6,689 tonnes in 2015.

According to Figure 6B, which shows the export value of commodities derived from live fisheries, the value of live lobsters' exports was Rs. 0.12 million in 1973 and varied between Rs. 0.15 million and Rs. 0.32 million between 1979 and 1982. In 1989, the export value was Rs. 0.04 million, and by 2021, it had increased to Rs. 100 million. Between 2001 and 2010, the growth rate was minus 9.45%, and between 2011 and 2020, it was 1,048.3%. In 2021, the value reached a maximum of Rs. 100 million and a minimum of Rs. 0.002 million. The value of live crab climbed to Rs. 1,798 million in 2021 from Rs. 0.002 million in 1974 and Rs. 0.07 million in 1989. Between 1991 and 2000, the growth rate was 182.32%; between 2020 and 2021, it was 0.08%. The highest value recorded in 2021 was Rs. 1,798 million, while the lowest figure was Rs. 0.002 million in 1974.

3.9. Canned Fishery Products

The export of canned fisheries products is shown in Figure 6C, which shows that in 1973 there were 1,804 tonnes of exports, while in 2000 there were just 30 tonnes. From 1981 through 1990, the growth rate was negative 9.78%, and from 1991 through 2000, it was 2.5%. There was a minimum of 5 tonnes in 1988 and a maximum of 1,804 tonnes in 1973. Fishery products in cans were not exported between 2001 and 2021. Canned fisheries products were worth Rs. 58.0 million in 1973 and Rs. 2.34 million in 2000 when they were exported. From 1981 to 1990, the growth rate was negative 9.94%, and from 1991 to 2000, it was 62.8%. The value was recorded as low as Rs. 0.32 million in 1990 and as high as Rs. 58.04 million in 1973.

3.10. Export of fishmeal products

Fishmeal exports are shown in Figure 6D; it appears that the amount exported decreased from 23,032 tonnes in 1973 to 3,702 tonnes in 2021. The growth rate was negative 9.02% from 1981 to 1990 and 27.22% from 1991 to 2000. In 1973, 23,032 tonnes was the maximum amount exported, and in 1984, 2 tonnes was the least. Exports value of fishmeal climbed from Rs. 54.4 million in 1973 to Rs. 347.9 million in 2021. Between 1981 and 1990, the growth rate was minus 7.89%, and between

1991 and 2000, it was 56.55%. Values range from Rs. 0.02 million in 1984 to Rs. 347.9 million at the maximum in 2021.

4. Discussion

Aquatic foods are crucial for food security and nutrition, providing protein, omega-3 fatty acids, and minerals. Despite progress, 3 billion people cannot afford healthy food and 811 million people go hungry daily. The urgent transformation of agri-food systems must prioritize fisheries and aquaculture products [12].

Pakistan's total fish production has steadily increased from 214,231 metric tonnes to 737,025 metric tonnes from 1973 to 2021 (Fig. 1A). The high growth rate during 1981 to 1990 was primarily due to the introduction of deep sea fishing under a joint venture scheme by foreign flag vessels [13]. The slow growth rate from 2011 to 2020 was due to the use of artisanal local fishing boats with mechanical trawl winches and net haulers [15]. The high growth rate from 2020 to 2021 was attributed to an increase in aquaculture production [10]. The marine sector produced 196,614 metric tonnes in 1973 and rose to 426,025 metric tonnes in 2021. The inland sector produced 17,617 metric tonnes in 1973 and increased to 307,000 metric tonnes in 2021.

Figure 1A also shows the marine sector fish production trends in Sindh, Baluchistan, and the EEZ. Sindh province's fish production increased from 158,892 metric tonnes in 1973 to 230,314 metric tonnes in 2021. The slow growth rate between 1973 to 1980 was due to fishing boats were being mechanized [13], while the high growth rate during 1981 to 1990 was partly due to bycatch sold by deep-sea fishing vessels to local fishing boats [13, 14]. The negative growth rate was due to intensive fishing by artisanal boats, leading to overexploitation and reduced fish production [15]. Balochistan's fish production increased from 37,722 metric tonnes in 1973 to 195,711 metric tonnes in 2021. The high growth rate during 2020 and 2021 is attributed to fishing for small pelagic fish species, particularly sardine and Indian mackerel, since 2018 [16]. Fish production EEZ began in 1982 and peaked at 9,986 metric tonnes in 1985 due to deep sea fishing by foreign-flag fishing vessels, there were

reportedly nine (09) trawlers in 1982, twelve (12) from 1983 to 1984, and six (06) in 1986 [13]. The production of 25,338 metric tonnes in 1992 and 30,677 metric tonnes in 1993 was due to foreign flag tuna longliners fishing for tuna and related species. These vessels were reportedly fifty in number [14].

The Trade Development Authority's data on fish production and exports from 2000-2001 shows a significant increase from 468,000 metric tonnes in 2000-2001 to 817,000 metric tonnes in 2022-23 (Fig. 1B). Marine fish production increased from 316,000 metric tonnes in 2000-01 to 430,000 metric tonnes in 2022-23, while inland water fish production increased from 152,000 metric tonnes in 2000-01 to 308,000 metric tonnes in 2022-23 [9]. Fig. 1B also shows the total fish and fisheries products exported from 2000-01 to 2022-23. The export value increased from 135 million US dollars in 2000-01 to 496 million US dollars in 2022-23 [9].

The FAO Fishery Country Profile of Pakistan also offers statistics on fisheries, including data on total fish production, production from capture fisheries (in marine and freshwater), aquaculture, exports, and imports of fish from 1980 to 2021 [10]. Fig. 1C showed that production from aquaculture sector was 5,200 metric tonnes in 1980, increased steadily, and reached 164,527 metric tonnes in 2021, with 102.22% growth rate during 2001 to 2010 [10]. Additionally, Fig. 1C showed the imports and exports of fishery goods. In 1980, fish exports totalled 24,623 metric tonnes, while in 2021 they climbed to 217,030 metric tonnes. The amount of fish imported rose from 108 metric tonnes in 1980 to 5,770 metric tonnes in 2021 [10].

Pakistan's fish consumption increased from 99,368 metric tonnes in 1973 to 500,866 metric tonnes in 2021 [7]. The overall growth rate from 1973 to 2021 was 9.7 percent per year (Fig. 1D). The proportion of fish eaten by humans rose from 49% in 1973 to 82% in 2010 [6], with a subsequent rise to 84% in 2021 (Fig.2A) [7]. The fish reduction for fishmeal was 114,863 metric tonnes in 1973 and decreased to 106,988 metric tonnes in 2021 [7].

The fish production for human consumption was utilized for different purposes, which include marketed fish fresh, canning, freezing, curing, and subsistence, and their distribution is

shown in Fig. 2B. Fish utilization for subsistence was 1,559 metric tonnes in 1973, which increased to 91,123 metric tonnes in 2021 [7].

Pakistan exports only 25% of the total fish production. The export value of fishery goods was 450 million US dollars in 2017–18 [9], rising to 496 million US dollars in 2022–23 [2]. Pakistan exports fish and fishery goods at an average unit price of 2 to 2.5 US dollars per kilogramme [9], while the global average price is 5.0 US dollars per kilogramme [18]. This is lower than any other neighbouring country.

From 1973 to 2021, the total export of fish and fisheries products increased from 44,276 metric tonnes to 134,261 metric tonnes (Fig. 2C). The contribution of fish increased from 14,159 metric tonnes in 1973 to 110,843 metric tonnes in 2021. The high growth rate from 1981 to 2000 was due to the export of frozen fishery products after the introduction of deep-sea fishing [13, 14]. The shellfish contributed from 6,759 metric tonnes to 19,716 metric tonnes. The high rate of growth from 1981 to 2020 is due to intensive shrimp fishing by local shrimp trawlers, which was more than 2,500 in 2020 [16]. In Pakistan during the 1970s and early 1980s, shrimps constituted the foundation of the fish industry [17]. The growth rate of fish products decreased from 23,358 metric tonnes in 1973 to 3,702 metric tonnes in 2021 [7]. The high growth rate of fishery products from 2011 to 2020 was due to the large contribution of fishmeal exports in this category [16]. The export value of fish, shellfish, and fish products increased from Rs. 350 million in 1973 to Rs. 27,728 million in 2021 (Fig. 2D). The fish made a contribution of Rs. 41 million in 1973, which increased to Rs. 21,663 million in 2021. Shellfish contributions climbed from Rs. 249 million in 1973 to Rs. 5,717 million in 2021. The contribution of fish products rose from Rs. 60 million in 1973 to Rs. 348 million in 2021 [7]. The reduction in the contribution of shellfish means that shellfish resources are overexploited and cannot support the fishery anymore [15, 16].

Fish and shellfish from the nation have undergone processing for a number of uses, such as reduction to meal, freezing, canning, and curing. Between 1973 and 2021, all inland fish

harvested in the nation was devoured. The fresh or chilled fish increased from 14 metric tonnes to 8,188 metric tonnes (Fig. 3A), while dried fisheries products increased from 14,412 metric tonnes to 17,281 metric tonnes. Frozen products grew from 5.013 metric tonnes to 102,018 metric tonnes, and live fisheries products increased from 2 metric tonnes in 1973 to 3,072 metric tonnes, during the same period respectively [7].

Fresh or chilled fish items have shown a significant increase in export value since 1973. From Rs. 0.1 million to Rs. 1,710 million between 1973 and 2010, and then it dropped to Rs. 633 million in 2021 (Fig. 3B). Dried seafood products were valued at Rs. 45 million in 1973 and Rs. 1,634 million in 2021. In 1973, frozen goods contributed Rs. 191 million, and in 2021, they contributed Rs. 23,215 million. By 2021, live fishery goods brought in Rs. 0.01 million that amount had increased to Rs. 1,898 million [7].

Curing, the earliest food preservation method, involves drying, salting, or smoking to reduce water availability for bacteria. It has been practiced in Europe since the early Middle Ages [19, 20, and 21] and is still consumed in Asia and Africa [22]. There are three methods for salting aquatic food: dry salting, moist salting, and mixed salting. Dry salting is common for fermented fish, marine catfish, and Indian mackerels, and salt-fermented seafood dishes in Southeast Asia [25; 26; 27; and 28]. Salted fish in Pakistan are dried outdoors in the sun for 6-8 hours, depending on weather, which can be susceptible to pollutants and insect infestation. If weather prevents drying, fish are kept in tanks, impacting price and quality. Traditional curing methods are still used in rural areas of Balochistan and Sindh provinces [6]. Exports of cured and dried fishery products increased from 14,412 metric tonnes in 1973 to 17,281 metric tonnes in 2021 (Fig. 3C) [7]. Bycatch from deep-sea fishing vessels employed to produce cured goods may have contributed to the increase between 1980 and 1990 [23]. Between 1973 and 2021, the export value increased from Rs. 44.84 million to Rs. 1,633.10 million [7].

The cured fisheries product, consisting of dried salted fish and dry unsalted fish products, experienced a decline in exports from 13, 965 metric tonnes in 1973 to 12.475 metric tonnes in

2021 (Fig. 3D) [7]. The export value of dried salted and unsalted fish products increased from Rs. 39.2 million in 1973 to Rs. 1,137.6 million in 2021. The contribution of dried, unsalted product was Rs. 0.6 million in 1979 and increased to Rs. 496.74 million in 2021 [7].

Other dried fisheries products, such as dried prawns, fish maws, and shark fins, significantly contribute to the value of all cured fisheries products despite their small quantities. The exports of dried shrimp were 120 metric tonnes in 1973 and 32 in 2002, then zero since 2003 to 2021 (Fig. 4A) [7]. There was an increasing demand for block frozen shrimp in European market [17]. Dried fish maw exports were 23 metric tonnes in 1973 and 31 metric tonnes in 2006, then zero from 2007 to 2021. Dried shark fins were 304 metric tonnes in 1973 and had a fluctuating trend, reaching 55 metric tonnes in 2002 and since then these are not exported.

The export value of dried fishery products in Southeast Asia has shown significant growth, with dried shrimp exports increasing from Rs. 1.62 million in 1973 to Rs. 5.52% in 2002 (Fig. 4B). Dried fish maws also experienced growth, increasing from Rs. 1.01 million in 1973 to Rs. 71.10 million in 2006 [7]. Dried shark fin exports also saw significant growth, reaching Rs. 2.98 million in 1973 and Rs. 63.02 million in 2002 [7]. Other dried fish goods exported to Southeast Asia include dried shark fins and fish maws, which are primarily shipped to Malaysia, Singapore, and Hong Kong. Shark fins were reportedly shipped from Pakistan to China, Hong Kong, Malaysia, Singapore, and Taiwan between 2000 and 2011, despite the fact that HBFS data for the period 2003 to 2021 shows no export of dried shark fins since 2003 [29; and 30].

Balochistan produces the majority of dried and salted fish due to its dry weather and lack of processing facilities before 2000. The Fisheries Department also published instructions for the curing process and curing yard facility [31]. Larger species like Spanish mackerel, snappers, groupers, trevallies, and sharks are the main types. The curing process involves sea separation and salting, followed by processing at yards. Despite ideal drying conditions and hygiene, quality suffers

[32]. Simple processing methods disregard safety and quality assurance. Artificial dryers have been offered to avoid sun drying during rainy seasons, but traditional processors reject them [6]. Karachi merchants transport dried fish for export, with Sri Lanka being the main importer [1].

The freezing process of aquatic food is crucial to prevent spoiling, which can start even at temperatures below -1°C . British law requires freezing at a temperature of -30°C before cold storage [33]. The food's ability to be frozen at -18°C depends on its species, type, and preparation [34]. Pakistan exports a significant quantity of frozen seafood products, primarily to the Middle East, Southeast Asia, and Europe. The market for frozen prawns dominated in the 1970s and 1980s. The introduction of deep-sea fishing by foreign-flag vessels increased the amount of frozen fish, making local exporters more visible [13]. Under the pretence of stock evaluations of tuna resources in the EEZ of the country, longliners operating under foreign flags reached their greatest export of frozen tuna fish during 1992 and 1993 [14].

Pakistan's main fish export hub, primarily exports fresh or chilled fish, cephalopods, marine finfish, and marine shrimp to foreign countries in frozen and block forms. Semi-IQF and IWP goods are also produced for Middle Eastern and Asian markets to some extent [6]. Currently, there are 20-25 facilities operating in Karachi [7], out of that only two facilities were permitted to export fishery products to markets within the European Union during 2013 [35]. However, another processing plant was added to the approved list in 2022 by European Union [36]. The rest of the processing companies selling their products to non-EU countries, such as China, Korea, Malaysia, Hong Kong, Japan, Saudi Arabia, the UAE, Kuwait, and Oman in the Middle East [7].

Frozen seafood exports, including lobster, crab, shrimp, fish, and mollusks, have seen significant growth since 1973. The total export of frozen fishery products increased from 5,013 metric tonnes in 1973 to 102,018 metric tonnes in 2021. The value of frozen fisheries products increased from Rs 191 million in 1973 to Rs. 23,199 million in 2020 and Rs. 23,215 million in 2021 [7]. The slow growth rate of frozen fisheries

products from 2000 to 2010 was due to less fish production from the EEZ because there were few deep-sea fishing vessels operating up until 2006 [14]. In 2009, which was a record year for exports to 46 countries, frozen fisheries products were exported to the United Kingdom, Japan, Sri Lanka, the United Arab Emirates, and the United States, who were the leading buyers of frozen commodities [6].

The exports of frozen fisheries commodities are shown in Fig. 4C. Frozen fish was exported at 180 metric tonnes in 1973 and increased to 89,956 metric tonnes in 2021. Frozen shrimp exports were 4,775 metric tonnes in 1973 and increased to 8,499 metric tonnes in 2021. Other frozen shellfish exports were 58 metric tonnes in 1973 and 3,553 metric tonnes in 2021 [7]. The operation of deep sea fishing vessels that produced frozen fish products for South Korea and Japan was the reason for the high growth rate between 1981 and 1990 and then between 1991 and 2000 [13, and 14].

The export value of frozen fisheries commodities is shown in Fig. 4D. The export value of frozen fish was Rs. 1.87 million in 1973 and Rs. 19,872 million in 2021. Frozen shrimp were valued at Rs. 186 million in 1973 and Rs. 2,696 million in 2021. Overexploitation of shrimp resources by local wooden shrimp trawlers resulted in a decline of production, which was the cause of the negative growth rate of frozen shrimp between 2001 and 2010 [15]. Other frozen shellfish were valued at Rs. 3.0 million in 1973 and Rs. 646 million from 2020 to 2021. The significant growth rate between 1981 to 2000 was brought on by the export of cephalopods that deep-sea fishing vessels had collected and processed [13, 14].

Pakistan's majority of freezing is done using contact and blast freezers, with no IQF equipment in place. Unlike other Southeast Asian countries, Pakistan produces few value-added fishery products. Some value-added products include stingray minced meat [6]. Most exports are traditional block-frozen commodities. Recent value gains have been driven by industry participants altering facilities to comply with EU regulations. Products are converted into semi-IQF and IQF forms using contact and blast freezers.

The consumption of fresh or chilled fishery products,

including tropical species, has increased over the past decade due to improved post-harvest handling, growth of transportation networks, and the availability of high-quality fishery products. Imports of fish and shellfish have grown significantly worldwide, with finfish being the main component [37]. Exports of these products have increased significantly, from 14 metric tonnes in 1973 to 8,188 metric tonnes in 2021 (Fig. 5A). The export value of these products has also increased, from Rs. 0.1 million in 1973 to Rs. 632.7 million in 2021 [7]. More tropical fish species are being offered in North America, Europe, and Asia, with traditional markets including the Far East, Asia, China, and the Gulf States. Traditional markets include Japan, Hong Kong, Malaysia, Singapore, and Taiwan, all part of the Far East [37]. Imports of fish and shellfish expanded dramatically worldwide since 1990 [38].

The export of fresh or chilled fishery products has seen a significant increase, with the export of finfish products increasing from 14 metric tonnes in 1973 to 3,606 metric tonnes in 2021 (Fig. 5B). Fresh shrimp exports have also seen a growth rate, with a maximum of 11,591 metric tonnes in 2005. Fresh lobster exports were non-existent until 2004, with a maximum of 901 metric tonnes in 2021 [7]. The export value of fresh or chilled fishery products commodities has seen significant growth over the years.

The export value of finfish has seen a significant increase from Rs. 0.08 million in 1973 to Rs. 156.32 million in 2021 (Fig. 5C). Shrimp exports have seen a similar growth rate, from Rs. 0.5 million in 1979 to Rs. 110.4 million in 2021. Lobster exports have seen a growth rate of 73.25% from 2004 to 2010. Fresh mollusc's exports have seen a growth rate of 6.36% from 2012 to 2020, with a maximum quantity of 95 metric tonnes in 2021. The export value of molluscs has also seen a significant growth rate from Rs. Rs. 0.05 million in 2005 to Rs. 49.4 million in 2021 (Fig.5D) [7].

The live fish trade in Pakistan involves selling aquarium ornamental fish and live fish for human consumption, primarily imported from Southeast Asia. This global network connects fishing communities with markets in Hong Kong and mainland China. Customers often request specific fish species, especially

tiny and medium-sized ones, as they purchase these fish directly from restaurants and stores [37]. Pakistan's live fishery exports, including live lobster and mud crab, have grown significantly since 1973. The exports of live fishery products, which were 2 metric tonnes in 1973, increased to 3,072 metric tonnes in 2021 (Fig. 6A), valued at Rs. 0.12 million in 1973 and increased to Rs. 1,898 million in 2021 [7]. The exports of live fisheries product commodities are shown in Fig. 6B. The live lobster exports were 2 metric tonnes in 1973 and had fluctuating trend and 76 metric tonnes in 2021. Maximum export was 228 metric tonnes in 2011, whereas there was no export during 1975 to 1978 and then 1983 to 1989. Regular export live mud crab was started in 1990, with 47 metric tonnes, and increased to 2,996 metric tonnes in 2021. A maximum quantity of 6,689 metric tonnes in 2015 and a minimum of 1 tonne in 1974 were exported [7]. The major importers are China, Thailand and UAE.

Fig. 6B also depicts the export value of live fishery product commodities. The export value of live lobster ranged from Rs. 0.15 million to Rs. 0.32 million from 1979 to 1982 and increased to Rs. 100 million in 2021. The value of live crab was Rs. 0.002 million in 1974 and increased to Rs. 1,798 million in 2021 [7].

In 1998 and 1999, demand for high-value fishery products in Hong Kong, Singapore, Taiwan, and Malaysia declined significantly. The catering sector for live crabs had declined by 50% in these markets. Exports to the Thai market began to decline in 2000 [37]. Overfishing and mangrove destruction in Sindh have led to a decline in local crab supplies [6]. Asian markets demand larger crabs, and China is the major importer of live mud crab from Pakistan [43].

Canned food is practical due to its long shelf life but cannot be stored for long. The fish canning industry uses sealed cans and boiling fish to prevent contamination and damage. Container types include glass jars, flexible containers, metal cases, and hard plastic [39]. The principal processing method for small-sized prawns in Pakistan, fish canning, has experienced a downturn in recent times. Due to the high cost of cane and growing demand for block-frozen products [17],

many factories have closed, despite the fact that there are 11 canneries with a combined capacity of 106.29 million metric tonnes per day [7]. Even while year-round raw materials such as skipjack and yellowfin tuna are readily available, the majority are exported in dry salted or frozen state and yield less profit [23].

Exports of canned seafood products totalled 1,804 metric tonnes in 1973 (Fig. 6C). In 2000, this amount dropped to 30 metric tonnes. Fisheries products in cans were not exported between 2001 and 2021. In 1973, the highest recorded amount was 1,804 metric tonnes, while in 1988; the lowest was 5 metric tonnes [7]. Cannery products had an export value of Rs. 2.34 million in 2000, compared to Rs. 58.0 million in 1973. The value ranged from a minimum of Rs. 0.32 million in 1990 to a maximum of Rs. 58.04 million in 1973 [7]. The demand for processed or ready-to-eat fish is very high; in 2001, 10.1% of the world's catch was canned tuna; in 2010, this percentage increased to 12.1% in 2020, and dropped to 11% due to COVID [12]. Because of their stability and mobility, cans are widely used in Southeast Asian and European nations [12]. Southeast Asian and European nations choose canned goods due to their stability and mobility [12]. With Western African countries selling tuna in cans to Europe, processing has increased dramatically in Thailand. From 2018 to 2010, Pakistan exported fish products in cans to the USA and Thailand [11].

Fishmeal is a widely used protein source in the aquaculture industry, swine and poultry feed, and pet food. Fishmeal is also used in the pet food industry [40]. It is primarily used for protein, and over 6 million metric tonnes of fish were produced in Chile and Peru in 1993 [41]. Fishmeal is typically composed of 66-72% protein, 4-6% fat, 13-21% ash, and 9-10% moisture, depending on the raw materials used and processing technique [42].

Pakistan's fishmeal supply is largely dependent on by-catch of small fish, inedible species collected by shrimp trawlers and small pelagic fish species. The country has nine (9) fishmeal factories built in the 1970s, but the lack of industrial fishing has hindered the country's ability to meet the increasing global

demand for fishmeal. The majority of fishmeal consumed domestically is used as livestock and poultry feed, but some is also exported [7]. The fishmeal exports have fluctuated from 1973 to 2021 (Fig. 6D); exports peaked in 1973 at 23,032 metric tonnes then fell to 3,702 metric tonnes in 2021 [7]. In 2009, Pakistan exported 1,694 million metric tonnes of fishmeal to China for Rs. 0.201 million, with China, Sri Lanka, and Vietnam being the major importers [43]. Fishmeal exports were valued at Rs. 54.4 million in 1973 and increased to Rs. 347.9 million in 2021 [7].

Fish is often used as fertilizer [19], composted, meal, solubilized, or hydrolysed, and as fish-soluble by-products [44, and 45]. Other non-food and non-feed products include pharmaceuticals like fish oils, omega-3 concentrates, adrenalin, insulin, liver oil, squalene, pearl essence, leather, fish gelatine, and fish glue. Whole fish is rarely used, except for fish oil, which is occasionally made using underutilized pelagic species with high oil content [6].

Ornamental fish is a significant part of global fish trade, with global imports and exports reaching \$257 million and 174 million in 1998, respectively. Since 1985, exports have grown at a 14% annual rate, with developing countries accounting for over two-thirds of global exports [47]. There is no separate statistics on export of ornamental fishes from Pakistan.

5. Conclusion

Fish and aquatic foods are crucial sources of protein for local people and animal groups worldwide. Fish production has grown at a steady 4.9% annual rate from 1973 to 2021, but the marine sector's growth rate is only 2.4%. To meet the growing demand for fish for human consumption, aquaculture must be developed and promoted. Fish exports have grown at an 8.8% annual rate over the past 20 years, with a total value of 496 million US dollars in 2022-2023. Fish is sold in canned, frozen, cured, fresh or chilled forms and fishmeal, with frozen fishery products dominating the exports. Other fish-derived non-food items include fish oils, omega-3 concentrates, adrenalin, insulin, liver oil, squalene, leather, fish gelatine, and fish glue.

Data Availability statement

The data presented in this study are available on request from the corresponding author.

Conflicts of Interest

Authors declare that, they have no conflict of interest.

Author Contributions

MWK: Investigation, Methodology, Writing - Original Draft; GA: Conceptualization, Supervision; Review and Editing.

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