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Is there a relationship between human development and dependence on fisheries?

by

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Abstract

International food and raw material security issues has gained much more importance than ever. This study examines that the following questions 'Who depends on whom?' and 'What is the level of dependency?' considering relationships between "fisheries context" (catch and aquaculture production, total fisheries export and import, fisheries export and import value, fish consumption per capita, and processed fisheries product) and human development of countries (as Human Development Index-HDI). The overall result of the study pointed that the countries located in the highest categories in terms of HDI were both export and import-dependent. The most importance levels of dependency for the Low Developed Countries (HDI < 0.550) were fish consumption, and total imports; for Medium Developed Countries (0.550 ≤ HDI < 0.699) were export value, exports, and catch production; for High Developed Countries (0.699 ≤ HDI <0.80) was total exports; for Very High Developed Countries-I (0.80 ≤ HDI < 0.900) was exports; and for Very High Developed Countries-II (HDI ≥ 0.90) was import value. To improve the human development of the countries and maintain the food security around the world, the following points could be suggested: i) to increase the aquaculture production both in inland and marine environments where possible, ii) for low and medium developed countries, instead of raw material exporting, to support increasing the production capacity of processed fisheries products that have higher global market prices.

Key words: dependency on fisheries, human development, human development index

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1. Introduction

In an environment where poverty and food insecurity increasingly burden society, the concept of human development (as part of sustainable development) can play an important role in a decent standard of living, as its aim is to broaden people's choices. Sustainable development has been widely accepted as a political, legal and moral response of the international community to key global issues related to the environment and to development. Although there are many definitions of sustainable development, the definition put forward by the Brundtland Report is the most widely accepted: 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (England 1993, French 2005).

Globalisation is a term used to describe the interconnectedness and diffusion of technology, production and communication around the world. A consequence of economic globalisation is an interdependence between interrelated sectors in different parts of the world (Kyove et al. 2021). Peta et al. (2021), examined the role of globalisation, renewable energy consumption, natural resources abundance, and human development (as the Human Development Index) on environmental degradation for the top ten countries with the largest ecological footprint. They found that while the increase in human development and renewable energy consumption had a negative and statistically significant effect on the ecological footprint, the abundance of natural resources reduced the environmental quality, while globalisation did not affect environmental pressure.

Marine living resources are essential for livelihoods, food security and other relevant development goals such as education, health and gender equality. These developmental goals give meaning to the concept of human development. Human development can be thought of as the process of 'expanding people's choices, including access to resources needed for a long and healthy life, the acquisition of knowledge, and a decent standard of living'. From a human rights perspective, it is directly related to poverty, which consists of 'the non-fulfillment of a person's right to various basic abilities'. Human development includes social development aimed at providing 'good living conditions for both present and future generations'. In the context of human rights, these options relate to basic abilities such as living a healthy life and access to good education, a decent standard of living and without poverty. As the human dimension is placed at the center of sustainable development, human development concerns have become a topic of increasing interest. The human development dimension of fisheries is clear: millions of people, most of whom live in developing coastal states, depend on fishing for their food security and livelihoods. Development and poverty eradication in fishing communities also have spillover effects on aspects of the development process such as education, gender and health care (Hillgenberg 1999; Brunnée & Toope 2000).

Seafood (all tradable aquatic organisms) is one of the world's most traded food commodities and, with the global population expected to growing to 9.7 billion people by 2050, the demand for fish is also expected to increase. This offers valuable trading opportunities in the fisheries sector. In 2018, global fisheries and aquaculture amounted to approximately 179 million tonnes, with a 'first sale' value estimated at US$ 401 billion, with exports of over US$ 164 billion, 60% of which were from developing countries (Boyd et al. 2022). Approximately 20 percent of the average animal protein intake for nearly 3.3 billion people in 2017 came from seafood, and this proportion was estimated to be even higher in many poor countries. In 2017, seafood provided about 3.3 billion people with almost 20 percent of their average intake of animal protein, with an even higher proportion in many poor countries (Yarkina & Logunova 2022; Subasinghe 2017). In addition to human consumption, the industrial need for fishery resources is projected to rise in the coming decades due to increasing demand for fish oil and animal feed (Golub & Varma 2014).

Areas in which the fishing industry employs more than 5% or 10% of the workforce with having a significant production output have been described as "fisheries dependent areas" (Ross 2013). However, a discussion of "dependency" over the workforce is more commonly seen as a valid approach for local communities. Therefore, it is clear that there is a need for other approaches based on more than one parameter other than the workforce in the assessment of dependency on a global scale.

In addition to factors such as global warming and population growth, the fisheries sector has undergone steady 'internationalisation' over the past decades, mainly driven by the quest for access to resources and raw materials (OECD 2010). Especially due to the increasing size of the market in terms of both the number of people and the geographical area covered, in recent years, the conditions that determine the traditional use of fish have been slowly changing. While most consumers had access to an increasing variety of food and fish products and an increasing number of sellers, most primary producers were able to choose from a larger number of buyers. As a reflection of this, there has been an expanding range of possibilities both for meeting food needs and for generating income. As in all sectors, the increase in the number of trade opportunities has had and continues to have repercussions on the fishing and aquaculture sector. (FAO 2000). However, this has also caused other problems to arise. This situation is more dramatic in poor countries. Because fish is an essential part of food security for large segments of society, including the fishermen in the given countries, and the ever-expanding possibilities of export markets have led to a reduction in the number of fish available in local markets. The decision to sell fish to foreign markets rather than local markets, where it plays an important role in ensuring food security, is likely to become problematic in some countries over the next decade (FAO 2000). Paradoxically, this situation also increases the dependence of rich countries on fisheries resources. Therefore, it would be better to add some new points into the concept of dependency in terms of the fisheries context.

The dependence of countries on fisheries may be a reflection of not only economic reasons, but also other factors such as dietary preferences and education levels. Therefore, it would be more logical to use an index that will take into account other parameters as well as economic parameters in the evaluation and/or comparison of dependency. In this sense, a classification can be made according to the human development index (HDI), which is widely used in the world (Figure 1). The most recent attempt to establish a measure of human development and cross-country development benchmarking is the Human Development Index (HDI), which has been used since 1990 by United Nations Development Programme (UNDP 2022) to rank countries. This index is preferred because it eliminates the inadequacy of other economic indicators and indices such as GDP and economic growth (Noobakhsh 1998; Mazlum & Can 2021). It is more about expanding the wealth of human life than the wealth of the economy in which people live and an approach that focuses on people, people's opportunities, and choices (UNDP 2022). The HDI can also be used to question national policy choices in that it asks how two countries with the same GDP per capita could result in different human development outcomes. These contrasts can stimulate debate about government policy priorities.

The relationship between commodity dependence and human development measured by the human development index (HDI) was studied by Nkurunziza et al. (2017). Gani & Prasad (2007) tried to provide empirical evidence of food security and human development inter-relationships for a sample of low-income countries. The contribution of international trade in the human development of Pakistan was studied by Jawaid & Waheed (2017). Lindner and Wagner (2020) studied the agricultural productivity, economic growth and human development in Sub-Saharan Africa. The Human Development Index (HDI) of the fisherman community on Ransang Island in Indonesia was investigated by Ramodona et al. (2021). The relationship between fish consumption, wealth and economic growth (FAO

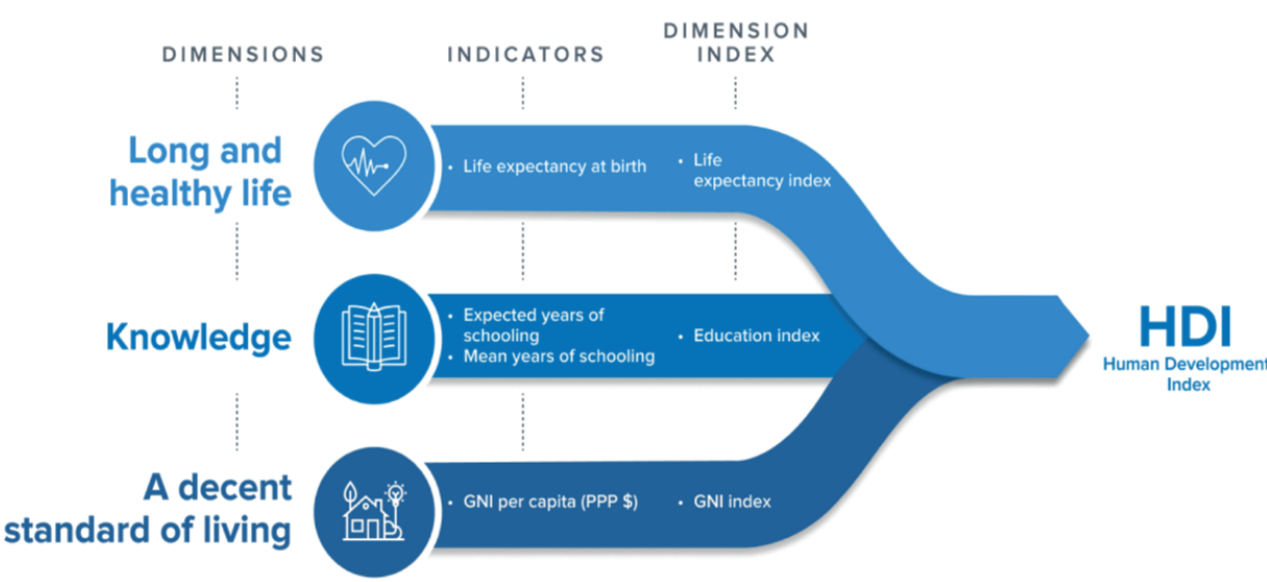

Figure 1
HDI dimensions and indicators (https://hdr.undp.org)

2000) and fishery exports in least developed countries was examined (Golub & Varma 2014).

Food and nutrition security are one of the biggest challenges of the 21st century. It is stated that the biggest obstacles facing human beings confronting how to feed a population that is expected to reach 9.5 billion people by 2050 are climate change, economic and financial uncertainty and increasing competition for natural resources (FAO et al. 2020). To overcome that issue requires an integrated response and an urgent transition of the world economy towards a sustainable, inclusive and resource-efficient path (Ababouch & Fipi 2015). In today's globalised world, considering fish as an important source of food and nutrition, it is also important to understand the relationships between countries' fishing context and human development levels in order to ensure the sustainability of the seafood supply. This study focused mainly on the analysis of the current situation, and then some suggestions for the future were made based on the results.

2. Materials and methods

In this study, we tried to answer the following two questions for fisheries in the world considering relationships between fisheries context (Table 1), and human development (in terms of Human Development Index-HDI) of countries:

i) Who is dependent on whom?

ii) What is the level of dependency?

The data used covers the year 2018. They were derived from FAO (Dataset: Fishery Commodities Global Production and Trade) and UNDP (https://hdr.undp.org/data-center/documentation-and-downloads) (Table 2).

The HDI is a summary measure of average achievement in key dimensions of human development: living a long and healthy life, being knowledgeable, and having a good standard of living. The HDI is the geometric mean of the normalised indices for each of the three dimensions (UNDP 2022): life expectancy index (LEI), education index (EI), and income index (II). The LEI is used as a measure of longevity and good health, and it is 1 when life expectancy at birth is 85 and 0 when life expectancy at birth is 20. EI helps to measure educational attainment (a term commonly used by statisticians to refer to the highest degree of education an individual has completed), while income index is used to indicate the gross national income at purchasing power parity per capita.

Table 1

The components of fisheries context

Catch Production (tonnes)	Fisheries Export Value (USD)
Aquaculture Production (tonnes)	Fisheries Import Value (USD)
Total Fisheries Export (tonnes)	Fish Consumption Per capita (kg)
Total Fisheries Import (tonnes)	
Processed Fisheries products (tonnes)	

We classified countries into five groups according to HDI values: Low Developed Countries (LDC), Medium Developed Countries (MDC), High Developed Countries (HDC), Very High Developed Countries-I (VHDC-I), and Very High Developed Countries-II (VHDC-II)(Table 2). There are four categories in UNDP's HDI classification (https://hdr.undp.org/data-center/documentation-and-downloads). If we had used this classification in the study, a total of 57 countries would be included in the VHDC (Very High Developed Countries) category. The coefficients of variation (CV, %) of these groups in terms of HDI are 8.60%, 6.85%, 3.69% and 5.90%, respectively. It is observed that the CV values of groups tend to decrease as HDI increases, but increases again when it comes to the VHDC group. Therefore, it would be more accurate to divide VHDC into 2 more homogeneous subgroups in order to make comparisons and evaluations more soundly. Therefore, by performing the classification in Table 2, the CV value in VHDC-I was reduced to 3.84% and the CV value in VHDC-II was reduced by 1.72%. In general, the countries having more GDP also they have a higher level of education, better living standards, and more selective consumer preferences on product choice (Friese et al. 2006).

Table 2

Classification of 145 countries according to HDI class ranges (NoC: Number of Countries, and CV: Coefficient of Variation in terms of HDI)

Group	HDI class range	NoC	CV (%)
Low Developed Countries (LDC)	HDI < 0.550	23	8.60
Medium Developed Countries (MDC)	0.550 ≤ HDI < 0.699	24	6.85
High Developed Countries (MDC)	0.699 ≤ HDI < 0.800	41	3.69
Very High Developed Countries-I (VHDC-I)	0.80 ≤ HDI < 0.900	35	3.84
Very High Developed Countries-II (VHDC-II)	HDI ≥ 0.90	22	1.72

Decision trees are used to solve classification problems and categorize objects depending on their learning features. They can also be used for regression problems or as a method to predict continuous outcomes from unforeseen data.

Decision trees can be used for different purposes depending on the problem to be solved. One of them is to reveal to what extent (as percentage) the variables in a model affect your target solution. In this study, the CART (Classification and Regression Tree) algorithm was used to identify the importance degree, as a percentage, of each component of fisheries context relating to human development. CART is a variation of the decision tree algorithm. It can handle both classification and regression tasks. CART is a powerful tool that does not require predefined underlying relationship between the dependent variable and independent variables. It is mostly categorised into a supervised learning approach (a data set is divided into training and test data sets (Pathak et al. 2018; Lawrence et al. 2001; Liaw & Wiener 2002). But, in this study we used unsupervised learning, also known as the 'learning without a teacher' approach. In this case one has a set of N observations (x1, x2,...,xN) of a random p-vector X having joint density Pr (X) to directly infer the properties of this probability density without the help of a supervisor or teacher providing correct answers for each observation (Hastie et al. 2009; Celebi & Aydin 2016).

These procedures were conducted in R using the 'rattle' package (Williams 2011). To visualize the importance of components by country groups in the form of cross-hierarchical clustering, Ward's algorithm with Euclidean similarity index was utilized by using the PAST software (Hammer et al. 2001).

3. Results

Some descriptive statistics (mean, coefficient of variation-CV, percent-P) of fisheries context's components and their degree of importance (Imp, %) by Human Development Index groups were given in Table 3. High Developed Countries (HDC) had the highest percentage for aquaculture and catch production (tonnes), fish consumption per capita (kg/year), and processed fisheries product (tonnes) with 82.96%, 46.52%, 27.53%, and 49.76%, respectively. The highest export (tonnes), import (tonnes), export value (USD), and import value (USD) were 46.04%, 44.60%, 38.49%, and 63.30% for Very High Developed Countries-II (VHDC-II), respectively. For all components, small values of coefficient of variation (CV, %) showed almost homogeneous patterns within each of the groups, i.e., there were no large differences among the countries within each group. The most homogeneous patterns were observed in VHDC-II.

In terms of world production, countries with a high human development index (VHDC-I and VHDC-II) had a share of 6.79% (2.50% and 3.79%, respectively) in aquaculture and 33.73% (13.90% and 19.83%, respectively) in fishing. However, they had a much higher share in the amount of exports and imports (61.34% and 61.32%, respectively) and values (54.53% and 78.68%, respectively) (Table 3). Especially in terms of import amount, the VHDC-II group constitutes 63.30% of the world's fish imports. This situation shows us that this group of countries are both export- and import-dependent.

The degree of importance of components for each of the HDI groups was given in descending order as follows (Table 3, Figure 2, Figure 3):

Low Developed Countries (LDC): Fish consumption per capita (17%), import (17%), import value (17%), aquaculture production (14%), export value (12%), export (12%), catch production (11%), and processed fish (3%).

Medium Developed Countries (MDC): Export value (16%), export (16%), catch production (16%), import value (15%), aquaculture production (14%), import (12%), fish consumption per capita (7%), and processed fish (4%).

High Developed Countries (HDC): Export (21%), catch production (16%), export value (15%), aquaculture production (13%), fish consumption per capita (12%), import value (10%), import (10%), and processed fish (3%).

Very High Developed Countries-I (VHDC-I): Export (18%), import value (16%), import (15%), fish consumption per capita (13%), export value (12%), processed fish (9%), aquaculture production (9%), and catch production (8%).

Very High Developed Countries-II (VHDC-II): Import value (26%), import (21%), fish consumption per capita (15%), export value (9%), catch production (8%), aquaculture production (7%), and processed fish (2%).

The three countries with the highest share in the world ranked according to HDI groups for each component are given in Table 4. China has a very high share compared to other countries in the world in terms of many components and is in the HDC group. But it is seen that the expected increase in the HDI value of China, which has an HDI increase rate above

Table 3

Some descriptive statistics (mean, coefficient of variation-CV, percent-P) of fisheries context's components and their degree of importance (Imp, %) by Human Development Index groups

	Aquaculture Production (tonnes)				Catch Production (tonnes)			
	Mean	CV %	P %	Imp-%	Mean	CV %	P %	Imp-%
LDC	20115.24	3.13	0.42	14.00	206594.10	1.30	5.08	11.00
MDC	478127.41	3.14	10.33	14.00	595915.90	1.95	15.28	16.00
HDC	2247422.06	4.67	82.96	13.00	1062218.50	2.59	46.52	16.00
VHDC-I	79255.10	2.88	2.50	9.00	355686.00	2.68	13.30	8.00
VHDC-II	191522.11	1.83	3.79	7.00	843966.70	1.55	19.83	8.00
	Total Fisheries Export (tonnes)				Total Fisheries Import (tonnes)			
	Mean	CV %	P %	Imp-%	Mean	CV %	P %	Imp-%
LDC	53894.96	3.14	2.72	12.00	41574.13	2.61	2.69	17.00
MDC	162050.04	2.03	8.54	16.00	54631.96	1.50	3.68	12.00
HDC	304151.02	2.57	27.39	21.00	280627.32	3.08	32.31	10.00
VHDC-I	199055.60	2.24	15.30	18.00	170117.91	1.40	16.72	15.00
VHDC-II	952896.18	1.82	46.04	9.00	721989.27	1.09	44.60	21.00
	Total Fisheries Export Value (USD)				Total Fisheries Import Value (USD)			
	Mean	CV %	P %	Imp-%	Mean	CV %	P %	Imp-%
LDC	114511.30	2.49	1.62	12.00	60152.43	2.83	0.91	14.00
MDC	553291.40	2.62	8.19	16.00	80216.42	1.10	1.27	15.00
HDC	1410411.00	2.70	35.65	15.00	707020.88	3.36	19.14	10.00
VHDC-I	743286.40	1.98	16.04	12.00	665587.63	1.96	15.38	16.00
VHDC-II	2837831.00	1.03	38.49	12.00	4357689.91	1.31	63.30	26.00
	Fish Consumption per capita/year (kg)				Processed Fish (kg)			
	Mean	CV %	P %	Imp-%	Mean	CV %	P %	Imp-%
LDC	9.39	0.76	7.76	17.00	87801.15	2.24	2.92	3.00
MDC	18.73	0.97	16.16	7.00	303317.16	1.80	9.57	4.00
HDC	18.67	0.93	27.53	12.00	1109561.37	3.00	49.76	3.00
VHDC-I	18.89	0.70	23.77	13.00	310780.53	3.14	15.48	9.00
VHDC-II	31.33	0.61	24.78	15.00	638522.00	1.42	22.27	2.00

the world average, in the next 10 years will put it in the category of highly developed countries (it reached HDI values of 0.499 in 1990, 0.606 in 2001, and 0.755 in 2018) (Blomeyer et al. 2012; Lindner & Wagner 2020). This will likely also affect the degree of dependency of different HDI groups in terms of fisheries content around the world (Table 4).

Table 5 provides cross-correlations between fisheries context components (as a percent of total). Although seafood production from fishing has become stagnant in the world, aquaculture production has been tending to a growing trend. Therefore, as it would be expected, there is a strong relationship between aquaculture production and processed fisheries products of countries (r = 0.91). The correlation between processed product and total import (r = 0.80) shows that importing countries also have high production of processed products. Countries with high imports have a significant fish consumption rate (r = 0.25, $p < 0.05$). On the other hand, countries with a higher export value have a slightly higher fish consumption (r = 0.26). When the relationship between the amount of imported product and fishing (r = 0.56) and aquaculture (r = 0.41) are examined, the products obtained as a result of fishing are exported at a higher rate, while the relationship between imports and fishing (r = 0.69) and aquaculture (0.68) are almost similar.

In terms of factor dependency, the linkage ordering of groups was following: LDC and VHDC-I; LDC and HDC; and VHDC-II (Figure 3). VHDC-II appeared to differ remarkably from other groups (especially for import value, import, and consumption). At the same time, the „processed fishery" component seems to be the last linked to hierarchical clustering. Therefore, differences in the amount of processed fishery products of country groups may also affect the level of importance hierarchy among the components for each group.

Table 4

Three countries that have the highest share of each component in the world ranking according to HDI groups

	Aquaculture Production (%)				Catch Production (%)			
	Country contribution to world (%)			P %	Country contribution to world (%)			P %
LDC	Nigeria (0.26)	Uganda (0.09)	Tanzania (0.01)	0.42	Mauritania (1.0)	Nigeria (0.94)	Senegal (0.52)	5.08
MDC	India (6.36)	Bangladesh (2.16)	Myanmar (1.01)	10.33	India (5.71)	Myanmar (2.17)	Bangladesh (1.99)	15.28
HDC	China (59.54)	Indonesia (13.26)	Vietnam (3.74)	82.96	China (15.84)	Indonesia (7.76)	Peru (7.70)	46.52
VHDC-I	Chile (1.16)	Malaysia (0.35)	Turkey (0.28)	2.50	Russia (5.47)	Chile (2.53)	Malaysia (1.56)	13.30
VHDC-II	Norway (1.22)	Japan (0.93)	USA (0.42)	3.79	USA (5.72)	Japan (3.42)	Norway (2.85)	19.83
	Total Fisheries Export (%)				Total Fisheries Import (%)			
	Country contribution to world (%)			P %	Country contribution to world (%)			P %
LDC	Mauritania (1.74)	Senegal (0.56)	Tanzania (0.12)	2.72	Nigeria (1.47)	Benin (0.30)	Mozambique (0.26)	2.69
MDC	India (3.15)	Morocco (1.57)	Myanmar (1.23)	8.54	Ghana (1.00)	Morocco (0.28)	Cameroon (0.54)	3.68
HDC	China (9.33)	Vietnam (3.77)	Peru (3.51)	27.39	China (14.63)	Thailand (5.98)	Vietnam (1.53)	32.31
VHDC-I	Russia (5.11)	Chile (3.04)	Argentina (1.05)	15.30	Italy (3.20)	Poland (1.74)	Portugal (1.47)	16.72
VHDC-II	UK (17.82)	Norway (5.98)	USA (3.46)	46.04	USA (8.12)	Japan (6.66)	Spain (4.96)	44.60
	Total Fisheries Export Value (%)				Total Fisheries Import Value (%)			
	Country contribution to world (%)			P %	Country contribution to world (%)			P %
LDC	Mauritania (0.80)	Senegal (0.31)	Tanzania (0.13)	1.62	Nigeria (0.55)	Benin (0.07)	Mozambique (0.05)	0.91
MDC	India (4.28)	Morocco (1.45)	Namibia (0.47)	8.19	Ghana (0.19)	Morocco (0.16)	Cameroon (0.16)	1.27
HDC	China (13.47)	Vietnam (5.50)	Thailand (3.75)	35.65	China (9.81)	Thailand (2.69)	Vietnam (1.22)	19.14
VHDC-I	Chile (4.27)	Russia (3.27)	Poland (1.56)	16.04	Italy (4.69)	Poland (1.71)	Portugal (1.70)	15.38
VHDC-II	Norway (7.40)	USA (3.79)	Netherlands (3.50)	38.49	USA (15.80)	Japan (10.37)	Spain (5.70)	63.30
	Fish Consumption per capita/year (kg)				Processed Fish (%)			
	Fish Consumption (kg)			P %	Country contribution to world (%)			P %
LDC	Gambia (27.53)	Sierra L. (26.3)	Senegal (18.09)	7.76	Mauritania (1.49)	Nigeria (0.27)	Yemen (0.24)	2.92
MDC	Kiribati (76.69)	Myanmar (47.32)	Cambodia (42.69)	16.16	India (3.65)	Myanmar (1.91)	Morocco (1.21)	9.57
HDC	Maldives (90.41)	Antique B. (52.54)	Indonesia (44.67)	27.53	China (28.70)	Vietnam (4.27)	Thailand (3.85)	49.76
VHDC-I	Malaysia (57.62)	Portugal (56.84)	Barbados (39.97)	23.77	Russia (8.74)	Chile (2.21)	Poland (1.20)	15.48
VHDC-II	Iceland (90.71)	Honk Kong (70.75)	Norway (51.35)	24.78	Japan (5.74)	USA (3.90)	Norway (3.31)	22.27

Table 5

Cross-correlations between fisheries context components. The lower triangle shows correlation values, and the upper triangle shows *p* values at 95% confidence level based on the pairwise two-sided *t*-test

Factor	Catch	Aquaculture	Export	Import	Processed Fish	Export Value	Import Value	Consumption
Catch		0.00	0.00	0.00	0.00	0.00	0.00	0.01
Aquaculture	0.79		0.00	0.00	0.00	0.00	0.02	0.12
Export	0.56	0.41		0.00	0.00	0.00	0.00	0.03
Import	0.69	0.68	0.54		0.00	0.00	0.00	0.00
Processed Fish	0.89	0.91	0.54	0.79		0.00	0.00	0.03
Export Value	0.81	0.72	0.68	0.76	0.84		0.00	0.00
Import Value	0.52	0.39	0.43	0.87	0.54	0.56		0.00
Consumption	0.23	0.13	0.18	0.25	0.20	0.26	0.23	

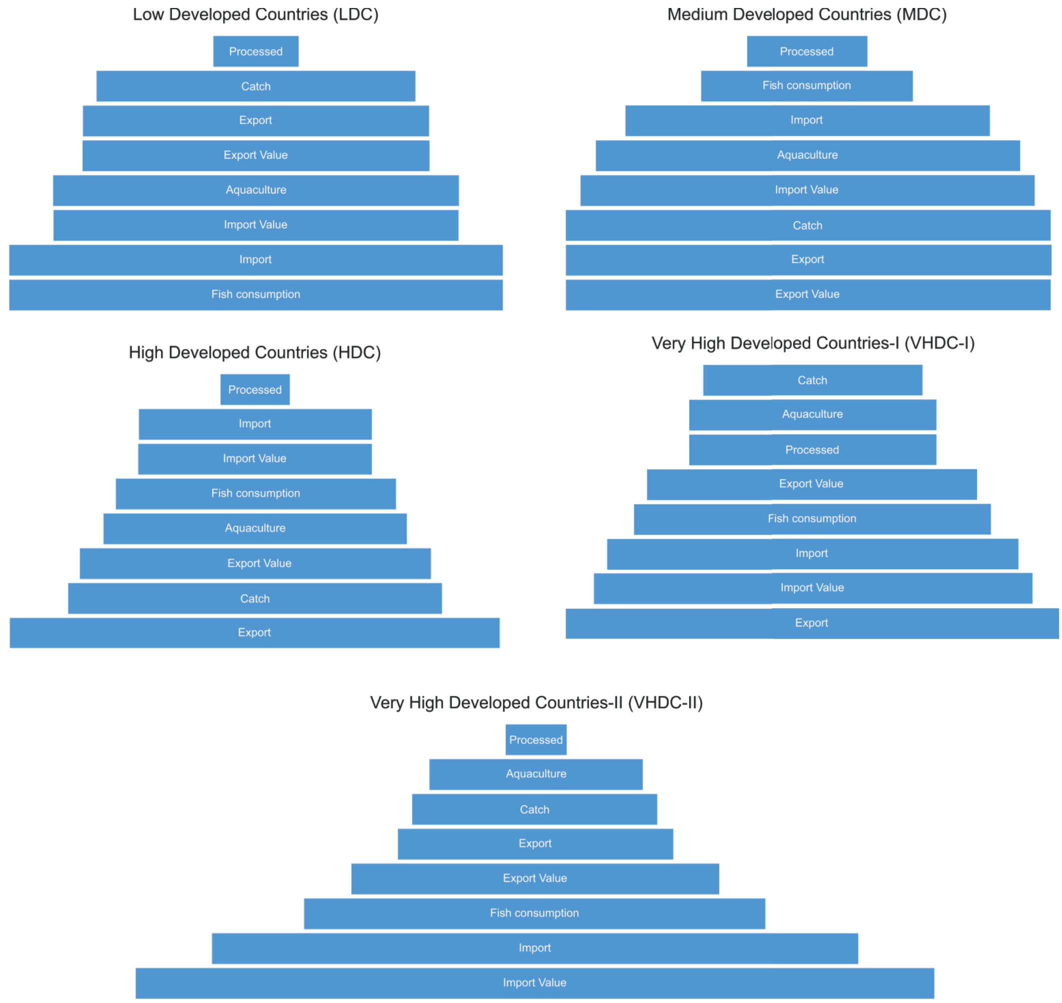

Figure 2

Hierarchical representation of fisheries context dependency as a percentage, by groups

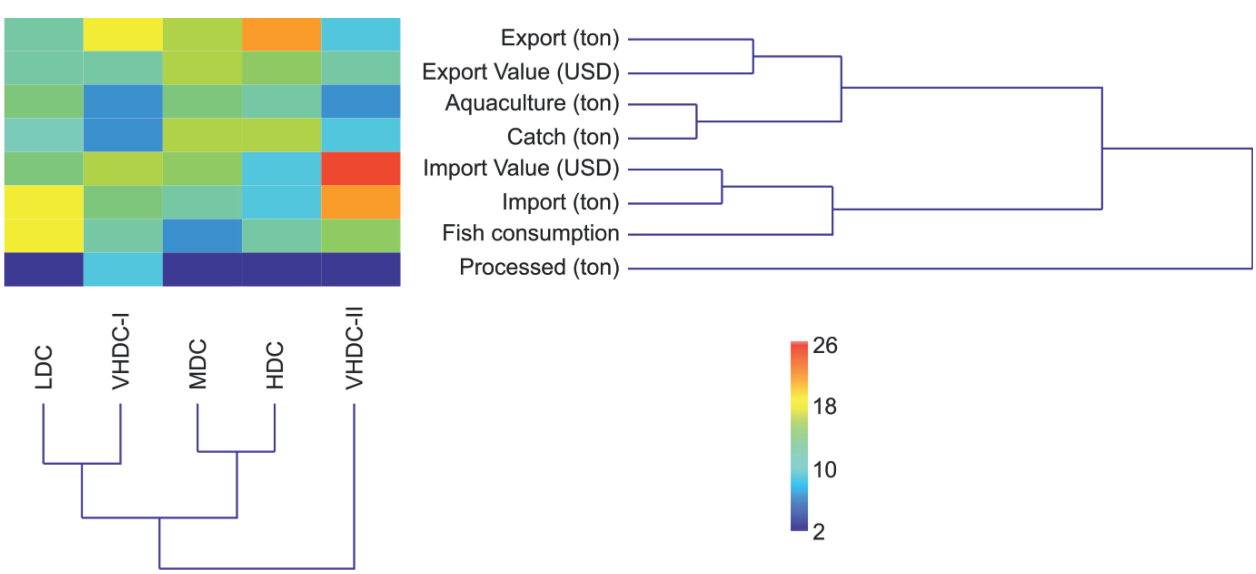

Figure 3

Cross-hierarchical clustering of importance of components with groups of countries

4. Discussion

In this study, "the relationship between human development and dependence on fisheries" was tried to clarify by considering two basic questions. These were (i) Who is dependent on whom? and (ii) What is the level of dependency on the fishery? For doing so, the relationship of some fishery-related factors (briefly referred to as "fisheries context") and human development index (HDI) of countries were considered.

Prior to the dealing with discussion of major findings, it may be better to highlight why some highly correlated factors (such as import quantity and import value etc.,) were used at the same time. Before applying liner models such as Linear Regression, Logistic Regression, etc., one of the important assumptions is there should not be multicollinearity (high correlation among predictors) in the dataset. Variance Influence Factor (VIF) is one of the detecting measures for multicollinearity in a model (Shrestha 2020). Nevertheless, decision trees are intrinsically greedy algorithms. Therefore, there is not much concern about the multicollinearity in the data (Kotsiantis 2013). Although we did not attempt to use any linear modeling in this study, due to the nature of Pearson correlation (Ahlgren 2003) as shown in Table 5, we tried to clarify the use of these variables with the linear model.

So, if we model the HDI against the export value (VIF = 4.33), import value (VIF = 4.58), export amount (VIF = 4.45), and import amount (VIF = 4.73), the model produced acceptable variance influencing factor values. Also, based on the each of coefficients of predictive variables against the HDI, while there is an inverse relationship between HDI and export amount, there is a positive relationship between HDI and export value. The same pattern is valid for import amount and import value (Figure 4). Another point is that there is not a high correlation between the amount and value of exports for all countries, as can be seen from the moderate correlation between the amount and value of exports (Table 5). This is particularly evident for countries that raise high market value fish (such as Turkey, Norway) and export them after increasing the added value of the product through processing plants (especially VHDC-I and VHDC-II).

The pandemic is the most important experience we have had recently, especially in terms of showing how countries are dependent on each other in terms

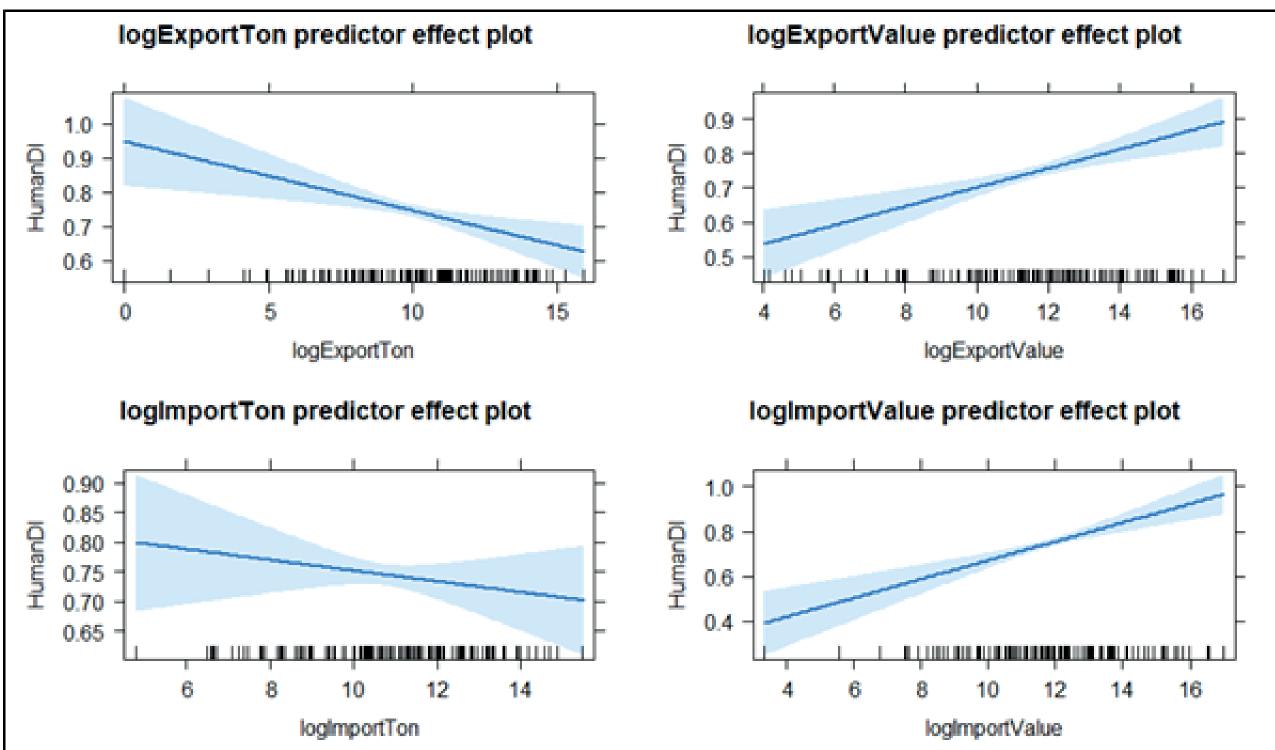

Figure 4

Predictor effect plots of HDI against the export value, import value, export amount (tonnes) and import amount (tonnes) of both raw materials and processed products on a global scale. This situation, as in other sectors, has led to the emergence of concerns about ensuring food safety and related measures. In addition, assessments are made that climate change will increasingly threaten food security on a global scale. Therefore, the questions whose answers are investigated in this article gain importance in order to make the future plans for correct understanding and adoption of these changing conditions in terms of food safety. The overall conclusion of the study is that countries in the highest categories of human development are to some extent dependent on both exports and imports. Dependency levels of HDI groups were found to differ considerably for "fisheries context". The most important component of dependency level for LDCs is fish consumption and total imports; for Middle Developed Countries (MDC) it is export value, export and catch production; for High Developed Countries (HDC) as well as for Developed Countries-I (VHDC-I), it is total exports; and for Very High Developed Countries-II (VHDC-II) it was the import value.

In the agriculture sector, it was pointed out that commodity dependence negatively affects human development through several channels, including the negative secular terms of trade affecting commodity-dependent developing countries (CDDCs), slow economic growth, high macroeconomic instability, and political instability. They also found that although the effect of commodity dependence on human development is negative, in general, this relationship is complex. It changes with the level of dependences as well as the type of commodity a country depends on. This negative effect is strongest in countries where commodities account for more than 60 percent of total merchandise exports (Lindner & Wagner 2020). Nkurunziza et al. (2017) found that import and export dependence are negatively associated with the level of human development. Many commodity-dependent developing countries (CDDCs) are doubly hurt by commodity dependence as they are dependent on both export and imports. In addition to the increasing world population and internationalisation, the near-term possibility of global warming-induced change in geographical production patterns will also change the level of dependency of country groups.

Fish consumption per capita, which was 9.9 kg on average in the 1960s in the world, has now exceeded 20 kg and it is predicted that the amount will rise in the future. Overall, fish consumption differs between continents and also between countries on each continent, and on average, it always appears to be higher in rich countries than in poor countries. In developing regions, it was reported that fish consumption growth was low (from 3.5 kg to 7.6 kg), however annual fish consumption per capita in low-income food-deficit countries (LIFDCs) has increased steadily. People in rich or industrialised countries consume more fish (26.8 kg per capita in 2013). The World Bank predicts that despite the expected increase in fish consumption in Asia and Latin America, this figure in the African region may decline significantly over the next two decades (World Bank 2013).

In an age where the contribution of fish to global food and nutrition security has been fully recognised, such a prediction is alarming and warrants attention (FAO 2005). It was estimated that per capita fish intake will continue to increase worldwide over the next three decades, and that most of this increase will result from economic prosperity. The positive income elasticity of fish demand supports this finding, although the manner in which consumption responds to increases in wealth seems not only to depend on the level of wealth attained, but also on the quantities of fish that are currently eaten by the average consumer (FAO 2000). It appears that, for most of the high consumers, there is no clear relationship between changes in income and volume of consumption, although a clear exception is Norway, where fish still seems to be a much-preferred food. On the other hand, Germany seems to have reached stagnation at a very low level of consumption. However, in Japan, this picture seems to be different. The negative correlation – although weak – between growth and volume of consumption could be taken to mean that increased incomes have given the Japanese the possibility of switching from their staple to other foods. The correlation between economic growth and fish consumption in China is very high, most likely reflecting the responsiveness of freshwater aquaculture to the stimulus of the market (Ross 2013).

Three countries were taken into account when answering the question, 'Can marine fisheries and aquaculture meet the fish demand of a growing human population in a changing climate?'. Among these countries, Norway is in the VHDC-II, China is in the HDC category and Bangladeshis in the MDC category. Norway, as the world's largest producer of Atlantic salmon, ranks high in the human development index and generates a revenue of US$2.75 billion mainly by exporting salmon production (Brugère & Ridler 2004; Failler 2007). More than 67% of the world's aquaculture production is in China, and this rate is expected to increase in the coming decades. Whether Chinese aquaculture moves towards species with high fishmeal inclusions or continues with its current species composition will be a critical driver for the future of fishmeal markets in the world, and hence for fish farming. If species bred currently are bred in the future, the Chinese aquaculture industry could potentially continue to increase its fish supply to meet its demands. Bangladesh's population is expected to increase to 194.3 million by 2050. Fish is an important component of the Bangladeshi diet with a per capita consumption rate of 14 kg per year that accounts for 50-60% of the total animal protein intake. Calculations assume that 83% of marine fishery production is used directly for human consumption and the rest is reduced to fishmeal (Merino et al. 2012).

The factors affecting the total fisheries production of countries in the world are (i) the management system (ii) developments in technology, (iii) geographic location, and (iii) dependence on fisheries products to obtain animal protein (Avşar 1998). As can be seen from this study, whatever the purpose of fisheries production, the point where the purposes generally converge is economic activity. It is often overlooked that more than 500 million people depend, directly or indirectly, on fishing and aquaculture for their livelihoods. Fish is highly tradable with more than 37% of production entering the international trade, and exports from low-income food-deficient countries are equivalent to 50% of the cost of their food imports (FAO 2020). In many developing countries, the economic importance of fish increased in the second half of the twentieth century and, by the end of the 1990s, the fisheries sector had become an important source of food, employment and foreign exchange – a situation that is likely to continue. A stable source of foreign currency is vital for countries, as increased participation in international trade is an essential condition for their economic growth, particularly for smaller countries with limited or no mineral resources (FAO 2000).

5. Conclusion

The study revealed that there is an important relationship between countries' fisheries production, export amount, and unit value of exports and the countries' human development. Considering that the three basic parameters of human development are income level, education level, and life expectancy, to increase both fisheries production and exports have emerged as important issues in the sector. Firstly, it is, of course, necessary and important to increase the exports of the countries in the said sector in terms of quantity. However, the results of the analyses showed that increasing exports based on quantity does not lead to significant effects on the income level and human development of countries. This situation reveals that the production of products with high added value is more important in terms of exports and therefore human development. In this sense, increasing the quantity and quality of processed seafood seems to be an important solution. Since the additions to the values of input and intermediate goods express the concept of added value, the contribution of the sector to the welfare of the country and human development by processing the products and thereby creating high added value will be made evident. In this context, countries with a relatively low level of human development and welfare should produce and processing sub-products for export as opposed to exporting unprocessed seafood. However, the increase in added value in production is also directly related to human capital. For this reason, countries need to increase the quality and productivity of their labor stock, leading to an increase in added value in their production and exports. This situation will bring about an increase in the competitiveness of the countries in the sector.

Therefore, in the long run, the following two paths, strongly interconnected, could be recommended:

I) to increase aquaculture production both in inland and marine environments, where possible;

II) for low and medium developed countries, instead of raw material exporting, to support increasing the production capacity of processed fisheries products that have higher global market prices.

These two suggestions might improve the human development of countries, especially for low and medium developed countries, and help to maintain food security around the world. For these purposes, it would be better if national policy makers and international organizations such as the United Nations (UN) subsidize and promote fisheries processing investments.

Authorship Contributions

Mehmet Fatih CAN: Conceptualisation, methodology, formal analysis & editing, writing – original draft, review & editing.

Yavuz MAZLUM: Investigation, data curation, resources, writing – original draft, review & editing.

Birol ERKAN: Conceptualisation, writing – review & editing.

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Data Availability Statement

The data that supports the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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