Enabling Sustainable blue Economy in Egypt: Towards Addressing Sustainable Fisheries and Supporting Food Security

(Deductive approach using Econometric and Comparative Analysis)

تمكين الاقتصاد الأزرق المُستدام: مع التركيز على مصايد الأسماك المستدامة و دعم الأمن الغذائي

(نـهج استنباطي مبني علي النماذج القياسية والتحليلات المقارنـة)

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المستخلص:
يهدف هذا البحث إلى إلقاء الضوء على أهمية إلى التحول "للاقتصاد الأزرق المُستدام" مع التركيز على دور "مصايد الأسماك المستدامة" في تحقيق "الأمن الغذائي". لذلك تم أولاً تقديم تحليلاً مقارناً لتجارب بعض دول جنوب شرق آسيا متمثلة في كل من إندونيسيا و الهند والصين حيث قامت حكومات تلك الدول بتصميم إطارًا واضحاً من أجل تعظيم الاستفادة من الاقتصاد الأزرق من خلال تعزيز وسائل مصايد الأسماك المستدامة مما ينعكس إيجابًا على الأمن الغذائي. ثانياً، تم تنفيذ نموذج تطبيقي من خلال تقديم نموذج اقتصادي قياسي مبسط بإستخدام نموذج الإنحدار الخطي المتعدد لتصحيح ثبات تباين الخطأ العشوائي من عام ٢٠١٢ حتى عام ٢٠٢٢ في مصر. و من ثم يخلص النموذج إلى أن مصايد الأسماك المستدامة في مصر يعد قطاعًا واعدًا من خلال تحفيز تمكين الاقتصاد الأزرق مما ينعكس على تحقيق الأمن الغذائي ومن ثم ضمان الأمن الغذائي للأجيال القادمة. وأخيرًا، يقترح استراتيجية طويلة المدى للأمن الغذائي من خلال تمكين الاقتصاد الأزرق ومعالجة مصايد الأسماك المستدامة في مصر في شكل خطة عمل.

الكلمات المفتاحية: الاقتصاد الأزرق المستدام، مصايد الأسماك المستدامة، الأمن الغذائي، الهدف الرابع عشر من أهداف التنمية المستدامة، الحفاظ على المحيطات، التنمية المستدامة، مصر، مؤشر الأمن الغذائي العالمي، مؤشرات مصايد الأسماك المستدامة، إنتاج الأسماك.

Abstract:

This paper aims to shed light on a broader transformation to sustainable blue economy by focusing on the role of “sustainable fisheries” in achieving food security. To fulfil this aim, firstly, it presents a comparative analysis of experiences of Indonesia, India and China whom their governments designed a framework and are getting benefits from the blue economy and are guaranteeing means of sustainable fisheries which is reflected positively on food security. Secondly, it performed reduced applied econometric model using multiple linear heteroskedasticity regression model from 2012 till 2022 in Egypt. It concludes that adopting sustainable fisheries in Egypt is a promising sector by enabling blue economy whereby reflections of these appeared on food security and serves at the end for guaranteeing food security for future generations. Finally, it proposes long-term food security strategy by enabling blue economy and addressing sustainable fisheries in Egypt through providing an action plan.

Keywords: Sustainable Blue economy, Sustainable fisheries, Food security, SDG (14), Conserve Oceans, Sustainable Development, Egypt, Global Food Security Index (GFSI), Sustainable Fisheries Indicators, Fish production.

1. Introduction

The incidences of Global inflation, Coronavirus disease (COVID-19), Russian-Ukraine War, Palestinian-Israeli War (Boycotting), and Climate Change have contributed to exacerbating food insecurity crisis globally. However, the number of undernourished people reached about 735 million people between 2021 and 2023, which indicates a global hunger crisis (Morgan et al., 2022).

According to Food and Agriculture Organization (FAO), by 2050, World population will reach 9.1 billion which necessities a rise in food production by 70% to feed them.

Moreover, by viewing the local Egyptian situation presented mainly in rising food inflation, low earnings, high unemployment rates, and high poverty rates have contributed to exacerbating the food insecurity in Egypt (Ramadan, 2015; UN SDG website). Whilst, according to World Food Programme (WFP) in 2024, 14.4% of the population are food insecure in Egypt and 29.7% live beneath the income poverty line. From here, searching for means to guarantee sustainable food is a must.

For this, food security acceleration is vital, whereby the achievement of food security has various means, among them could be through enhancing the need for sustainable fisheries. Thus, sustainable fisheries could contribute to narrowing the nutritional gap of protein, guaranteeing trusted healthy source of food and heading to conserve and sustainably use the ocean's, sea and marine resources for sustainable development. Hence, it serves in supporting the achievement of food security.

The key to this acceleration is through understanding and effectively managing the blue economy. Developing a framework for blue economy is highly prioritized by international agencies such as United Nations Development Programme (UNDP), World Bank (WB), United Nations Environment Programme (UNEP), Worldwide Fund for Nature and Asian Development Bank (ADB) (Peter J. Morgan et al., 2022). In addition to benefiting from experiences of governments who have designed a roadmap to sustainable fisheries by stressing on enhancing the role of blue economy to serve at the end in achieving food security in Egypt.

By spotting light on East Asia and the Pacific, it was found out that they provide a model for depending on oceans as a mean for providing food security (Morgan et al., 2022) through designing framework by their governments to get benefit from the blue economy and guarantee means of sustainable fisheries which is reflected positively on food security.

Concerning the Egyptian situation, since 2016, Egypt has launched the National Sustainable Development Strategy (Egypt vision 2030) in line with United Nations Sustainable Development Goals (UN SDGs). Additionally, at the mentioned date, it has addressed “blue economy” as a catalyst to enhance the achievement of SDGs (Sarhan, 2021; UN Statistical Division, 2024), whereby multiple opportunities are existing in Egypt as Coastlines on the Red Sea and the Mediterranean Sea (Sarhan, 2021). Hence, Egypt has incentives and drivers through enabling sustainable blue economy and could be well placed to reap it’s benefits through adoption of sustainable use of fisheries.

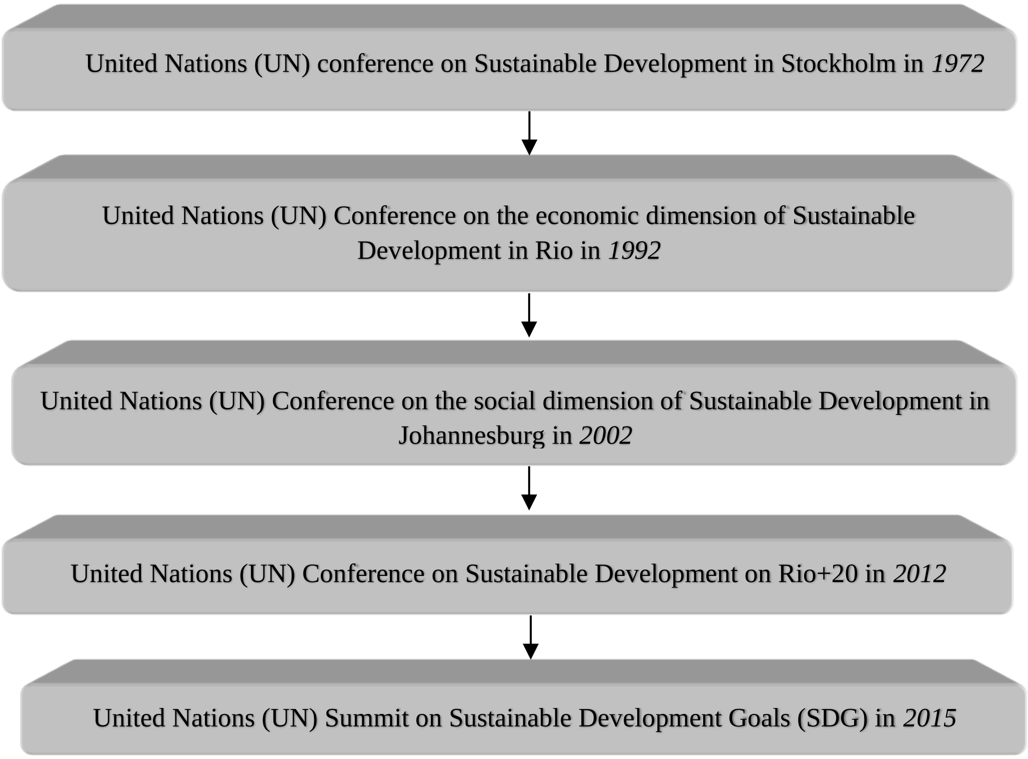
Therefore, this paper will start by presenting literature review on blue economy, sustainable fisheries and food security in accordance with referring to previous studies that have dealt with them. Then proceeding to presenting experiences of some Asian countries (Indonesia, India and China). Then, using inferral statistical methods through adopting an econometric model with its appropriate statistical tests to measure the role of Egyptian sustainable fisheries under the lens of blue economy in supporting the achievement of food security. Finally, providing a portfolio of solutions to be applied and adapted in Egypt through presenting an action plan.

2. Literature Review

2.1 Blue Economy

The idea of the blue economy was clarified in several conferences forasmuch each one of them represents a milestone in the concept of blue economy which will be clarified in the following figure:

Figure (1)
Emergence of blue economy concept



Source: Figure made by the researcher from (Mussa et al., 2021; Morgan et al., 2022)

From the above figure, it can be concluded that the emergence of the concept started in UN conference in 1972 through elaborating sustainable development concept, then UN conference in 1992 by focusing on the economic dimension, followed by UN conference in 2002 by focusing on the social dimension (Mumtaz and Smith, 2022). Then, a turning point appeared in UN Conference on SD on Rio+20 in 2012, where the blue economy was introduced clearly as a development paradigm (Mussa et al., 2021) followed by UN SD summit in 2015, whereby the concept of blue economy was explicitly addressed in SDGs in SDG (14): “Life Below Water” which calls for a healthy and sustainable manner of using marine resources (Morgan et al., 2022).

Since that blue economy has become an obvious interest for various institutions, governments, and researchers. For this, they have tried to clarify blue economy by offering multiple definitions. Here are some of these well-known definitions:

- According to the World Bank (2017), the blue economy "involves the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health"
- According to the UN, it specifies the blue economy as "a range of economic activities related to oceans, seas and coastal areas, and whether these activities are sustainable and socially equitable" (United Nations, 2024).

To the best of the author knowledge, no study has specified certain characteristics for the blue economy, here is an attempt to set general characteristics.

Blue economy can be characterized by sustainability, inclusiveness, lower emissions and inclusive governance.

Here is a simple clarification for each characteristic:

- Sustainability: blue economy aims to ensure the idea of sustainability through its three dimensions.[1]
- Lower emissions: blue economy seeks to reduce carbon footprints through several aspects as enhancing marine biodiversity (Mitra et al., 2021). Also, in 2022 the Intergovernmental Panel on Climate Change (IPCC) released a report that indicated that one-third of carbon dioxide was absorbed by oceans (Morgan et al., 2022).
- Inclusive governance: blue economy aims to adopt an accepted inclusive agreed path towards SDG (14) through inclusive governance principles (Morgan et al., 2022).

There are various sectors that can be helpful and supporting in implementing the blue economy represented mainly in fisheries, sea transportation, maritime industry, salt industry, deep sea water, maritime energy, seabed mineral, shipload of shipwreck and marine tourism (Mahardianingtyas et al., 2017).

[1] Three dimensions are: economic sustainability, environmental sustainability and social sustainability.

Wherefore, it appears that blue economy has the potential for enhancing sustainable development for societies, encouraging productive nations, promoting sustainable socioeconomic management of capture fisheries and aquaculture and ensuring future human security for different nations (Morgan et al., 2022, Mitra et al., 2021 and Mumtaz and Zachary Smith, 2022).

However, various challenges undermining the blue economy presented mainly in inadequate management tools, inefficient governance institutions, impacts of climate change and inadequate economic incentives (World Bank Group, 2016).

The blue economy has become increasingly common in public discourse whereby some studies started by presenting literature review on it as Marwan Youssef (2023) study elaborated literature review on blue economy through presenting its's origins, dimensions and impact on the global economy. Godfrey (2016) study drew an approach aiming at analyzing, managing and applying blue economy. Goddard (2015) study discussed blue economy and has indicated that blue economy refers to sustainable ocean economy countries aims at balancing ocean systems' capacity and resilience to explore marine resources. Rosa Maria, Juan Milan and Jaime De Pablo (2021) study presented challenges of the blue economy and concluded that governments are interested in enhancing blue economy as a mean for the development. Finally, several studies have discussed the transition towards blue economy (Sarhan, 2021, Aanesen et al., 2023, Can and Dartanto, 2023, Chaymm et al., 2022)

After elaborating the concept, definition, features, characteristics, sectors and previous studies of the blue economy. Now it's the turn to spotlight on the role of the blue economy in supporting the implementation of sustainable fisheries and SDG (14) (Sarhan, 2021) and enhancing the achievement of food security at the end.

2.2 Sustainable Fisheries & Food Security

Blue economy concept was reflected in the 2030 Agenda and in specific in SDG (14) which calls for a healthy and sustainable manner of using marine resources which maintains the ecosystem while enabling economic development (Morgan et al., 2022).

According to the World Bank, blue economy involves on one hand sustainable use of ocean resources as means of employment, economic development and generally better livelihoods and on the other hand maintaining the conservation of the ocean environment (Mussa et al., 2021). For this, sustainable fisheries are a dominant key concern in the path of transforming to blue economy. Eventually, addressing sustainable fisheries serves in supporting food security.

2.2.1 Sustainable Fisheries

Sustainability concept was mentioned generally in the World Commission on Sustainable Development Report and then sustainable use and conservation of marine living resources of the high seas objectives were mentioned in Agenda 21, article 17.46 which states that:

"States commit themselves to the conservation and sustainable use of marine living resources on the high seas" (Doring, 2001).

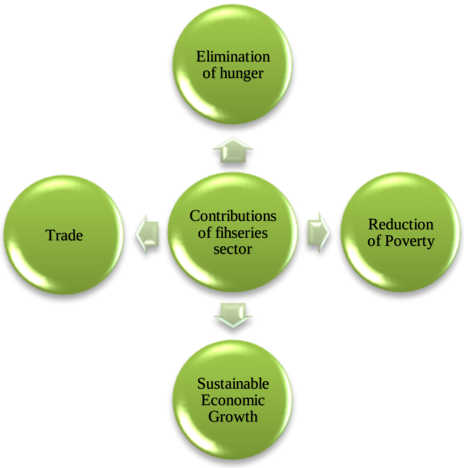
And since those discussions about sustainable fisheries increased, multiple definitions were offered, for instance:

- According to the Canadian Department of Fish and Oceans, Sustainable fisheries can be defined as: "the stewardship of the fisheries resources so as to provide economic and social benefits for the present while conserving the renewable resource base for future generations" (Sarhan, 2021)
- According to FAO (1988), Sustainable fisheries can be defined as: "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations".

Among the important sectors of the blue economy is fisheries sector (Sarhan, 2021). According to World Bank Group (2016), fisheries industry and aquaculture industry are among the main drivers of growth for food security (World Bank Group, 2016).

The following figure indicates reflections of significant contributions for fisheries sector on the economy:

Figure (2)
Significant contributions for fisheries sector on the economy



Source: figure made by the author from multiple sources (World Bank Group, April 2016, World Bank Group, April 2016)

It can be extracted from the above figure that contributions of fisheries sector can appear in trade as seafood is among the most highly valued internationally traded food commodity (World Bank Group, 2016), sustainable economic growth as fisheries represent significant part of gross domestic product for developing coastal nations, elimination of hunger as fisheries represented a reliable source for fulfilling food gap and reduction of poverty as fisheries represents a source of income for fishermen.

Management of Sustainable Fisheries was introduced through Maximum Sustainable Yield (MSY) in 1954 and then was replaced by precautionary principle (Doring, 2001). Additionally, false paradigm for sustainable fisheries was introduced in “The Tragedy of the commons” article from the principle that overuse of fish stock will appear if individual property rights were not well-defined (Doring, 2001). However, management of fisheries will remain to be difficult, and this could be attributed to uncertainty whereby no one can predict accurately about the expected amount that should be produced and even have definite information about the availability of the key ingredient (Doring, 2001).

According to FAO (2016), Fisheries and other coastal, marine resources industries represented 5% of the global gross domestic product (Morgan et al., 2022). Moreover, the role played by the private sector is a narrow one whereby formal private sector capital committed only $42 million globally during the period 2005 till 2015 to support sustainable fisheries and aquaculture projects between 2004 and 2015 (IIED 2020 and Morgan et al., 2022) however estimates indicated that for every $1 spent on sustainable ocean food production, benefits can be yield up to $10 (USAID, 2020)

On the other hand, continued overfishing will impact food security at the current situation and the livelihoods of vulnerable people in the future (Morgan et al., 2022). Additionally, habitat destruction, pollution, over-exploited marine and freshwater stocks, natural trepidation, human-induced environmental disturbances and introduced species lead to decline in fishery production (Haweet and Karjalainen et al., 2005). According to World Bank (2020), the percentage of fish stocks within biologically sustainable levels have declined from 90% in 1974 to reach 65.8% in 2017.

For this, stimulating sustainable fisheries management practices have got major attention globally which appeared in a set of internationally agreed commitments on the conservation and sustainable use of fisheries as UN Convention on the Law of the Sea in 1982 which came into force in 1994, then in 1995 FAO conducted voluntary Code of Conduct for Responsible Fisheries (Garica, 1996) then Sustainable fisheries were explicitly declared in Rio+20, UN conference on SIDS and UN GA (Morgan et al., 2022). Then, the United Nations set goal (14) of the Sustainable Development Goals (SDGs) in 2016 that aims to: "Conserve and Sustainably use the oceans, seas and marine resources for sustainable development".

A study by Doring (2001) described concepts for sustainable fisheries, various models for explaining sustainable fisheries idea and arguments around sustainable fisheries. Another study by Karjalainen and Marjomaki (2005) presented an overview of fisheries management systems and offered steps that assist towards shifting to sustainable fisheries through adjusting the main objective from Maximum Sustainable Yield to Optimal Sustainable Yield and from false determinism to accepting uncertainty and managing risk and at the end it called for new, holistic risk-averse approaches.

To sum up, sustainable fisheries are aiming to sustain fish stocks and harvests and to produce healthy ecosystems and human systems through seeking to return to a healthy nation (Doring, 2001).

2.2.2 Food Security

To comprehend food security, return to its definitions whereby various international institutions and authors offer multiple definitions, among these prominent definitions:

- According to FAO (1983), Food security was defined as "Ensuring that all people at all times have both physical and economic access to the basic food that they need".
- According to World Summit (1996), Food security was defined as "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".

By 2050, there will be around 9 billion people suffering from food insecurity (Ramadan, 2015). And since that, food insecurity is becoming a global challenge, then searching for means to guarantee sustainable food is a must. For this, food security is a global concern for all levels for International Institutions, Governments and human beings (Abd El Tawab, 2021).

Concerning measurement of food security, several indicators were suggested by multiple institutions, the most popular index is "the Global Food Security Index" which was constructed by the Economist impact and enhanced by Corteva Agriscience whereby it is a composite dynamic indicator that presents quantitative and qualitative scoring model that concentrates on determinants of food security (Thomas et al., 2017) and aims at measuring drivers of food security (United Nations Convention to Combat Desertification website).

The Global Food Security Index is used mainly in assessing the state of food security and it consists of four dimensions which are food affordability, availability, quality, and safety, alongside sustainability and adaptation (Mohyee Eldin et al., 2023).

Each dimension seeks to measure specific area in food security whereby:

- "Affordability" is a key component of food security that targets subsistence and well-being for all, in order to fulfil this target, it aims at ensuring safe and nutritious food at affordable price for all (The Economic Impact, 2022).
- "Availability" is measuring the consistent presence of a safe, diverse and nutritionally food sources that is vital for meeting the dietary needs of individuals and communities (Mohyee Eldin et al., 2023).
- "Quality and Safety" is targeting nutritional quality food through measuring the nutritional quality and characteristics offered from food consumed by individuals in terms of minerals, vitamins and nutrients (Mohyee Eldin et al., 2023).
- "Sustainability and adaptation" are aiming at meetings food security needs for current generation with reassuring their presence and availability for future generations to protect natural resources, ecosystems and the environment as a whole (Mohyee Eldin et al., 2023).

Diverse studies have dealt with food security whereby some studies have discussed the concept of food security in early periods as Rotter and Keulen study (1970) whereby it agreed upon the idea that the end target of food security is to reach to a healthy and well-nourished population. Another study as Wnepeng and Berry study (2018) which started by presenting the definition of food security followed by the evolution of the concept, identifying its four dimensions then understanding food security from pillars to paths, integrating food security explicitly in the sustainable agenda, suggesting indicators for measuring food security and then ending up with methods of monitoring food security. In addition to multiple studies that were also concerned with concept, evolution, definition, drivers, dimensions and levels of food security (Napoli, 2010, Saikia and Dutta, 2018 and Gallegos et al., 2023)

Other studies aimed at studying food security situations in specific countries and offered multiple methods in measuring food security as Houcine Jeder, Sabrine Hattab and Iheb Frija (2020) study that performed an econometric analysis for food security using Vector Error Correction Model approach (VECD) and studied the influence of certain variables on food security in Tunisia and resulted that all variables are significant in the long-run while inflation, food imports and land water cereals are significant in the short-run and other variables as climate change and population are insignificant to explain Tunisia's food security. Another study presented by Rafael Perez-Escamilla (2024) summed up that there are various methods used in assessing Food Insecurity (FI). Therefore, various studies have offered diversified methods in measuring food security and the relation between food security and other factors (Applanaidu et al., 2014, Dieterwang et al., 2020, Antamoshkina and Rogachev, 2020 and Mohyee Eldin et al., 2023)

2.3 Linking Sustainable Fisheries to Food Security through the transition to Blue Economy:

One of the most nutritious, efficient, high-quality food is fisheries (HLPE, 2014). Management of sustainable fisheries encourages nutrition and food security (HLPE, 2014).

Opportunities for benefiting from fisheries that were presented in increased farmed fish production, development of aquaculture, lower carbon footprint per kilogram of aquatic production, promotion of fish stock, health benefits, improvements in capture fisheries management make crucial contributions to food security globally, nationally and locally (HLPE, 2024, European Commission, 2020, Nicholas Institute, Duke University, 2018).

In addition, recognition of small-scale fisheries is vital to nutrition and food security (European Commission, 2020).

A global survey was performed in 2020 and published in Asian Development Bank Institute concerning institutional investors concluded that 90% of them have assured that they consider applying blue economy projects is participating in the achievement of Sustainable fisheries and SDG (14) (Peter J. Morgan et al., 2022).

Despite that the fisheries sector has assured that governments need to move towards enhancing sustainable practices through a diverse range of sectoral reforms (Morgan et al., 2022) and that will be reflected on providing a source of nutritious and sustainable food for life (Salet et al., 2023)

But lack of attention has contributed in widening the disconnection between sustainable fisheries and food security and ignoring the vital role that can be played by the future ocean as a source of food supply and at the end its contribution in global food security (Saleh et al., 2023)

For this; few studies have discussed the intersection of sustainable fisheries, food security and blue economy among them Mohd Azim Sardan et al. (2023) study that has contributed for deeper understanding for the sophisticated interaction between blue economy and food security through shading light on the diversified challenges that hinder the achievement of sustainable growth and has offered new paths in literature of sustainable development. Another study by Shahzad Ali Gill and Jawad Iqbal (2021) aimed at exploring the role of blue economy in sustainable development by applying on Pakistan.

Other studies linked fisheries with food security without referring to blue economy as Yaseen E. Abd El Tawab (2021) study addressed food security of fish from an economic dimension resulted that an increase in investment in agricultural production and in real per capita income could result in an increase in the fish factor food security (Hendriks, 2014, Hapsari et al., 2024).

Also, some studies linked blue economy with sustainable fisheries without referring to its impact on food security as Sapriani et al. (2024) study that proposed a comprehensive vision blue economy that contributes in managing fisheries resources (Ababouch, 2015, Indrajaya, 2022).

In short, transition to blue economy through sustainable use of fisheries is a healthier roadmap towards the achievement of food security and linking them together contributes to enhancing and supporting the achievement of UN SDGs agenda.

3. Methodology

To fulfil the aim of this paper, firstly the paper presents a comparative analysis of some experiences of East Asian countries (Indonesia, India and China) whom their governments designed a framework that enhance benefitting from opportunities of the blue economy and guarantying means of sustainable fisheries which eventually have supported food security in their countries in comparison with the Egyptian situation. Secondly, the paper presents an applied analysis for Egypt through addressing and evaluating the contribution of sustainable fisheries in supporting food security.

Concerning the comparative analysis, it is important to indicate that every and each country is using its own structure, appropriate mechanisms, and unique techniques, so the paper offers a comparative framework among the three East Asian countries and comparing them with the Egyptian situation through presenting sustainable fisheries indicators (whereby data sources for the indicators were depending on UN Statistics Division Website, FAO Website, World Bank Database) in supporting the achievement of food security (whereby data sources were depending on Economist Intelligence Unit) and it is important to indicate to the fact that there will be some missing information. And after presenting the related indicators the paper upgrade to indicate to governmental efforts adapted by each one of the three comparative countries and compare them with the Egyptian situation.

Concerning the applied analysis, it is essential to mention that due to the limited availability of data for the study variables-whereby according to UNEP (2024) almost 68% of SDGs are unavailable indicators. Also, according to our UN Statistics Division, almost 50 % of SDG (14) indicators started in 2016 in addition to some missing indicators. Hence, according to the availability of data for study variables, collection of data included a reduced time series that consists of 11 years that starts from 2012 till 2022 on annual basis forming 11 observations for an applied study on Egypt. The reason for starting from 2012 is that the first issue for the Global Food Security Index (GFSI) was in 2012.

4. Analysis of sustainable fisheries in supporting food security through enabling blue economy:

4.1 Comparative analysis of Indonesia, India and China compared to that of Egypt:

By spotting light on East Asia, it was found out that they deployed a framework for getting benefits and invested in opportunities that supports using oceans as a mean for providing food security (Morgan et al., 2022) through designing frameworks by their governments to benefitting from the blue economy and guarantying means of sustainable fisheries which are supported the achievement of food security.

Selection of Asian Countries was due to their dependence on healthy oceans as means for food security, livelihoods and health (Morgan et al., 2022). These countries are Indonesia, India and China. In addition to comparing them with Egypt in order to determine the Egyptian situation concerning sustainable fisheries and enhance the transition to the blue economy through getting benefits for the experiences of these countries.

Therefore, firstly presenting sustainable fisheries indicators for Indonesia, India, China and Egypt.

Table (1)
Sustainable Fisheries Indicators for Indonesia, India, China and Egypt

	Indonesia	India	China	Egypt
Rank in fisheries production	2nd	3rd	1st	6th globally in fish farming.
Total Fisheries Production (metric tons) (2022)	22,032,425	15,774,325	88,567,716	1,992,627
Aquaculture Production (metric tons) (2022)	14,633,869	10,235,300	75,388639	1,552,430
Share of Aquatic foods consumption as a percentage of animal proteins (2021)	49.6%	15.1%	49.6%	26.9%
Share of fish proteins over animal proteins (2019)	49.6%	15.1%	20.9%	26.9%
Share of fish proteins over total proteins (2019)	19.8%	3.6%	19.8%	8.1%
Indicator (14.1.1) in SDG (14) Chlorophyll-a deviations, remote sensing (%)	1.10832	5.69669	2.58786	0.35452

Source: UN Statistics Division website, World Bank Database website, FAO website, "Fishery and Aquaculture Statistics – Yearbook 2021"

It is apparent from the above table that according to Sustainable Fisheries indicators of the three comparative countries (Indonesia, India and China) that they are among the top drivers in fisheries sector, and that this sector has succeeded in accomplishing obvious progress compared to Egypt that is still at the earlier stages of adopting sustainable fisheries.

The success of the above comparative countries could be attributed mainly to the efforts exerted by these countries' governments through adopting and enabling blue economy in a form of lens of institutional and financial mechanisms and a specific established framework.

Hence, the following table presents comparative framework for governmental efforts among the four comparative countries compared to Egypt:

Table (2)
Comparative framework for governmental efforts among Indonesia, India, China and Egypt

Indonesia	India	China	Egypt
	Similarities		
- **Fisheries sector is governed by central ministry.** - **Financing blue economy is through budgetary allocations.** - **Partnerships with NGOs and international agencies.**			**Fisheries sector is governed by central ministry.**
	Differences		
	Strategic Plan		
- The state did not develop a specific well-designed plan for the fisheries sector.	**The state developed a roadmap for fisheries and aquaculture sector.**	**- The state is continuously updating a specific plan for reducing the capacity in Chinese water through developing rapid distant-water fisheries.**	**- The state is planning for sustainable use of coastal resources.**
	Integration of sustainability considerations		
	➢ **At the central level**		

Ministry of Marine Affairs overseas the fisheries sector. - Planning agency (BAPPENAS)	Ministry of Fisheries, Animal Husbandry and Dairying oversees the fisheries sector. - National Fisheries Development Board was issued for developing fisheries sector.	Ministry of Agriculture and Rural Affairs and Bureau of Fisheries. - Bureau of Fishing Vessel Inspection is aiming at exercising the function of supervising and inspecting fishing vessel.	Ministry of agriculture and land reclamation. - The National Institute of Oceanography and Fisheries (NIOF) is responsible for fisheries management and development.
➢ At the local level			
- MacAruthur Foundation and Rare were established for the purpose of managing at the community level.	- Central Marine Fisheries Research Institute is considered as a leader tropical marine research institute.	- China Academy of Fisheries Science seeks at controlling the Fisheries Research Institutes of the three regional management authorities. - Every region has its own specific fisheries research institution.	- The General Authority for Fish Resources Development is in Cairo and is the governmental authority responsible for fisheries management and data collection.
Financing mechanisms framework			
- Marine and Fisheries Financing Institution was issued for the purpose of promoting sustainability and accessing finance to enable private sector fund flows.	- Global Fisheries Sustainability Fund was issued for the purpose of putting up a sustainable management plan for bait fisheries. - Fisheries and Aquaculture	- Preferential treatment is provided in China through funding allocations and tax policies for the purpose of developing distant water fisheries.	- The Central Department for Commercial, Administrative and Financial Affairs is responsible for implementing financing policies and preparing the annual budget.

	Infrastructure Development Fund was issued for the purpose of infrastructure development and the provision of viability gap funding for setting up processing plants.		- USAID is contributing funds for fish development.
	Fiscal policy tools and instruments		
- Open to innovative instruments (as blue bonds) - Part of nationally determined commitments. - Budgetary support.	- Creation of a sector-specific fund. - Budgetary support, traditional taxes, and levies.	- There is availability for fiscal support related to fisheries.	- GAFRD budget is the main source of finance.
	Private sector		
- Attracting cash flows from private sector. - Increasing interest from international fisheries investors and funds.	- Primarily domestic operators. - Limited interest in international funds.	- Primarily domestic operators. - Limited interest of international funds.	- Capacity development is a main concern for the public sector.
	Partnerships		
- RARE, other private sector agencies and international agencies work with the local administration and communities	- In 2023, Sustainable Fisheries Partnership announced a new landscape-based	- There are almost 17 fishing agreements between China and African States. - Access agreements of Chinese fishing	- Egypt has implemented almost 60 cooperatives accounts for almost 85% of the total fish production.

for the purpose of promoting sustainable activities in the sector.	**aquaculture initiative.**	**vessels are undocumented. - Fisheries agreements are characterized by lack of transparency.**	
Future approach			
- There is a request for financing institutions which are specialized for a marine and fisheries.	**- Separate Ministry: Formulation of a separated ministry. - Financing scheme: announcing a sector-specific fund and a financing scheme.**	**- Seeking for self-sufficiency in fisheries.**	**- Seeking responsible management to ensure Sustainable fisheries. - Fostering growth for aquaculture sector. - Eliminating illegal practices**

Source: Data collected from various sources: (Morgan et al., 2022, European Parliament, 2012, Hongzhou, 2015, Abdel-Hady, 2024, Mehanna, 2022, Indian Council of Agricultural Research website, 2024)

The above table have presented a comprehensive overview for the three countries governmental efforts under the lens of enabling blue economy comparing to Egypt. There are three similarities among Indonesia, India and China and only one similarity with Egypt. It can be extracted that although the three countries (Indonesia, India and China) have a long tradition in fishing and that they were relying on inter-ministerial coordination setups, however each country is adopting its own strategy that addresses its circumstances, strategic plan, integration of sustainability considerations, institutional mechanisms framework, financing mechanisms framework, fiscal policy tools and instruments, private sector, partnership and future approach. These in turn resulted in specific institutional structures, financing mechanisms and collaborations suitable for each country.

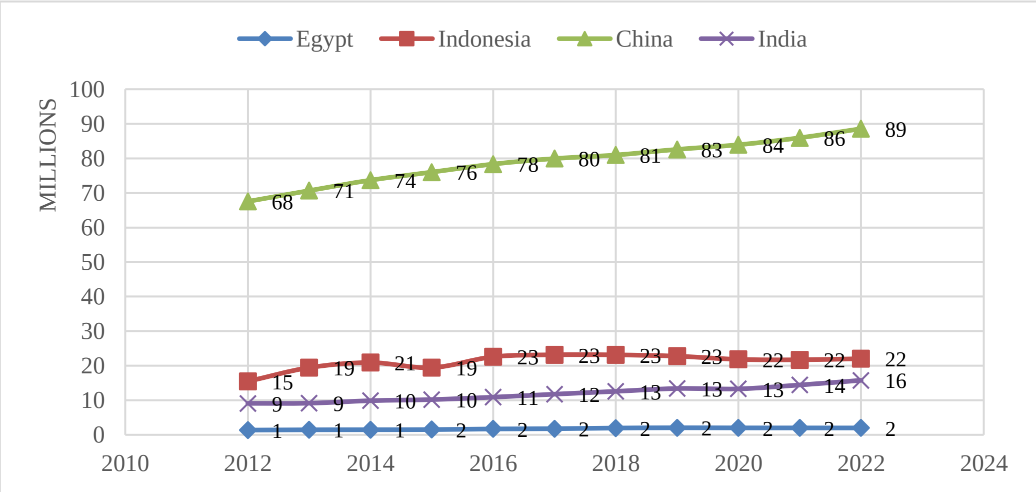
Hence, the framework devoted for each country in table (2) participated in enabling blue economy and addressing sustainable fisheries presented in table (1).

Despite the above mentioned concerning the efforts exerted in the four countries, still there are remaining challenges mainly represented in inadequate data management systems, access to finance, and suboptimal adoption of sustainable fishing processes (Morgan et al., 2022).

By focusing on Egypt, it is apparent that the Egyptian Government is moving in steps towards adopting sustainable development and applying institutional and fiscal mechanisms to enable blue economy as apparent in table (2) whereby it is reflected on sustainable fisheries indicators in table (1).

Going in depth, through analyzing total fisheries production (metric tons) as one of the fundamental indicators in sustainable fisheries (which is added in following section as independent variable in the econometric model) during the period from 2012 to 2022 among the comparison countries: Indonesia, India, China and Egypt:

Figure (4)
Total Fisheries Production (metric tons) during the period (2012-2022) among comparison countries

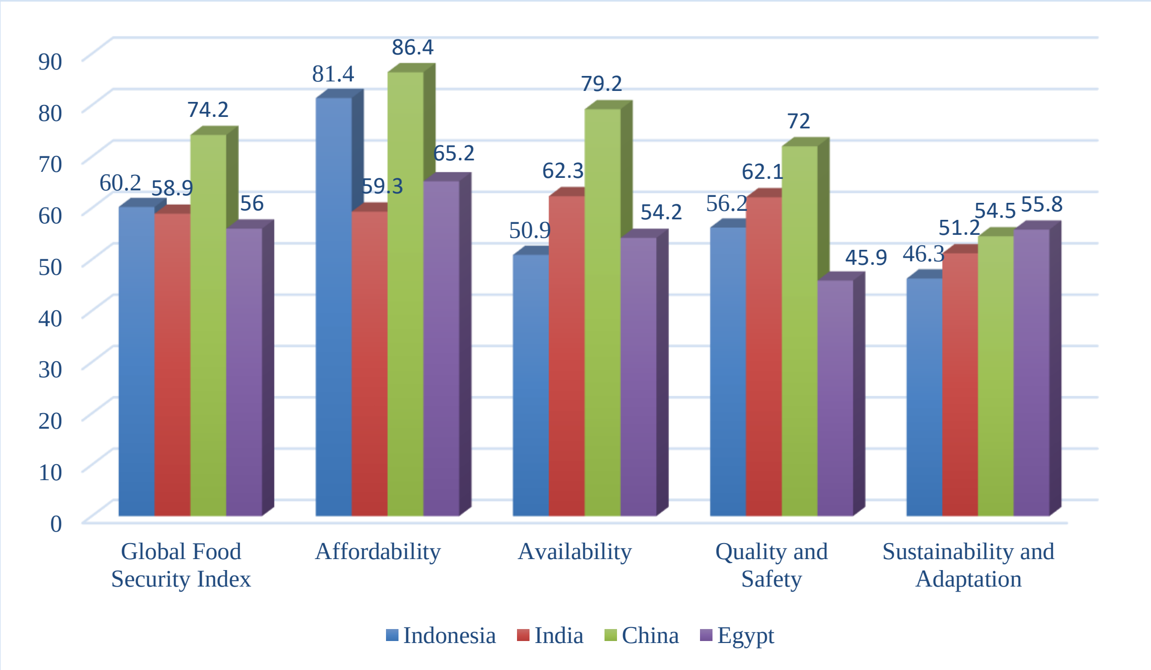


Source: World Bank database website, access link: https://data.worldbank.org/indicator/ER.FSH.AQUA.MT, access date: 21 October 2024

It can be extracted from the above figure that China is the largest producer of total fisheries among the comparative countries and is also the 1st one globally, while Egypt and comes at the end of the comparative countries and Indonesia in the 2nd place followed by India are in the middle.

Moreover, accomplishments achieved in sustainable fisheries under the lens of enabling blue economy for each one of the three countries in comparison with Egypt through adopting a framework that relies on inter-ministerial coordination setups participated in supporting food security which will be presented in the following figure:

Figure (5)
Global Food Security Index among comparison countries in 2022



Source: The Economist Newspaper Website, access link: https://impact.economist.com/sustainability/project/food-security-index/explore-countries, access date: 24 October 2024

From the above figure, it is obvious that Sustainable fisheries have participated in GFSI Score, whereby with respect to Global Food Security Index, and according to 2022 statistics that China is the highest performer -with regard to the comparative countries-as it is seeking to achieve self-sufficiency in fishery products to contribute in its food security (Hongzhou, 2015) while Egypt is the lowest performer leaving Indonesia and India in the middle. This is applied also at the three other scores which are Affordability, Availability and Quality and Safety.

While with respect to Sustainability and Adaptation, the situation is debatable as Egypt was the highest performer and this could be attributed to adopting sustainability plan presented in Egypt Vision 2030, while China came in the second place which is attributed to overexploitation of fisheries, high pressures on marine ecosystems that resulted in the loss of almost half coastal wetlands. Followed by India and then Indonesia.

4.2 Applied Analysis of sustainable fisheries in supporting food security through enabling blue economy in Egypt:

This section will examine the role of Sustainable Fisheries under the lens of blue economy in supporting Food Security in Egypt. The following table presents variables that are used in the study during the period 2012-2022:

Table (3)
Variables used in the study

Variables Nature	Variables	Symbol	Data Source
Independent Variables	Global production by production source Quantity (Fisheries and Aquaculture) (Tonnes Live Weight)	**X_1**	**FAO**
	Chlorophyll-a deviations, remote sensing (%)	**X_2**	**UN Statistics Division Database**
	Capture fisheries production (Metric Tons)	**X_3**	**World Bank Database**
	Total Fisheries Production (Metric Tons)	**X_4**	**World Bank Database**
	Aquaculture Production (Metric Tons)	**X_5**	**World Bank Database**
	Local Production of Fish (Thousand Tons)	**X_6**	**CAPMAS**
Dependent Variable	Global Food Security Index	**Y_1**	**Economist Intelligence Unit**
	Affordability	**Y_2**	
	Availability	**Y_3**	
	Quality and Safety	**Y_4**	
	Sustainability and Adaptation	**Y_5**	

Source: table formulated by the researcher

Selection of data related to independent variables depended on previous studies mentioned in the literature review, working papers mentioned in the references and UN Statistics Division website agreed upon indicators in SDG (14) whereby these indicators are representing sustainable fisheries indicators. On the other hand, selection of data related to dependent variables were aiming at selecting an index that assess the state of food security, for this, GFSI was selected with its four dimensions as dependent variables.

For fulfilling the purpose of this paper, the above variables were used in the form of reduced time-series analysis using Multiple Linear Heteroskedasticity Regression model. Here are the statistical techniques and tests that were employed:

1. ***Descriptive analysis:*** the study variables (mentioned in the above table) were used to determine the measures of central tendency presented in the arithmetic mean, minimum value and maximum value, also measures of dispersion were employed to determine the percentage of variability each variable.

2. ***Test of Normality***: the study applied Shapiro-Wilk test to determine whether the variables of study (dependent and independent ones) follow the normal distribution or not.
3. ***Correlation Matrix:*** the study used correlation matrix to determine the relation between the variables in form of relation strength and direction between each two variables.
4. ***Multiple linear Heteroskedasticity Regression model:*** the reduced time-series regression model used to determine the impact of the independent variables on each dependent variable.

4.2.1 Descriptive Statistics and test of Normality:

The study variables were analyzed to determine the measures of central tendency and measures of dispersion. The percentage of variability in each variable was determined through standard deviation and coefficient of variation. Additionally, the Shapiro-Wilk test was applied to determine whether the main variables of study follow the normal distribution or not, Shapiro-Wilk test is a Chi-squared test of normality which its null hypothesis states that variables are not normally distributed if the test *p-value* is less than or equal 0.05.

Table (4)
Variables descriptive analysis

Variable	n	Min.	Max.	Mean	Standard Deviation	Coefficient of Variation	Normality test	
							Statistic	*P-value*
Y_1	11	50.90	56.90	54.75	1.63	0.03	0.893	0.153
Y_2	11	51.40	66.00	61.19	4.84	0.08	0.860	0.057
Y_3	11	48.70	61.50	54.95	3.27	0.06	0.854	0.048
Y_4	11	45.90	59.00	54.95	4.41	0.08	0.852	0.046
Y_5	11	40.60	55.80	45.75	4.59	0.10	0.848	0.040
X_1	11	4.90e-07	7.20e-07	5.80e-07	0.90e-07	0.16	0.854	0.049
X_2	11	0.22	1.63	0.70	0.47	0.67	0.871	0.079
X_3	11	12.72	12.99	12.84	0.09	0.01	0.912	0.260
X_4	11	14.13	14.53	14.37	0.15	0.01	0.854	0.049
X_5	11	13.83	14.31	14.12	0.18	0.01	0.868	0.074
X_6	11	7.22	7.62	7.46	0.15	0.02	0.855	0.049

Source: prepared by the researcher from E-views software output.

From the above table, it is concluded that:

- All dependent and independent variables have 11 observations which mean that there is no missing data, and all have standard deviation ranged from 0.90e-07 to 4.84 and coefficient of variation ranged from 1% to 67% which indicates a low to moderate level of dispersion of values around their weighted average mean.
- The dependent variables (Y_1 and Y_2) and all independent variables (X's) are normally distributed as their *p-value* of Chi-square statistic is greater than 0.05, so the alternative hypothesis will be accepted as variables are following the normal distribution, while the dependent variables (Y_3, Y_4, and Y_5) are not normally distributed as their *p-value* of Chi-square statistic is less than 0.05, so the null hypothesis will be accepted that variables do not follow the normal distribution.

4.2.2 Correlation Matrix:

Table (5)
Spearman correlation matrix

Variable	X_1	X_2	X_3	X_4	X_5	X_10	Y_1	Y_2	Y_3	Y_4	Y_5
X_1	1										
P-value	-										
X_2	0.309	1									
P-value	*0.356*	-									
X_3	0.786	0.683	1								
P-value	*0.004*	*0.020*	-								
X_4	0.453	0.309	0.786	1							
P-value	*0.000*	*0.356*	*0.004*	-							
X_5	0.996	0.242	0.726	0.996	1						
P-value	*0.000*	*0.473*	*0.011*	*0.000*	-						
X_10	*0.562*	*0.471*	*0.235*	*0.332*	*0.323*	1					
P-value	*0.000*	*0.001*	*0.011*	*0.000*	*0.022*	-					
Y_1	0.103	0.490	0.134	0.103	0.129	0.218	1				
P-value	*0.023*	*0.001*	*0.004*	*0.034*	*0.002*	*0.032*	-				
Y_2	0.151	0.429	0.121	0.151	0.181	0.174	0.852	1			
P-value	*0.008*	*0.188*	*0.022*	*0.008*	*0.003*	*0.001*	*0.001*	-			
Y_3	0.189	0.211	0.132	0.289	0.246	0.251	0.124	-0.386	1		
P-value	*0.003*	*0.023*	*0.934*	*0.012*	*0.034*	*0.021*	*0.716*	*0.241*	-		
Y_4	0.736	0.745	0.927	0.736	0.681	0.142	0.152	-0.170	-0.029	1	
P-value	*0.010*	*0.008*	*0.000*	*0.010*	*0.021*	*0.004*	*0.656*	*0.617*	*0.932*	-	
Y_5	0.563	0.862	0.901	0.563	0.494	0.396	0.419	0.395	-0.019	-0.928	1
P-value	*0.071*	*0.001*	*0.000*	*0.071*	*0.022*	*0.423*	*0.200*	*0.229*	*0.956*	*0.000*	-

Source: table formulated by the researcher from E-views software output

From the above Matrix, it can be concluded that:

- There is a significant, direct and weak relation between Global Food Security Index and each of (Global production by production sources Quantity, Chlorophyll-a deviations remote sensing, Capture fisheries production, Total Fisheries Production, Aquaculture Production, and Local Production of

Fish) with correlation coefficients ranges from 0.103 to 0.490 and *P-value*s less than 0.05.

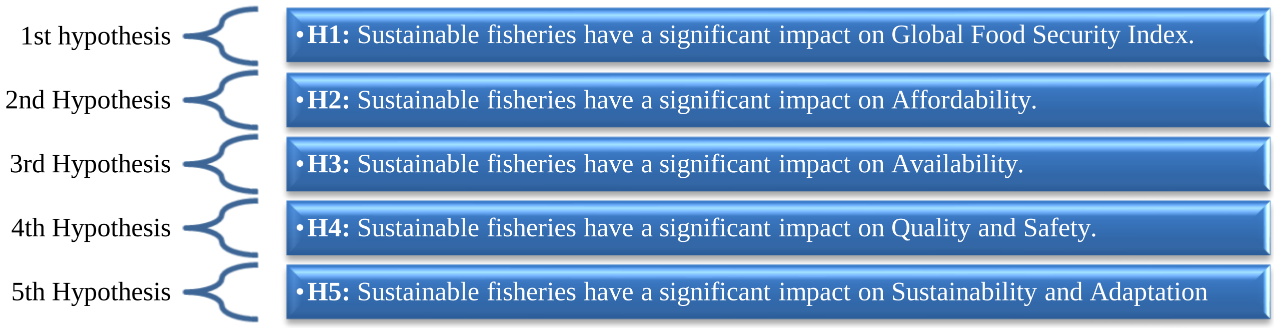
- There is a significant, direct and weak relation between Affordability and each of (Global production by production source Quantity, Chlorophyll-a deviations remote sensing, Capture fisheries production, Total Fisheries Production, Aquaculture Production, and Local Production of Fish) with correlation coefficients ranges from 0.121 to 0.181 and *P-value*s less than 0.05, while there is an insignificant, direct and weak relation between Affordability and Chlorophyll-a deviations.
- There is a significant, direct and weak relation between Availability and each of (Global production by production sources Quantity, Chlorophyll-a deviations remote sensing, Capture fisheries production, Total Fisheries Production, Aquaculture Production, and Local Production of Fish) with correlation coefficients ranges from 0.189 to 0.289 and *P-value*s less than 0.05.
- There is a significant, direct and moderate relation between Quality and Safety and Global production by production source Quantity with correlation coefficient value of 0.736 and *P-value* 0.010.
- There is a significant, direct and weak relation between Quality and Safety and Local Production of Fish with correlation coefficient value of 0.142 and *P-value* 0.004.
- There is a significant, direct and strong relation between Sustainability and Adaptation and Global production by production source Quantity with correlation coefficient value of 0.563 and *P-value* 0.071 at 10% significance level.
- There is a significant, direct and (moderate to strong) relation between Sustainability and Adaptation and each of (Chlorophyll-a deviations, remote sensing, Capture fisheries production, Total Fisheries Production, and Aquaculture Production) with correlation coefficients ranges from 0.494 to 0.901 and *P-value*s less than 0.05.
- There is an insignificant, direct and weak relation between Sustainability and Local Production of Fish with correlation coefficient value of 0.396 and *P-value* 0.423.

4.2.3 Testing the Applied Study Hypotheses:

An Heteroskedasticity correction regression model will be applied depending on reduced time series data which consists of 11 observations from year 2012 till 2022 to test the five hypotheses.

The following figure elaborates the contents of the variables of each equation for each hypothesis:

Figure (6)
Contents of each equation for each hypothesis



Source: prepared by the researcher

4.2.3.1 *Testing the First Hypothesis*

The independent variable Total Fisheries Production dropped from the reduced regression model due to the exact collinearity with the independent variable Capture fisheries production.

Table (6)

The reduced linear regression model of the first hypothesis H_1

Model	*Heteroskedasticity correction regression model*	**Dependent variable**		Global Food Security Index	**VIF Test**
Independent variables	***Coefficient***	***t-ratio***	***p-value***	**Significance**	
Constant	1.75858	10.328	<0.0001	**Significant**	
Global production by production source Quantity	2.76861	10.896	<0.0001	**Significant**	4.219
Chlorophyll-a deviations, remote sensing	13.1551	2.923	0.0431	**Significant**	3.759
Capture fisheries production	322.442	2.802	0.0487	**Significant**	3.831
Aquaculture Production	11.8109	2.714	0.0533	**Significant at 10%**	5.529
Local Production of Fish	3.57601	5.287	<0.0001	**Significant**	4.450
F-test	9.695630	***p-value***		0.000240	
Ramsey Reset test	11.0697	***p-value***		0.0829	
Heterosckadicity test	3.044	***p-value***		0.21827	
Adjusted R-squared			80.4307%		

Source: table formulated by the researcher depending on E-views software output

From the above table, it can be concluded that:

- The overall Heteroskedasticity correction time series model is significant as the overall F-test for significance has a value of 9.695630 and *p-value* <0.0001 which is less than 0.05, with adjusted R-squared value of 80.4307% which means that the independent variables explain the change in the Global Food Security Index by 80.4307% as Egyptian fisheries are considered as a primary source of income due to their contribution in food security (Sahar Mehanna, 2022).
- Constant has significant impact on Global Food Security Index.

- Global production by production source Quantity has direct and significant impact on Global Food Security Index which could be attributed to the increase in fish production especially in Tilapia and mullet species which was reflected on narrowing the food gap (Mohamed, Walaa M., et al. 2022 and Yahya M. M. Khalil, 2020).
- Chlorophyll-a deviations remote sensing, Capture fisheries production, Aquaculture production, and Local Production of Fish have direct and significant impact on Global Food Security Index, these have appeared in the development of international trade in increasing the amount of fish exports (Mohamed, Walaa M., et al. 2022).
- There is no problem of multi-collinearity between the independent variables as the VIF test showed results less than 10 for the independent variables.
- Ramsey reset test has a *p-value* of 0.0829 which is greater than 0.05, which means that the independent variables in the models are sufficient.
- Heterosckadicity test has *p-values* of 0.21827, which means that the residuals have a constant variance on long run and the model doesn't suffer from Heterosckadicity problem.
- The overall equation for forecasting the Global Food Security Index is:

$$\widehat{Y_{1t}} = 1.75858 + 2.76861\, X_{1t} + 13.1551\, X_{2t} + 322.442\, X_{3t} + 11.8109\, X_{5t} + 3.57601\, X_{6_t}$$

Therefore, the first hypothesis will be accepted which means that Sustainable fisheries have a significant impact on Global Food Security Index.

4.2.4.2 Testing the Second Hypothesis

The independent variable Total Fisheries Production dropped from the reduced regression model due to the exact collinearity with the independent variable Capture fisheries production.

Table (7)
The reduced linear regression model of the second hypothesis H_2

Model	*Heteroskedasticity correction regression model*	**Dependent variable**		Affordability	**VIF Test**
Independent variables	***Coefficient***	***t-ratio***	***p-value***	**Significance**	
Constant	2594.46	2.662	0.0563	**Significant at 10%**	
Global production by production source Quantity	4.92008	2.654	0.0532	**Significant at 10%**	4.219
Chlorophyll-a deviations, remote sensing	3.24122	3.954	0.0143	**Significant at 10%**	3.759
Capture fisheries production	689.281	2.765	0.0506	**Significant at 10%**	3.831
Aquaculture Production	2086.30	2.214	0.0913	**Significant at 10%**	5.529
Local Production of Fish	306.227	3.846	0.0184	**Significant**	4.450
F-test	5.660657	***p-value***		0.000521	
Ramsey Reset test	0.0897599	***p-value***		0.917633	
Heterosckadicity test	3.31994	***p-value***		0.190145	
Adjusted R-squared			73.6592%		

Source: table formulated by the researcher depending on E-views software output

From the above table, it can be concluded that:

- The overall Heteroskedasticity correction time series model is significant as the overall F-test for significance has a value of 5.660657 and *p-value* 0.047621 which is less than 0.05, with adjusted R-squared value of 73.6592% which means that the independent variables explain the change in the Affordability by 73.6592%.
- Constant has significant impact on Affordability at 10% significance level.
- Global production by production source Quantity has direct and significant impact on Affordability 10% significance level this appeared in difficulty of funding for fishermen.
- Domestic Production of Fish has direct and significant impact on Affordability whereby although seafood production had been doubled but self-sufficiency ratio (SSR) has decreased due to that average price which is attributed to the currency devaluation (Kamal, January 2021)

- Chlorophyll-a deviations remote sensing, Capture fisheries production, Total Fisheries Production, and Aquaculture Production have direct and significant impact on Affordability 10% significance level appeared in environmental degradation that have impacted marine and coastal ecosystems in Egypt in addition to the poor marketing services which impact the affordability (Khalil, 2020 and Sarhan, December 2021)
- There is no problem of multi-collinearity between the independent variables as the VIF test showed results less than 10 for the independent variables.
- Ramsey reset test has a *p-value* of 0.917633 which is greater than 0.05, which means that the independent variables in the models are sufficient.
- Heterosckadicity test has *p-values* of 0.190145, which means that the residuals have a constant variance on long run and the model doesn't suffer from Heterosckadicity problem.
- The overall equation for forecasting the Affordability is:

$$\widehat{Y_{2t}} = 2594.46 + 4.92008\, X_{1t} + 3.24122\, X_{2t} + 689.281\, X_{3t} + 2086.30\, X_{5t} + 306.227\, X_{6_t}$$

Therefore, the second hypothesis will be accepted which means that Sustainable fisheries have a significant impact on Affordability.

4.2.4.3 *Testing the third Hypothesis*

The independent variable Total Fisheries Production dropped from the reduced regression model due to the exact collinearity with the independent variable Capture fisheries production.

Table (8)
The reduced linear regression model of the third hypothesis H_3

Model	*Heteroskedasticity correction regression model*	Dependent variable		Availability	VIF Test
Independent variables	*Coefficient*	*t-ratio*	*p-value*	Significance	
Constant	9475.35	4.330	0.0123	Significant	
Global production by production source Quantity	1.44661e+09	4.955	0.0077	Significant	4.219
Chlorophyll-a deviations, remote sensing	7.52604	3.913	0.0173	Significant	3.759
Capture fisheries production	1337.81	2.313	0.0818	Significant at 10%	3.831
Aquaculture Production	1604.61	2.869	0.0455	Significant	5.529
Local Production of Fish	209.551	4.435	0.0114	Significant	4.450
F-test	7.532907	*p-value*		0.035494	
Ramsey Reset test	11.9935	*p-value*		0.0769618	
Heterosckadicity test	1.10144	*p-value*		0.576534	
Adjusted R-squared			79.6737%		

Source: table formulated by the researcher depending on E-views software output

From the above table, it can be concluded that:

- The overall Heteroskedasticity correction time series model is significant as the overall F-test for significance has a value of 7.532907 and *p-value* 0.035494 which is less than 0.05, with adjusted R-squared value of 79.6737% which means that the independent variables explain the change in the Availability by 79.6737%.
- Constant has significant impact on Availability.
- Global production by production source Quantity has direct and significant impact on Availability this appeared in the growth of food production whereby it was mostly used as supply for food but generally still the production was low than its potential (Khalil, 2020 and Mehanna, 2022)

- Chlorophyll-a deviations remote sensing, Capture fisheries production, Aquaculture Production, and Local Production of Fish have direct and significant impact on Availability whereby large water bodies and increasing industrial sources supported the rapid growth in capture fisheries production and aquaculture production since 2003 and reflected on the availability of food. (Mohamed, Walaa M., et al. 2022, Khalil, 2020).
- There is no problem of multi-collinearity between the independent variables as the VIF test showed results less than 10 for the independent variables.
- Ramsey reset test has a *p-value* of 0.0769618 which is greater than 0.05, which means that the independent variables in the models are sufficient.
- Heterosckadicity test has *p-values* of 0.576534, which means that the residuals have a constant variance on long run and the model doesn't suffer from Heterosckadicity problem.
- The overall equation for forecasting the Availability is:

$$\widehat{Y_{4t}} = 9475.35 + 1.44661e + 09\, X_{1t} + 7.52604\, X_{2t} + 1337.81\, X_{3t} + 1604.61\, X_{5t} + 209.551\, X_{6_t}$$

Therefore, the third hypothesis will be accepted which means that Sustainable fisheries have a significant impact on Availability.

4.2.4.4 *Testing the Fourth Hypothesis*

The independent variable Total Fisheries Production dropped from the reduced regression model due to the exact collinearity with the independent variable Capture fisheries production.

Table (9)
The reduced linear regression model of the fourth hypothesis H_4

Model	*Heteroskedasticity correction regression model*	**Dependent variable**		Quality and Safety
Independent variables	***Coefficient***	***t-ratio***	***p-value***	**Significance**
Constant	1547.01	0.5266	0.6263	**Insignificant**
Global production by production source Quantity	6.96826e+07	0.1778	0.8675	**Insignificant**
Chlorophyll-a deviations, remote sensing	1.81557	0.7032	0.5207	**Insignificant**
Capture fisheries production	44.4749	0.2240	0.8338	**Insignificant**
Aquaculture Production	66.2685	0.08534	0.9361	**Insignificant**
Local Production of Fish	23.0195	0.03066	0.9770	**Insignificant**
F-test	0.615623	***p-value***		0.934829

Source: table formulated by the researcher depending on E-views software output

From the above table, it can be concluded that:

- The overall Heteroskedasticity correction time series model is insignificant as the overall F-test for significance has a value of 0.615623 and *p-value* 0.934829 which is greater than 0.05, which means that the independent variables don't explain the change in the Quality and Safety, whereby generally, high population growth rates of Egyptians increased demand for fish and forced Egyptians to be concerned with quantity of food and ignoring quality to large extent. And by focusing on tilapia of fish, despite of the low local prices from tilapia fish, however, importing countries concerning tilapia fish from Egypt as USA and EU were having concerns regarding food safety from tilapia , hence, most Egyptian tilapia food remain the Egyptian market (Kamal, January 2021 and Abdel-Hady et al, 2024).

Therefore, the fourth hypothesis won't be accepted which means Sustainable fisheries have an insignificant impact on Quality and Safety.

4.2.4.5 *Testing the Fifth Hypothesis*

The independent variable Total Fisheries Production dropped from the reduced regression model due to the exact collinearity with the independent variable Capture fisheries production.

Table (10)
The reduced linear regression model of the fifth hypothesis H_5

Model	*Heteroskedasticity correction regression model*	**Dependent variable**		Sustainability and Adaptation	**VIF Test**
Independent variables	***Coefficient***	***t-ratio***	***p-value***	**Significance**	
Constant	−4.69710	−0.02344	0.9821	**Insignificant**	
Global production by production source Quantity	−624.943	−1.923	0.1028	**Insignificant**	1.147
Chlorophyll-a deviations, remote sensing	3.56575	2.681	0.0365	**Significant**	2.577
Capture fisheries production	171.326	2.389	0.0491	**Significant**	4.456
Aquaculture Production	483.458	1.911	0.1046	**Insignificant**	7.563
F-test	33.28026	***p-value***		0.000310	
Ramsey Reset test	1.81723	***p-value***		0.275	
Heterosckadicity test	7.467342	***p-value***		0.487148	
Adjusted R-squared			92.8120%		

Source: table formulated by the researcher depending on E-views software output

From the above table, it can be concluded that:

- The overall Heteroskedasticity correction time series model is significant as the overall F-test for significance has a value of 33.28026 and *p-value* 0.000310 which is less than 0.05, with adjusted R-squared value of 92.8120% which means that the independent variables explain the change in the Sustainability and Adaptation by 92.8120%.
- Constant has insignificant impact on Sustainability and Adaptation.

- Global production by production source Quantity has direct and significant impact on Sustainability and Adaptation this was presented in the sustainability of Egypt's tilapia aquaculture production (World Fish Website, 2024) whereby Egypt succeeded in being the 2^{nd} largest world producer of tilapia after China in 2016 (Kamal, January 2021)
- Chlorophyll-a deviations remote sensing, Capture fisheries production, and Total Fisheries Production have direct and significant impact on Sustainability and Adaptation as Egypt is facing development challenges represented mainly in destructive fishing practices, drastic fishing effort and excessive industrial expansion and increased tourism that destroys the habitat, however Egypt is exerting efforts to promote responsible and sustainable practice by preserving coastal and marine areas (Mehanna, 2022 and Kamal, January 2021)
- Aquaculture Production has direct and insignificant impact on Sustainability and Adaptation this was presented in that Egypt succeeded in being the 8^{th} largest aquaculture producer globally in 2016 (Kamal, January 2021)
- There is no problem of multi-collinearity between the independent variables as the VIF test showed results less than 10 for the independent variables.
- Ramsey reset test has a *p-value* of 0.275 which is greater than 0.05, which means that the independent variables in the models are sufficient.
- Heterosckadicity test has *p-values* of 0.276352, which means that the residuals have a constant variance on long run and the model doesn't suffer from Heterosckadicity problem.
- The overall equation for forecasting the Sustainability and Adaptation is:

$$\widehat{Y_{5t}} = 624.943\, X_{1_t} + 3.56575\, X_{2t} + 171.326\, X_{3t}$$

Therefore, the fifth hypothesis will be accepted which means that Sustainable fisheries have a significant impact on Sustainability and Adaptation.

To sum up, it can be extracted that Egyptian fisheries are concentrated mainly in tilapia and mullet species that were participating in growing fish and seafood production through *rapid expansion in capture fisheries production and aquaculture production. Reflections appeared in increasing exports of fish and being a source of wealth which tends to have a significant impact on food security generally and on affordability and availability specifically.*

Whilst difficulties in Egypt appeared in lessening self-sufficient ratio, funding obstacles for fishermen, poor marketing services, high population growth rates and currency devaluation was reflected on low quality and unsafety in food security.

Furthermore, weaknesses facing sustainable blue economy exemplified in marine and coastal ecosystems degradation, increased tourism, destructive fishing practices and excessive industrial expansions clarifies that blue economy is at the initial stage in Egypt.

Over and above, adoption of Egypt vision 2030 to sustainable fisheries, in addition to the efforts exerted by Ministry of Agriculture and Land Reclamation, NIOF, GAFRD and 60 implemented cooperatives in Egypt contemplate moving forward towards sustainability in food security.

Eventually, production of fisheries for food is still below than the potential and there are difficulties and weaknesses facing sustainable blue economy in Egypt.

5. Applied Study Limitations

The model utilized in this analysis is a linear multiple Ordinary Least Squares (OLS) model with heteroscedasticity correction. Its primary purpose is to provide an indication rather than precise predictions. The analysis is based on a limited dataset of 11 observations, representing a small time series (reduced time series). While this sample size restricts the model's ability to deliver highly accurate results, it has been employed due to resource constraints. Consequently, the outcomes should be interpreted with caution, as they reflect a simplified representation of the underlying trends. Nonetheless, this approach aligns with established econometric methodologies for handling limited data scenarios (Pesaran, 2015; Martin et al., 2013).

Despite its constraints, the model demonstrates a high level of reliability for long-term forecasting. This assurance stems from the assumption that the variation of random errors becomes constant (equal to one) over time, which is a key feature of a heteroscedasticity-corrected OLS model. This stability in error variation contributes to a consistent coefficient of determination, reinforcing the model's suitability for long-run analysis. Such characteristics underscore the importance of heteroscedasticity correction in econometric modeling, as highlighted in prior research (Pesaran, 2015; Martin et al., 2013).

6. Conclusion

This paper concluded that blue economy is “central” to sustainable fisheries represented in creating the appropriate environment, increasing fisheries production which results in multiple fruitful benefits reflected on macro-level represented mainly in supporting the achievement of food security in specific and could be reflected in the future on human security.

However, adopting blue economy’s concepts and principles is one of the major challenges due to its different aspects of oceanic and coastal sustainability including sustainable fisheries that need to be better understood and managed effectively.

Concerning the comparative analysis, experiences displayed for Indonesia, India, China and Egypt showed the vital role played by sustainable fisheries after enabling blue economy through specifying the strategic plan, integrating sustainability considerations, determining institutional mechanisms framework, determining financing mechanisms framework, setting fiscal policy tools and instruments, enhancing private sector participation and encouraging partnerships. In addition to presenting the reflections of sustainable fisheries in supporting food security (presented in the Global Food Security Index).

Concerning applied analysis, it was concerned with selecting the appropriate model that will test the extent to which enabling blue economy in Egypt will be reflected on food security. The applied analysis was conducted on the period from year 2012 till 2022. It started by applying descriptive analysis, then applying Shapiro-Wilk as a test of normality, then determining the degree of correlation through using correlation matrix, then applying heteroskedasticity correction regression model that consisted of 11 observations from year 2012 till 2022 to test the five hypotheses. Subsequently, it was proved that the first, second, third and fifth hypotheses were accepted whereby they reflect that the sustainable fisheries indicators (independent variables) tend to have a significant impact on GFSI, Availability, Affordability and Sustainability and Adaptation (dependent variables) in Egypt. While the fourth hypothesis was rejected whereby sustainable fisheries indicators (independent variables) tend to have insignificant impact on Quality and Safety.

At the end, it can be concluded that adopting sustainable fisheries in Egypt is a promising sector by enabling blue economy whereby reflections of these will appear on sustainable development and serves at the end for guarantying food security for future generations.

7. Recommendations

- Ensure that blue economy principles in Egypt adheres to internationally accepted environmental and fisheries standards.
- Develop a long-term development strategy that enable appropriate environment for “Sustainable fisheries” under blue economy lens that supports food security.
- Integrate sustainable management to govern fisheries and ensure continued productivity for the coming generations which promotes SDG (14) and SDG (2).
- Encourage transformation to blue economy broader participation in Sustainable fisheries which will grow Egypt’s contribution to global aquaculture production and increase Egypt’s competitiveness.
- Create an enabling environment that promotes contribution from fisheries to be reflected on the economic growth, Productivity, Employment and good health in Egypt.
- Develop regulatory and management mechanisms aimed to minimize adverse environmental impacts associated with fisheries practices.
- Enable Microfinancing sector (as implemented in Indonesia, Cambodia, India and China).
- Design appropriate financial mechanisms that aim at creating immediate financial solutions for the short-term and boost the growth of the sector in the long term.
- Enhance sustainable financing tool that support in addressing the financial gap.

- Develop innovative institutional and financial structures to support the development of sustainable fisheries.
- Enable the transition to sustainable blue economies through committing public resources.
- Encourage initiatives that draw private sector's interest to financing.
- Guarantee simple, clear and fast mechanisms to incentive the private sector to participate in fisheries and aquaculture sectors.
- Encourage increasing the resource base of fisheries / marine aquaculture from the few species currently being farmed to a more diverse suite of species and fish farming technology.

Hence, Egypt has potential opportunities in enabling sustainable blue economy through addressing sustainable fisheries which will serve at the end in narrowing food gap and supporting the achievement of food security.

And since that no one model can be applied on all and that there is no agreed upon principle or investment framework for applying blue economy. So, the following table offers an action plan that represents actionable steps to enhance Egypt by merging with lessons learnt form the presented above experiences (Indonesian Model, Cambodian Model, Indian Model and Chinese) in addition to steps to overcome weaknesses and threats and getting benefits from strengths and opportunities existed in the Egyptian economy extracted from the econometric model through adopting a portfolio of solutions that will be presented in the following Action Plan table:

Table (11)
Action Plan

Recommendation	Execution Authority	Executive Actions
Strategic Plan		
Ensure that blue economy principles in Egypt adheres to internationally accepted environmental and fisheries standards.	- Ministry of Environment. - Quality Assurance and Control Unit (in every environmental institution)	-Set a committee to establish blue economy principles. - Evaluate the Egyptian Standards and compare it with the international ones. - Revise regularly that Egyptian Principles are coping with the international ones and are continuously updated.
Develop a long-term development strategy that enable appropriate environment for "Sustainable fisheries" under blue economy lens that supports food security.	- Egyptian Cabinet. - Ministry of Environment. - Ministry of Agriculture and Land Reclamation. - Ministry of Planning, Economic Development and International Cooperation	- Consider the possibility of offering a broad plan covering blue economy drivers, incentives and challenges. - Position the Sustainable Fisheries situation in Egypt. - Apply SWOT analysis for Sustainable Fisheries. - Analyze food security situation and determine that food gap that can be fulfilled with sustainable fisheries. - Collaborate all the above-mentioned steps in one aggregate plan.
Integration of sustainability considerations		
Integrate sustainable management to govern fisheries and ensure continued productivity for the coming generations which promotes SDG (14) and SDG (2).	- National Institute for governance and sustainable Development (NIGSD). - Centre for Sustainable Development Solutions (CSDS).	- Regulating methods used in fishing. - Setup rules of avoid over-fishing and encourage distant-water fisheries. - Maintain ecological balance. - Regularly measure on quarterly basis achievements accomplished in SDG (2) and SDG (4) and determine the progress.
Institutional mechanisms framework		
➢ At the central level		

Encourage transformation to blue economy broader participation in Sustainable fisheries which will grow Egypt's contribution to global aquaculture production and increase Egypt's competitiveness.	**- The Egyptian National Competitiveness Council (ENCC). - General Authority for Fish Resources Development.**	**- Benefit from the four comparison countries through overseeing and developing fisheries sector (as Indonesia and India), concentrating on R&D as (as Cambodia) and shifting to distant water fisheries (as China). - Adopt to fisheries standards internationally to guarantee the Quality to encourage exports of fish.**
	➢ At the local level	
Create an enabling environment that promotes contribution from fisheries to be reflected on the economic growth, Productivity, Employment and good health in Egypt.	**- Ministry of Environment. - Ministry of Agriculture and Land Reclamation. - Ministry of Manpower.**	**- Encourage labour to work in the fisheries field and incentive them by high wages. - Determine malnutrition people and measure food deficit and specify to what extent fisheries sector can fulfil the gap.**
Develop regulatory and management mechanisms aimed to minimize adverse environmental impacts associated with fisheries practices.	**- Ministry of Environment. - Ministry of Agriculture and Land Reclamation. - Friends of Environment Association. - Nature Conservation Egypt (NCE).**	**- Impose penalties for institutions who harm the environment. - Impose penalties for fishermen who harm the life water.**
	Financing mechanisms framework	
Enable Microfinancing sector (as implemented in Indonesia, Cambodia, India and China).	**- Environmental Protection Fund (EPF). - Central Bank of Egypt.**	**- Categorizing fisheries separately. - Include financing for fisheries explicitly in the Egyptian government strategic plan. - Encourage innovative instruments (as blue bonds). - Encourage loans with simple interest (not compound interest) to encourage fishermen.**

Design appropriate financial mechanisms that aim at creating immediate financial solutions for the short-term and boost the growth of the sector in the long term.	**- Egyptian Financial Supervisory Authority (EFSA). - Central Bank of Egypt.**	**- Benefit from Indonesia through enabling private sector flow funds. - Take advantage of Cambodia by establishing mini-trust fund, developing finance facility and enhancing value chain investment opportunities. - Grab Chinese experience in developing distant water fisheries and promoting fisheries fiscal support.**
Enhance sustainable financing tool that support in addressing the financial gap.	**- Egyptian Banking Institute (EBI). -American Chamber of Commerce in Egypt.**	**- Offer feasibility studies for blue projects. - Issue Blue Bonds.**
	Fiscal policy tools and instruments	
Develop innovative institutional and financial structures to support the development of sustainable fisheries.	**- National Institute of Oceanography and Fisheries.**	**- Implement initiatives to diversify funding sources. - Benefitting from Cambodian, Indonesian and Indian experiences in adopting diverse financing institutions.**
Enable the transition to sustainable blue economies through committing public resources.	**- Egyptian Environmental Affairs Agency (EEAA). - Ministry of Irrigation and Water Resources. - International Water Management Institute (IWMI). - Hydraulic Research Institute (HRI).**	**- Promote investment in technology, governance and markets. - Extend common infrastructure and governance insight. - Enhance Budgetary allocations.**
	Private sector	
Encourage initiatives that draw private sector's interest to financing.	**- The Bureau of Fisheries (the Ministry of Agriculture). - International Seabed Authority (ISA).**	**- Invest in initiatives for entrepreneurship and investment. - Harnessing innovative solutions to expand private sector involvement.**
Guarantee simple, clear and fast mechanisms to incentive the private sector to participate in fisheries and aquaculture sectors.	**- General Authority for Fish Resources Development. - Evergreen Egypt United.**	**- Ensure the availability of appropriate institutional mechanisms. - Secure statutory support.**

Partnerships		
Encourage boosting resource base of fisheries and marine aquaculture from the few species currently being farmed to a more diverse suite of species and fish farming technology.	**- Animal Production Research Institute (APRI). - National Company Fisheries and Aquaculture. - Suez Canal Aquaculture Company.**	**- Implement initiatives to encourage partnerships with national, international agencies and non-governmental organizations. - Activate signed cooperations and put viable business plan to implement these cooperations.**

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