Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Bachelor Thesis

The Economic Impact of Climate change on the Main Economic Sectors of Egypt

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

Marwan Nomir

Business Administration

Thesis title

Economic impact of Climate change on the main economic sectors of Egypt

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Objectives of thesis

The primary objective of this bachelor's thesis is to assess the consequences of climate change on the principal economic sectors within the Arab Republic of Egypt. This research consists of a comprehensive evaluation and analysis of the impacts incurred by climate change on Egypt's economy, with a particular focus on the main sectors of trade and agriculture.
The objectives of this thesis are as follows:
- Conduct a literature review on the economic impacts of climate change in Egypt, trade, and agriculture.
- Identify climate change-induced events affecting Egypt's trade and agriculture sectors.
- Quantify economic losses in Egypt's trade and agriculture due to climate change.
- Analyze trade policies and international agreements influencing Egypt's trade sector in the context of climate change.
- Assess adaptation and mitigation strategies in Egypt's trade and agriculture sectors.
- Examine implications of climate change on food security, trade balance, and socio-economic consequences in Egypt.

Methodology

This study will use a comprehensive research approach, focusing on the analysis and comparison of existing data and information sources. This will provide an in-depth understanding of the economic impact of climate change on Egypt's key economic sectors, specifically trade and agriculture. To achieve the objectives of this study, the research process will be conducted through a collection of scientific articles, periodicals, and journals in English and Arabic. Data will be collected through various databases such as Science Direct, Google Scholar, Web of Science, Elsevier, WHO, etc. The thesis will rely mainly on previously collected data and information from primary and secondary sources from the region.

Data related to trade and agriculture, such as GDP contributions, trade balances, agricultural yields, and sector-specific economic indicators from official government reports and reliable international databases will be examined and critically analyzed.

Specific case studies within Egypt's trade and agriculture sectors to gain a deeper understanding of localized impacts, adaptation strategies, and challenges will also be analyzed.

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40 – 60 pages

Keywords

Climate Change, Economic Sectors, Egypt, Trade, Agriculture,

Recommended information sources

Ahmed, Y. N., Delin, H., Belford, C., Shaker, V., & Abdelrahaman, N. a. M. (2020). An estimate of the potential economic impacts of climate change on Egypt's agriculture: a multi-market model approach. Climate and Development, 13(3), 228–241.

Eid, H. M. (2022, July 1). Assessing the Economic impacts of climate change on agriculture in Egypt: A Ricardian approach

Onyeji, S., & Fischer, G. (2023). An economic analysis of potential impacts of climate change in Egypt. Global Environmental Change, 4(4), 281–299.

Smith, J. B., McCarl, B. A., Kirshen, P., Jones, R., Deck, L., Abdrabo, M., Borhan, M., El-Ganzori, A., Elshamy, M., Hassan, M., Elshinnawy, I. A., Abrabou, M., Hassanein, M. K., El-Agizy, M., Bayoumi, M. R., & Hynninen, R. (2018). Egypt's economic vulnerability to climate change. Climate Research, 62(1), 59–70.

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Prague on 14. 03. 2024

Declaration

I declare that I have worked on my bachelor thesis titled Economic Impact of Climate Change on the main economic sectors of Egypt by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15th of March 2024 Marwan

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I would like to thank and appreciate doc. Ing. Krepl Vladimir for his guidance, inspiration, and supervision during the period that I spent writing this thesis. I would also like to thank my parents and friends for their support.

The Economic Impact of Climate Change on the main Economic Sectors of Egypt

Abstract

Climate change poses a serious threat globally, especially to the various economic sectors of each country. The levels of impact vary according to the geographic regions and locations of the countries. This bachelor's thesis will investigate and explore the economic impacts of climate change on the economic sectors of Egypt, particularly addressing the agriculture, water, and trade sectors, with an emphasis on agriculture and water. Through analyzing the existing data and current liturature research sources, the thesis aims to create awareness and comprehensively understand the details of the economic losses and the extend of impact of climate change-related events in Egypt. Furthermore, the adaptation, implementation, and mitigation strategies and policies are presented to evaluate the progress of the country's current economy and future implications. By accessing detailed data sources, governmental projects, and academic articles and journals, this study was able to examine specific economic values, such as GDP, food security, economic losses, production losses, trade balance, supply and demand, etc, within the given sectors, and their ability to withstand the impacts of climate change. The findings from the existing research highlight the various efforts taken by the government of Egypt, such as launching the National Climate Change Strategy 2025, the Vision 2030 project, and the updated National Determined Contributions (NDC) in 2022, including sustainable green emission projects, implementing new policies, and conducting investment cost analysis for the various project proposals, up until 2050. The summary of findings are concluded with future recommendations to overcome the adverse effects of climate change while preserving the land, agricultural and water resources, and the economy of the country. The significance and importance of international collaborations and taking action for the submitted strategies are emphasised.

Keywords: Climate change, Egypt, adaptation policies, mitigation strategies, economic impact, agriculture sector, sustainable development, trade

Ekonomický dopad změny klimatu na hlavní hospodářská odvětví Egypta

Abstrakt

Změna klimatu představuje vážnou hrozbu v celosvětovém měřítku, zejména pro různá hospodářská odvětví jednotlivých zemí. Míra dopadu se liší podle zeměpisných oblastí a polohy jednotlivých zemí. Tato bakalářská práce bude zkoumat a zkoumat ekonomické dopady změny klimatu na ekonomická odvětví Egypta, zejména se bude zabývat odvětvími zemědělství, vodního hospodářství a obchodu, s důrazem na zemědělství a vodní hospodářství. Prostřednictvím analýzy existujících dat a současných literárních výzkumných zdrojů si práce klade za cíl vytvořit povědomí a komplexně pochopit podrobnosti o ekonomických ztrátách a rozsahu dopadů událostí souvisejících se změnou klimatu v Egyptě. Dále jsou představeny adaptační, implementační a mitigační strategie a politiky, aby bylo možné zhodnotit pokrok současného hospodářství země a budoucí důsledky. Díky přístupu k podrobným zdrojům dat, vládním projektům a akademickým článkům a časopisům byla tato studie schopna prozkoumat konkrétní ekonomické hodnoty, jako je HDP, potravinová bezpečnost, ekonomické ztráty, ztráty produkce, obchodní bilance, nabídka a poptávka atd. v rámci daných odvětví a jejich schopnost odolávat dopadům změny klimatu. Zjištění z existujícího výzkumu zdůrazňují různé snahy egyptské vlády, jako je zahájení Národní strategie pro změnu klimatu do roku 2025, projekt Vize 2030 a aktualizované Národní stanovené příspěvky (NDC) v roce 2022, včetně projektů udržitelných ekologických emisí, provádění nových politik a analýzy investičních nákladů pro různé návrhy projektů až do roku 2050. Shrnutí zjištění je zakončeno budoucími doporučeními k překonání nepříznivých dopadů změny klimatu při současném zachování půdy, zemědělských a vodních zdrojů a hospodářství země. Je zdůrazněn význam a důležitost mezinárodní spolupráce a přijetí opatření pro předložené strategie.

Klíčová slova: změna klimatu, Egypt, adaptační politiky, mitigační strategie, ekonomický dopad, zemědělský sektor, udržitelný rozvoj, obchod

Table of content

List of Figures

List of Abbreviations

NENA: Near East and North Africa

GDP: Gross Domestic Product

EGP: Egyptian pounds

UN: United Nations

SPSS: Statistical Package for the Social Sciences

GCMs: General Circulation Models

COP21: Conference of the Parties 21

NCCS: National Climate Change Strategy

NDC: National Determined Contributions

UNDP: United Nations Development Programme

MWRI: Ministry of Water Resources and Irrigation

SDS: Sustainable Development Strategy

MOPMR: Ministry of Petroleum and Mineral Resources

GHG: Greenhouse Gas

ISO: International Organization for Standardization

SCALA: Scaling-up Local Adaptation

USD: United States Dollar

ASEAN: Association of Southeast Asian Nations

1. Introduction

Climate change has been an ongoing global crisis for decades. As explained by the Met Office (2023)[1], the Earth's climate has been changing since 4.5 billion years ago. Due to the Earth's revolution around the sun, there were times of the Ice Ages prior to the Industrial Revolution. Since the 1800s, at the beginning of the Industrial Revolution, the rapid consumption of fossil fuels, coal, and gas, led to the accelerated increase in climate change. Human activity has been recognized as one of the main reasons for the rise in the Earth's temperature. Studies conducted by Gabric (2023)[2]; Lynas et al. (2021)[3]; and Hegerl et al. (2019)[4], all provide an understanding and supporting evidence to the human causes of climate change, with a brief overview of the natural causes of climate change throughout the decades.

Analysing and understanding the impact of climate change, not only in the Arab Republic of Egypt, but globally is crucial in taking the next best measures to decrease it. Climate change has affected the global population, for example, annual rise in temperatures across regions contribute to the depletion of necessary resources, such as the production of agriculture. Additionally, it also has a negative impact on biodiversity and health of all species, according to Muluneh (2021)[5]. In the study conducted by Smith et al. (2014)[6], the specific concerns for Egypt's economy comprises mainly of the following sectors, which are water and agriculture, the employment sector, healthcare, and tourism. This directly contributes greatly to the economic losses of the country impacted by climate change.

Egypt is located on the continent of Africa. Its borders are with Israel, the Gaza Strip, Sudan, and Libya. The Mediterranean Sea makes up around one-third of Egypt's coastline; the Red Sea contains the remainder. Egypt has a coastline of 3,500 km and a land area of over 995,000 km2. As of 2019, Egypt's population reached 100,388,000, and in 2017, 11.7% of the country's GDP

[1] What is climate change? (2023). Met Office. https://www.metoffice.gov.uk/weather/climate-change/what-is-climate-change

[2] Gabric, A. J. (2023). The Climate Change Crisis: A Review of its causes and Possible responses. Atmosphere, 14(7), 1081. https://doi.org/10.3390/atmos14071081

[3] Lynas, M., Houlton, B. Z., & Perry, S. (2021). Greater than 99% consensus on human caused climate change in the peer-reviewed scientific literature. Environmental Research Letters, 16(11), 114005. https://doi.org/10.1088/1748-9326/ac2966

[4] Hegerl, G. C., Brönnimann, S., Cowan, T., Friedman, A. R., Hawkins, E., Iles, C., Müller, W. A., Schurer, A., & Undorf, S. (2019). Causes of climate change over the historical record. Environmental Research Letters, 14(12), 123006. https://doi.org/10.1088/1748-9326/ab4557

[5] Muluneh, M. G. (2021). Impact of climate change on biodiversity and food security: a global perspective—a review article. Agriculture & Food Security, 10(1). https://doi.org/10.1186/s40066-021-00318-5

[6] Smith, J. B., McCarl, B. A., Kirshen, P., Jones, R., Deck, L., Abdrabo, M., Borhan, M., El-Ganzori, A., Elshamy, M., Hassan, M., Elshinnawy, I. A., Abrabou, M., Hassanein, M. K., El-Agizy, M., Bayoumi, M. R., & Hynninen, R. (2014). Egypt's economic vulnerability to climate change. Climate Research, 62(1), 59–70. https://doi.org/10.3354/cr01257

came from the agriculture sector, 34.3% from industrial production like textiles, chemicals, cement, pharmaceuticals, etc. Egypt ranks 107 out of 181 countries in the Notre Dame global adaptation initiative index. The index sums up countries' weaknesses to climate change and other global changes in merging with readiness improvement. This ranking shows that Egypt has high vulnerability levels and a low level of readiness to adapt to climate change.

Objectives and Methodology

Objectives

The primary focus of this bachelor's thesis is to assess the implications of climate change on Egypt's economy, with a particular emphasis on the sectors of trade and agriculture. The research objectives are outlined to facilitate a detailed investigation and analysis into the economic impacts of climate change within the Arab Republic of Egypt. The goal is to conduct an extensive review of existing literature and research related to the economic consequences of climate change in Egypt, specifically within the trade and agriculture sectors. This literature review aims to establish an understanding of the current state of knowledge and identifying gaps that the thesis can address.

The following objectives explore the specific impacts of climate change, such as extreme weather, temperature increases, and droughts, on Egypt's trade and agriculture sectors. The study seeks to quantify the economic losses and disruptions experienced by these sectors due to climate change-related events. Additionally, it explores the role of trade policies and international agreements in shaping Egypt's trade sector within the context of climate change. The research evaluates the effectiveness of adaptation and mitigation strategies implemented by the trade and agriculture sectors to cope with the impact of climate change. The study also examines the potential for climate-resilient agricultural practices and sustainable trade policies to enhance the long-term viability of these key economic sectors. Through this approach, this paper aims to contribute valuable insights into the broader implications of climate change on food security, trade balance, and the overall socio-economic well-being of Egypt, with a focus on farmers, traders, and related communities. Lastly, the alignment of government policies and initiatives with international climate goals is analyzed to measure the overall effectiveness of the country's response to climate change in these key economic domains.

Methodology

This study will use a comprehensive research approach, focusing on the analysis and comparison of existing data and information sources. This will provide an in-depth understanding of the economic impact of climate change on Egypt's key economic sectors, specifically trade and agriculture. To achieve the objectives of this study, the research process will be conducted through a collection of scientific articles, periodicals, and journals in English and Arabic. The collection of data will be found through various databases such as World Data, Science Direct, Google Scholar, Web of Science, Elsevier, WHO, etc. The thesis will rely mainly on previously collected data and information from primary and secondary sources from the region.

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Specific case studies within Egypt's trade and agriculture sectors to gain a deeper understanding of localized impacts, adaptation strategies, and challenges will also be analyzed.

2. Literature Review

2.1 Overview of Climate Change and its Global Economic Impacts

Climate change has extensive consequences that will affect the major global economic sectors, including agriculture, energy, and health. The shifts in climate patterns significantly alter the supply and demand for goods and services across the global economy. Key subsectors such as crop production, livestock, rangeland, and aquaculture have a pronounced impact.

The study conducted by Rosenzweig et al. (2013)[7], identifies the effects of climate change to be primarily negative, especially under moderate to high levels of warming at the regional level. Both positive and negative outcomes are expected among various regions, which are influenced by factors such as rainfall, atmospheric carbon dioxide (CO2) concentration, and ozone levels. The study also highlights future agricultural activities to be particularly impacted, both positively and negatively, such as high levels of CO2 concentrations to stimulate crop yield, and high levels of ozone to produce negative results.

The coastal systems comprise natural and human-made features, including beaches, cliffs, settlements, cities, ports, and food production areas. These natural coastal ecosystems, as well as the human activities and productions within them, face significant impacts from climate change (Edenhofer, et. al., 2014)[8]. Furthermore, factors such as increased storm, frequency, and intensity, rising precipitation, warmer ocean temperatures, and ocean acidification contribute to the susceptibility of coastal zones. In particular, sea level rise is noted as the primary aspect of damage to coastal areas, negatively impacting the provision of both market and non-market goods and services through events like storm surges, submergence, saltwater intrusion, and coastal erosion (Edenhofer, et. al., 2014).

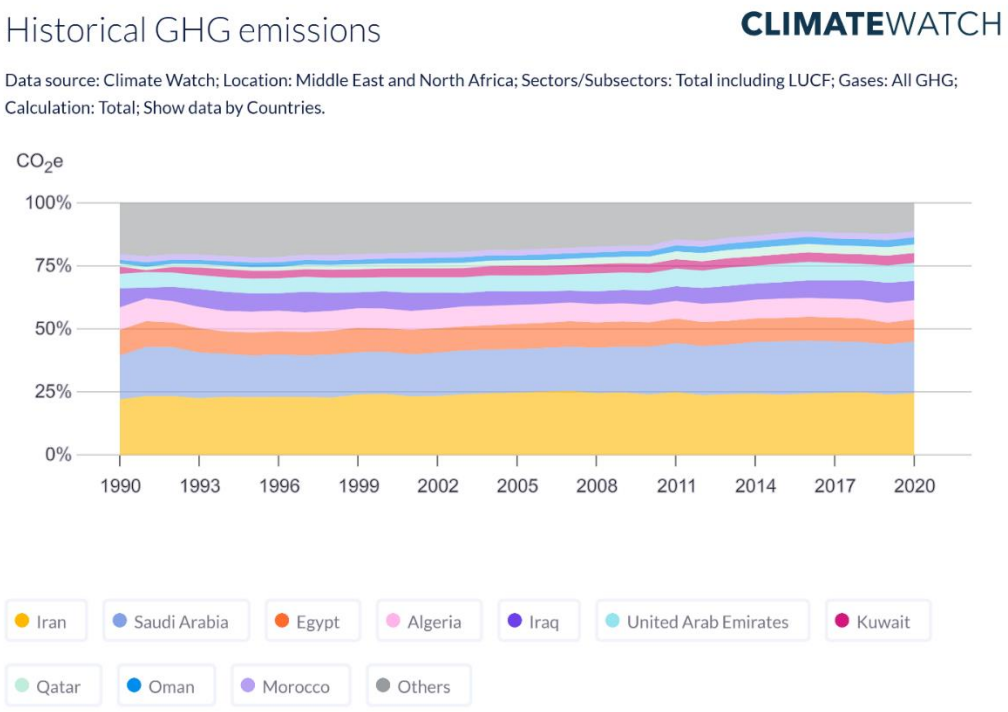
Studies show that climate change has the potential to have a significant impact on the world's economy, primarily due to the global CO2 emissions that contribute to increasing heat in the Earth's atmosphere. The economic impact of climate change is said to be experienced by several

[7] Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A. C., Müller, C., Arneth, A., Boote, K. J., Folberth, C., Glotter, M., Khabarov, N., Neumann, K., Piontek, F., Pugh, T. a. M., Schmid, E., Stehfest, E., Yang, H., & Jones, J. W. (2013). Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. Proceedings of the National Academy of Sciences of the United States of America, 111(9), 3268–3273. https://doi.org/10.1073/pnas.1222463110

[8] Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Minx, J. C., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlomer, S., von Stechow, C., Zwickel, T. (2014). Climate change 2014: Mitigation of climate change. https://www.ipcc.ch/site/assets/uploads/2018/03/WGIIIAR5_SPM_TS_Volume-3.pdf

nations. Therefore, it is important that such countries should create and apply macroeconomic policies that are capable of accommodating more frequent weather shocks. On a global scale, studies show substantial risks to macro financial stability in relation to climate change. Non-financial firms will be impacted by the repercussions of climate change, in addition to the decrease in value of assets (Climate and the Economy, 2020)[9]. For example, the data presented by Climate Watch (n.d)[10] for the North African region in CO2 emissions in thee year 2020 reveals Iran to be responsible for 844.71 million tonnes of CO2 emmissions, which equals 1.78% of global emissions. Iran is followed by Saudi being the second largest of CO2 emissions in the Middle East/ North Africa regions, contributing 1.50% in global emissions, and with Egypt in third place with a 0.63% of global emissions (see Figure 1). In the world global CO2 emitters, China, the United States, and India rank in the top three, with 25.88%, 11.13%, and 6.67% of global emissions respectively (see Figure 2).

Figure 1 - CO2 Emissions in the Middle East & North Africa Regions

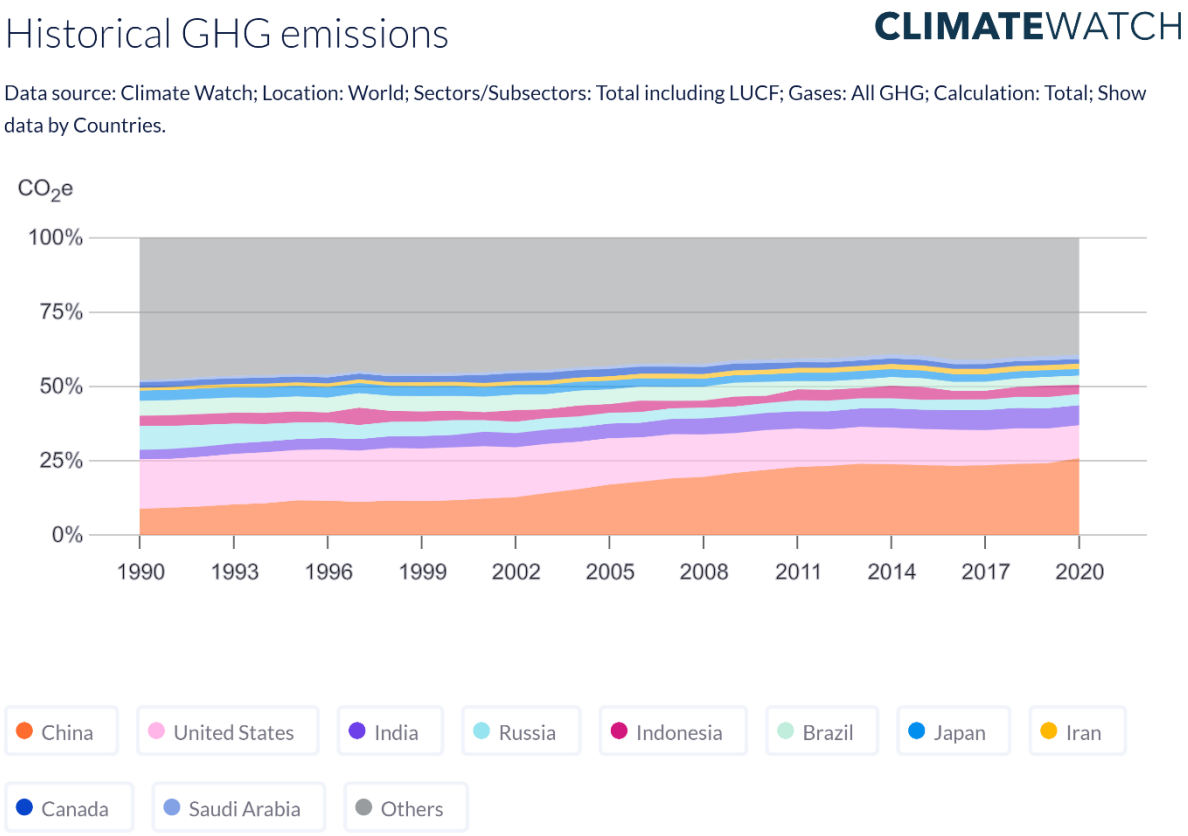


Source - https://www.climatewatchdata.org/ghg-emissions?end_year=2020&regions=MNA&source=Climate%20Watch&start_year=1990

9

[10] Climate Watch (n.d) - *https://www.climatewatchdata.org/ghgemissions?end_year=2020&regions=MNA&source=Climate%20Watch&start_year=1990*

Figure 2 – Global CO2 emissions until 2020 in %



Source - https://www.climatewatchdata.org/ghg-emissions?chartType=percentage&end_year=2020&regions=WORLD&source=Climate%20Watch&start_year=1990

On 12 December 2015, world leaders at the UN Climate Change Conference (COP21) in Paris reached a historic agreement to combat climate change. The agreement was set to guide all nations to significantly reduce greenhouse gas emissions, maintaining global temperatures well above 2°C above pre-industrial levels, and aim to limit the increase to 1.5°C. This data was recognised as a critical step in reducing the risks and significant impacts associate with climate change (United Nations, n.d.)[11].

Financial assistance is essential to support poorer countries in effectively dealing with and managing the effects of climate change. Additionally, regular progress monitoring towards

[11] United Nations. (n.d.). The Paris Agreement | United Nations. https://www.un.org/en/climatechange/paris-agreement

meeting the goals outlined in the agreement is crucial. According to Guo et al. (2021)[12], global temperature rises will have an adverse impact on GDP across all regions by mid-century. The world is projected to experience a temperature warming of 2.0-2.6°C, assuming that the mitigation pledges are met by then (see figure 3). In comparison with the goal of the Paris Agreement, which is less than a 2°C temperature rise, the loss in global economic value could be up to 10% higher in this scenario, with Southeast Asian (ASEAN) economies being affected the most. In a severe scenario, with a temperature rise of 3.2°C, the global GDP loss could exceed the goal of the Paris Agreements by up to 14%.

Figure 3 - Simulating for economic loss impacts from rising temperatures in % GDP, relative to a world without climate change (0°C)

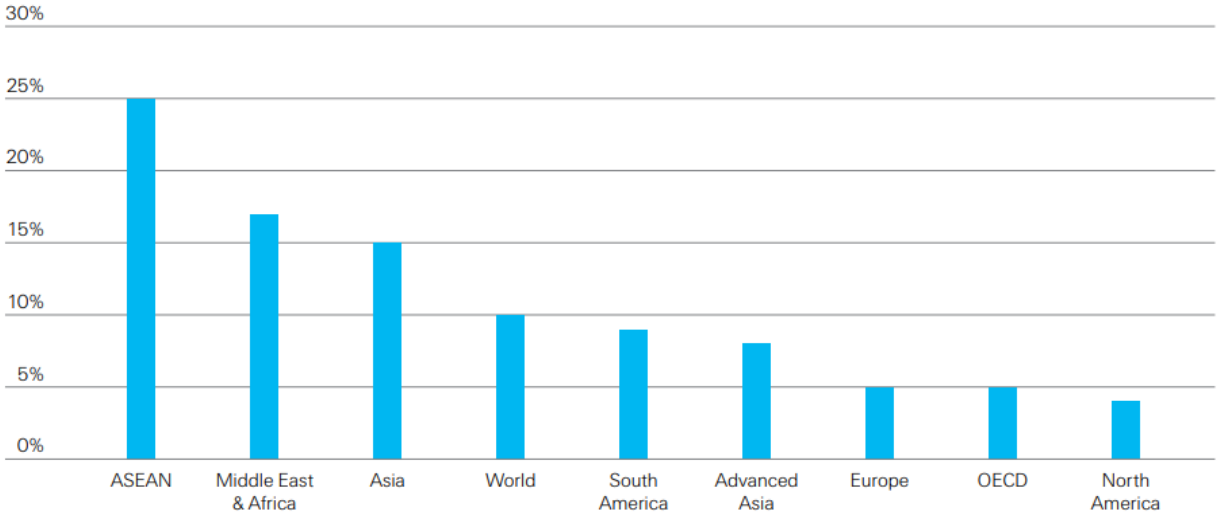
	Temperature rise scenario, by mid-century			
	Well-below 2°C increase	2.0°C increase	2.6°C increase	3.2°C increase
	Paris target	*The likely range of global temperature gains*		*Severe case*
Simulating for economic loss impacts from rising temperatures in % GDP, relative to a world without climate change (0°C)				
World	−4.2%	−11.0%	−13.9%	−18.1%
OECD	−3.1%	−7.6%	−8.1%	−10.6%
North America	−3.1%	−6.9%	−7.4%	−9.5%
South America	−4.1%	−10.8%	−13.0%	−17.0%
Europe	−2.8%	−7.7%	−8.0%	−10.5%
Middle East & Africa	−4.7%	−14.0%	−21.5%	−27.6%
Asia	−5.5%	−14.9%	−20.4%	−26.5%
Advanced Asia	−3.3%	−9.5%	−11.7%	−15.4%
ASEAN	−4.2%	−17.0%	−29.0%	−37.4%
Oceania	−4.3%	−11.2%	−12.3%	−16.3%

Source: Swiss Re Institute pg.4

By meeting the Paris Agreement target of well below 2°C warming, up to 10% of anticipated global GDP losses by mid-century could be avoided. Based on figure 4 below, in more exposed regions, meeting the Paris Agreement target could reduce or prevent GDP losses by 25% by midcentury, as opposed to a 2.6°C rise in temperatures. Indonesia, Thailand, and Saudi Arabia are among the biggest relative winners among emerging markets.

[12] Guo, J., Kubli, D., Saner, P. (2021). The economics of climate change: no action not an option. Swiss Re Institute. https://www.swissre.com/dam/jcr:e73ee7c3-7f83-4c17-a2b8-8ef23a8d3312/swiss-re-institute-expertise-publication-economics-of-climate-change.pdf

Figure 4 - The % of GDP that will vary between the Paris scenario and the 2.6°C scenario



Source: Swiss Re Institute pg.4

Furthermore, in the report by Widjaja, et.al (2023)[13], the key global economic sectors facing the most impacts due to climate change are agricultural, energy and insurance. Due to the progressive increase in temperature, fluctuations in rainfall, and uncertain weather conditions, sectors such as agriculture face direct impact up to 15 % decrease in production globally, with a 25% loss in agricultural production in Africa within the past 10 years (see Figure 5). Similarly, a 30% decrease in GDP is calculated in the Southeast Asian countries, caused by "rising sea levels and storm intensity in coastal regions ". The Energy sector faces direct consequences of climate change-induced extreme weather events resulting in at least a 10% loss in the annual revenue for the sector. Additionally, from the research conducted by the authors, a 20% increase of claims to the insurance has been shown to be a direct result of climate change related calamities (see Figure 6).

[13] Widjaja, G., Mahmudin, T., Judijanto, L., Arifin, Z., Al-Shreifeen, I. A. (2023). Impacts of climate change on the global economy an in-depth analysis of economic loss projections and mitigation strategies. International Journal Of Economic Literature. 1(2) 231-244. https://injole.joln.org/index.php/ijle/article/view/22/26

Figure 5 - Economic Impact on Key Sectors

Sector	Decrease in Productivity	Losses as a Percentage of Revenue
Agriculture	15%	-
Energy	-	10%
Insurance	-	20%

Source - https://injole.joln.org/index.php/ijle/article/view/22/26

Figure 6 - Economic Losses in Selected Regions

Region	Decrease in Agricultural Output	Economic Losses as a Percentage of GDP
The Sahel Region	25%	-
Southeast Asia	-	30%

Source - https://injole.joln.org/index.php/ijle/article/view/22/26

2.2 Overview of Egypt's Agriculture and Trade Sector

Egypt's agriculture sector has been historically significant due to the fertile lands along the Nile River, however, currently facing challenges in meeting the food demands due to the continuous increase in population. Egypt heavily relies on food imports, despite being popular in the production of crops like rice, wheat, and corn. The country's agricultural sector is significant in contributing to its economy, but issues such as limited land and water resources prevent independency in food production (Britannica, n.d[14]; Siam, 2003[15]; Tellioglu & Konandreas, 2017[16]). The country's growing population has led to a reliance on food imports, which caused a substantial portion of Egypt's export revenue to be spent on agricultural imports (Kassim, et. al., 2018)[17]. Focusing primarily on high-value exportable products, like cotton, and facing market

[14] Egypt—Agriculture, Fishing, Nile | Britannica. (n.d.). Retrieved February 29, 2024, from https://www.britannica.com/place/Egypt/Agriculture-and-fishing

[15] Siam, G. M. (2003). WTO Agreement on agriculture: The implementation experience - Developing country case study: Egypt. Food And Agriculture Organization of the United Nations: Commodities and Trade Division. https://www.fao.org/3/Y4632E/y4632e0c.htm#bm12

[16] Tellioglu, I. and Konandreas, P. (2017). Agricultural policies, trade, and sustainable development in Egypt. Food and Agriculture Organization of the United Nations: International Centre for Trade and Sustainable Development (ICTSD). https://www.fao.org/3/i7117en/I7117EN.pdf

[17] Kassim, Y., Mahmoud, M., Kurdi, S., Breisinger, C. (2018). An agricultural policy review of Egypt. International Food Policy Research Institute: Middle East And North Africa.

access issues, especially with the European Union, the agricultural trade policies and challenges of Egypt are crucial for its economic stability, given its limited resources (Siam, 2003). As mentioned, according to Britannica (n.d) the economy of Egypt heavily relies on agriculture, which contributes to the GDP and employment significantly. As per the data presented by the UNDP (2022)[18], 11.4 % and up to 23 % of the countries economy is the GDP and employment. The focus on field crops like cotton, strict crop rotation practices, and the commercial preference of the sector increase its productivity. The land reform measures since the 1950s aimed to distribute the land more equally among farmers, which led to o increased land yields. Although the growth is slow in the livestock farming and poultry production, they are promoted by the government. Additionally, the construction of various projects like fish farms have boosted the country's fishing industry after the construction of the Aswan High Dam (Britannica, n.d). It can be understood that Egypt's heavy reliance on agriculture emphasizes its importance in the economy, however, also highlights the need and requirement for sustainable strategies to address food security challenges in a growing population and limited resources (Britannica, n.d; Siam, 2003; Tellioglu & Konandreas, 2017).

In the study conducted by Said and Shelaby (2014)[19], the data provides an overview of the agricultural exports and imports in Egypt. Due to the sector being the largest contributer to the economey, the trade among the region includes all Arab countries. The countries with the highest export and import percentages compared to Egypt's agricultural trade are Saudi Arabia, Syria, Libya, Sudan, and Jordan, with 85% and 82% respectively. As shown in figure 7, USD 107 million in worth of agriculture imports are delivered to Egypt by UAE and USD 58 million by Lebenon, making these two countries the most significant in agricultural imports in Egypt.

[18] United Nations Development Programme (UNDP), 2022. https://www.preventionweb.net/news/egypt-scales-climate-adaptation-actions-its-agriculture-water-and-agrifood-sectors.

[19] Said, M. A. and Shelaby, A. A. (2014) Said, Mohamed & Shelaby, Ayman. (2014). Potentials of Egypt Agricultural Bilateral Trade with Arab Countries: Gravity Model Evidence. International Journal of Food and Agricultural Economics. 2. 133-144. https://www.researchgate.net/publication/260115587_Potentials_of_Egypt_Agricultural_Bilateral_Trade_with_Arab_Countries_Gravity_Model_Evidence

Figure 7 - Directions of the Egyptian agricultural exports and imports in 2010

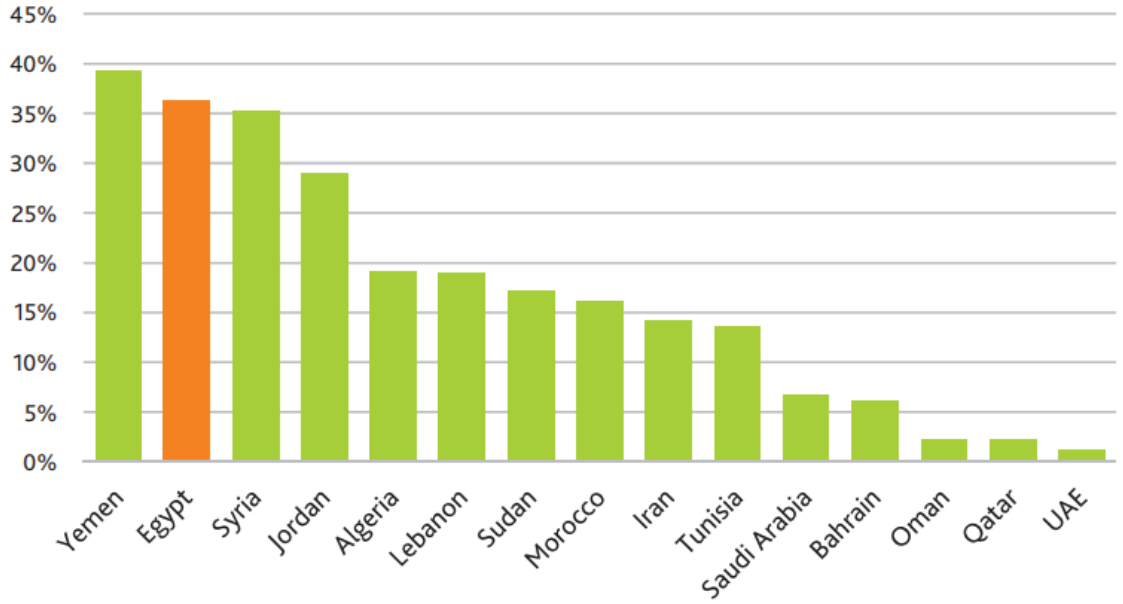
Destination of exports			Origin of imports		
Country	Value (in million dollars)	%	Country	Value (in million dollars)	%
KSA	284	20.5	UAE	107	34.3
Syria	234	16.9	Lebanon	58	18.6
Libya	144	10.4	Sudan	44	14.0
Sudan	138	10.0	Syria	17	5.5
Jordan	93	6.7	KSA	14	4.4
UAE	89	6.4	Libya	12	3.8
Kuwait	87	6.2	Jordan	3	1.1
Lebanon	81	5.8	Iraq	2	0.5
Iraq	36	2.6	Kuwait	1	0.4
Total		85.4	Total		82.5

Source - Calculated from the Arab Agricultural Statistics Yearbook (different issues), The Arab Organization for Agricultural Development. https://ageconsearch.umn.edu/record/163715/?v=pdf

2.3 Economic Impacts of Climate Change on Egypt's Agriculture and Trade Sector

Egypt ranked second among the nations in the Near East and North Africa (NENA) area in terms of the percentage of total revenue from merchandise and service exports that went toward paying for imports of agricultural products. As shown below in Figure 8, this proportion was just 3% points less than Yemen's. It is evident that the cost of agricultural imports into Egypt accounted for about 40% of total export revenue.

Figure 8 - Agricultural import expenditures as a share of total export revenues, Egypt vs selected Countries



Source UN Comtrade 2016 and author's estimations

As previously stated, studies show that Egypt's trade and agricultural sectors are expected to have a significant decline in production and employment by 2060. Agriculture is heavily dependent on the Nile River in Egypt, and climate change poses a serious and significant threat to the productivity and sustainability of the sector (El-Shaer et al., 1997)[20]. The predicted decrease in the agricultural sector ranges from 8% to 47%, while the decrease in employment production is up to 39%, which is due to climate-induced factors such as sea level rise, air pollution, and heat stress. Substantial economic losses are foreseeable, equivalent to 2% to 6% of the GDP, which amounts to hundreds of billions in Egyptian pounds (EGP). Additionally, the study conducted by Smith et al (2013) outlines the predicted losses due to the susceptibility of the Nile River Delta to rising sea levels, which pose potential threats to property between 7-16 billion Egyptian pounds in value. The tourism sector, which is a crucial division of the Egyptian economy, is also at risk with an expected decrease in annual revenues ranging from 90 to 110 billion EGP.

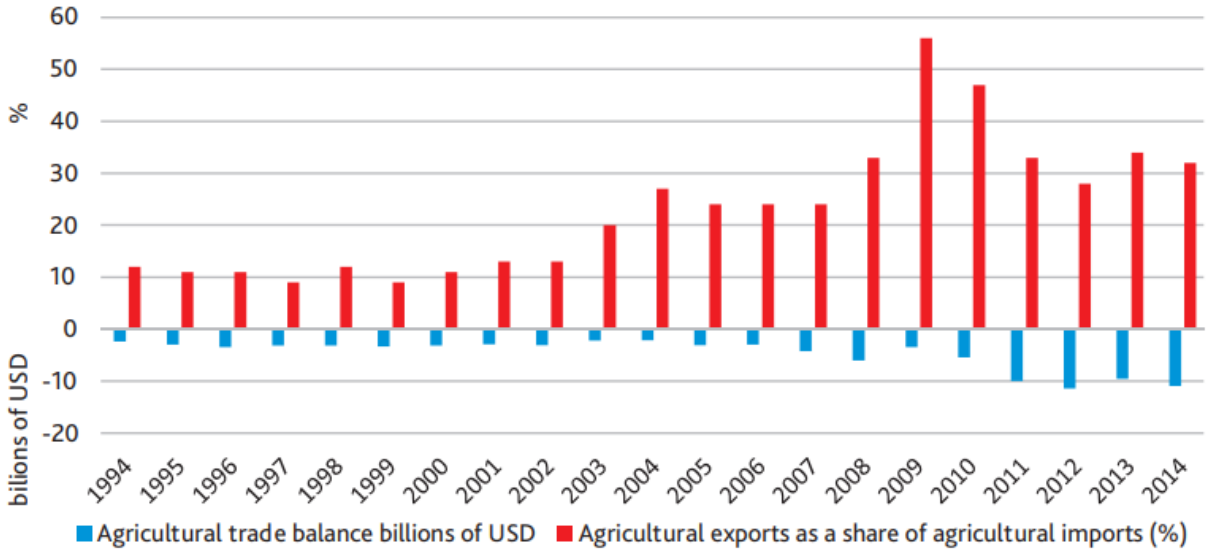
[20] El-Shaer MH, Rosenzweig C, Iglesias A, Eid HM & Hellil D, 1997. Impact of climate change on possible scenarios for Egyptian agriculture in the future. Mitigation and Adaptation Strategies for Global Change 1: 233–250. https://doi.org/10.1007/BF00517805

Eid et al. (2007)[21], support the aforementioned findings with previous research and studies conducted on the agricultural sector in Egypt. In the research conducted by Eid et al. (2007), studies found potential yield losses and increased water requirements, predicting a reduction of 11% in the national rice production, 28% in soybeans, 19% in maize, 20% in barley grain, and temperature change based impact on cotton seed yield (Eid & EL-Marsafawy, 2002; Eid et al., 1997b, 1995, 1997a) as cited by Eid et al. (2007). Additional challenges of the agricultural sector are the inadequacy of certain measures, such as livestock raising, and the potential adverse effects of warming on water resources, which were identified by the authors using the Riccardian approach, that evaluated the economic impacts on farm net revenue. To address these challenges faced due to increasing temperatures, policy responses were proposed, that primarily focus on land, crop, and water management, with a particular emphasis on irrigation. Immediate and extensive measures are necessary to mitigate the potential economic and environmental repercussions, given the data predicted in the research and studies (Smith et al., 2013; Eid et al., 2007).

Numerous studies have conducted in-depth research to identify and recognize the effects of climate change on Egypt's economy, particularly on the trade and agriculture sectors, highlighting the risks and vulnerabilities of the economic sectors due to climate change. Despite the importance of agriculture to Egypt's economy, contributing to food security, industrial raw materials, export earnings, and employment, studies show a decline in the GDP contribution of the sector over the past years. In the early 2000s, agricultural value added of 16% dropped to 11% by 2015, with agriculture-related exports decreasing from twice the total merchandise exports, dropping to 2% in 2013 (World Bank, 2016), as cited by Smith et. al. (2013). Egypt being strategically geographically located close to the major European, African, and Middle Eastern markets, makes them a significant and ideal trade entity. The country heavily relies on food imports, estimating over 50% of its food supplies coming from abroad. The dependency on food imports exposes and makes Egypt susceptible to global food price fluctuations and supply interruptions.

[21] Eid, H. M., El-Marsafawy, S. M., & Ouda, S. A. (2007). Assessing the Economic impacts of climate change on agriculture in Egypt: A Ricardian approach. ResearchGate. https://www.researchgate.net/publication/23550292_Assessing_the_Economic_Impacts_of_Climate_Change_on_Agriculture_in_Egypt_A_Ricardian_Approach

Figure 9 - Evolution of trade in agriculture products in Egypt, 1994 - 2014



Source - FAOSTAT and World Bank 2016, author's estimations

As shown in the previous literature and as highlighted in the study conducted by Perez et al. (2021)[22], climate change poses a serious threat to Egypt's trade sector, particularly due to the adverse impacts on agriculture. Egypt's farming industry is heavily impacted, with higher temperatures and reduced water availability, crops, fish, and animals are negatively affected. As noted in the study, given Egypt's significant reliance on irritation, any shifts in water quality and availability become critical. Rapid rises in temperatures over the next few decades are predicted by climate models, especially during the crop growth period in the summer, therefore requiring more water for irrigation. Additionally, the potential decrease in rainfall increases the difficulties in farming and other challenges faced by the agricultural sector. The study uses both biophysical and economic models to explain how changes in temperature and rainfall can impact Egypt's agricultural economy. By 2050, the majority of the biophysical impacts, including temperature, precipitation, potential evapotranspiration, and elevated salt levels, are expected to be negative. When compared with a 'no climate change scenario', food crop yields are expected to decrease by an average of 10%, mainly due to heat stress (4.9%), water stress (4.1%), and salt (1.6%). The greatest decreases in biophysical output, as displayed by the commodities forecast, can be seen in maize (16.2%), sugar crops (12.0%), and fruits and vegetables (11.7%). Rising

[22] Perez, N. D., Kassim, Y., Ringler, C., Thomas, T. S., Eldidi., Breisinger, C. (2021). Climate-resilience policies and investments for Egypt's agriculture sector: Sustaining productivity and food security. International Food Policy Research Institute. https://doi.org/10.2499/9780896294189

temperatures seem to be the most significant stressor, presenting a notable decline in yields for various crops (as seen in Figure 10).

Figure 10 - Changes in productivity due to biophysical and economic effects of climate Egypt projected by 2050

Commodities	Biophysical effects, Egypt				Combined Biophysical and Economic Effects	
	Heat Stress	Water Stress	Salinity	Cumulative Effects	Egypt	Rest of World
% change from a no climate change scenario						
All food crops	-4.94	-4.14	-1.55	-10.29	-6.17	-5.24
All cereals	-4.66	-2.57	-1.59	-8.59	-10.36	-7.74
Maize	-12.86	-2.46	-1.36	-16.16	-19.54	-17.66
Rice	-5.81	-1.59	-1.58	-8.78	-8.53	-5.61
Wheat	2.27	-3.25	-1.78	-2.81	-0.56	0.82
Fruits & vegetables	-4.73	-5.88	-1.48	-11.66	-8.28	-1.95
Oilseeds	-6.98	-3.18	-1.53	-11.31	-12.08	-6.69
Pulses	-5.46	0.04	-1.57	-6.92	-9.98	0.01
Roots & tubers	2.61	-0.29	-1.79	0.47	3.56	-4.58
Sugar crops	-6.66	-4.19	-1.56	-11.96	-13.28	-10.39

Source - Changes in productivity due to biophysical and economic effects of climate change

The adverse effects of climate change spread beyond the agriculture sector, impacting both producers and consumers. Reduced productivity and food supply due to these effects increase food costs, which decreases food demand. The data shows that global commerce, including Egypt, will face impacts, demanding the consideration of both biophysical and economic impacts on a global scale. Despite the potential adverse effects on food systems, the combined biophysical and economic implications worldwide are expected to be lower than those within Egypt.

In terms of agricultural production, the study shows an average decrease of 6.2% by the year 2050, due to the influences of both biophysical and economic climate change. This is a significant reduction when compared to the 10.3% decrease that could result from biophysical changes alone. Wheat and potatoes are comparatively less impacted, while maize, oilseeds, and sugar crops face severe damage. The detrimental effects on agricultural yields can be seen via the 5.7% decrease in Egyptian food output predicted for 2050. The global food output is expected to decline by 4.4%, primarily in maize, with the largest production reduction both in Egypt (-21.8%) and worldwide (-22.1%). Additionally, there is a significant production decrease in pulses, with Egypt experiencing a 23.9% reduction compared to a 0.2% decline globally.

Furthermore, the study highlights the expected significant increase in food expenses by the year 2050 as a result of the economic implications of climate change. Maize prices are predicted to increase by 22.8% and rice prices by 18.7%, due to global yield and production losses. Higher costs for animal feed are expected to increase costs for oilseeds, roots & tubers, and poultry. The significant rise in food prices poses a critical threat to food sec urity, particularly among the less fortunate members of society, as it limits their access to food.

The study further shows the direct impact on Egypt's trade balance, with a 1.3 million mt (4.5%) decrease in food imports due to the increase in pricing. Similarly, exports are also expected to decline, with a predicted reduction of 4.6 million mt in fruit and vegetable exports from Egypt. Due to the global reductions in yields and food output, tightened food markets will make it difficult for Egypt to rely on imports for additional local food supplies. By 2050, Egypt is expected to encounter a 1.7% decrease in calorie availability and a 2.1% decrease in per capita food crop consumption. The main cause is identified as the decrease in consumption of rice (-5%), oilseed crops (-7%), and roots & tubers (-8%), due to the increase in food costs impacted by climate change. This highlights the significant threat that climate change poses to Egypt's food security.

Further explained in the research conducted by Kassem et. al. (2019)[23], farmers' views on climate change were examined, along with their awareness, and their adoption of adaptation measures using questionnaires. The questionnaire was divided into three sections, consisting of socioeconomic attributes, climate change awareness, and adaptation measures. The validity and reliability of the questionnaire were established using Cronbach's alpha. The awareness and adoption of the farmers were scored accordingly. Data was collected through interviews and statistically analysed using the SPSS program. Knowledge and feedback of the extension workers were gathered at the district level through workshops and focus group discussions were used among the governorate and national levels to identify plans and challenges related to climate change adaptation in agriculture. Key findings were summarised through data analysis.

The study discovered that 46% of the farmers were in the ages between 36 - 50 years, where 31.7% were identified as uneducated, and 32.3% of the farmers could read and write but had no further education. The socioeconomic results showed that the majority of the farmers (70.3%) were small-

[23] Kassem, H. S., Bello, A. R. S., Alotaibi, B. M., Aldosri, F. O., Straquadine, G. S. (2019). Climate change adaptation in the delta Nile region of Egypt: Implications for agricultural extension. MDPI. 11(3), 685; https://doi.org/10.3390/su11030685

scale farmers, operating 10 feddan or less, while 54.5% had between 16-30 years of experience practising farming. More than half of the farmers (56.3%) managed 1 to 2 farming activities. In the previous three farming seasons, over half of the farmers reported having only minimal contact with extension workers (three times or fewer). This included attending on-farm demonstrations (64%), taking part in training sessions or meetings (56%), or receiving extension visits (50.4%). Lastly, 15.4% of the participants identified as WUA members.

According to the research conducted by Nassr, et. al. (2021)[24], the climate change impact on agriculture production will have a negative effect on all the commodities presented in Figure 11. As per the study, pulses are the most affected crops, with -22.21% in 2050, with roots and tubers being the least affected. The total production will increase by 20% by the year 2030 and by 35% by 2050.

Figure 11 - Changes in total production due to effects of climate change in Egypt

Commodity	Total production (million metric tons)						
		Without climate change		With climate change		%	
	2010	2030	2050	2030	2050	2030	2050
Cereals	19.76	23.69	25.99	22.21	22.98	-6.24	-11.61
Meats	1.60	3.20	5.63	3.19	5.61	-0.17	-0.38
Fruits & Vegetables	29.24	46.45	66.07	44.44	63.31	-4.33	-4.18
Oilseeds	0.79	1.20	1.41	1.19	1.37	-0.65	-2.59
Pulses	0.41	0.63	0.81	0.56	0.63	-11.69	-22.21
Roots & Tubers	3.40	5.91	8.38	7.11	11.33	20.35	35.30

Source - IMPACT results

According to Figure 12, the household's demand for cereals will decrease by -9.63%; however, the demand for pulses will rise at a low rate. Furthermore, as per the data given in Figure 13, all the commodities will need to be understudied, as the demand for cereals will increase from 39.7% to 40.4% by 2050. The issue is due to the decrease in production at rates higher than the increase in demand for cereals. These production rates of cereals led to an increase in imports, offsetting the decrease in domestic production, which could lead to an increase in the trade deficit of the product. Additionally, crops that have a surplus, like fruits and vegetables, will decrease from 20.5% to 18.9% by the year 2050.

[24] Nassr, S. Z., Ahmed, Y. N., Siam, G. M., Soliman, N. Y., Sabbah, S. H. (2021). Analysis of climate change effects on food security in Egypt using the IMPACT model. Department of Agric. Economics, National Research Center. https://meae.journals.ekb.eg/article_221571_db09e1837a465486ae30ff595fab15cb.pdf

Figure 12 - Impact of climate change on household's demand for agricultural

Commodity	Total Demand (million metric tonnes)						
		Without climate change		With climate change		%	
	2010	2030	2050	2030	2050	2030	2050
Cereals	31.118	46.593	65.285	44.681	58.993	-4.104	-9.638
Meats	1.886	3.462	5.262	3.445	5.211	-0.515	-0.975
Fruits & Vegetables	27.557	37.997	45.606	37.501	44.416	-1.306	-2.610
Oilseeds	1.461	1.987	2.385	1.907	2.191	-4.022	-8.122
Pulses	0.997	1.643	2.330	1.649	2.347	0.357	0.728
Roots & Tubers	3.177	5.001	7.262	4.641	6.453	-7.196	-11.143

Source - IMPACT results

Figure 13 - Impact of climate change on net trade for agricultural products in Egypt

Commodity	Net trade (million metric tons)			
	Without climate change		With climate change	
	2030	2050	2030	2050
Cereals	-23.3	-39.7	-23.9	-40.4
Meats	-0.3	0.4	-0.3	0.4
Fruits & Vegetables	8.5	20.5	6.9	18.9
Oilseeds	-0.8	-1.0	-0.7	-0.8
Pulses	-1.0	-1.5	-1.1	-1.7
Roots & Tubers	0.9	1.1	2.5	4.9

Source - IMPACT results

The research conducted by UNDP (2011)[25], also reveals the agricultural products that are most vulnerable to the impacts to climate change. Supporting the previously given data, through simulation studies in different agricultural lands, considering the current climatic conditions and predicted impacts of climate change, over a time period of 25 to 40 years, Wheat, Maize, Cotton, Rice, Tomato, and Sugar Cane are seen to face direct consequences. Wheat production is estimated to decrease by 9 % - 18 % if there is a 2-4 degree Celsius rise in temperatures with an increase in water consumption of 6.2 %. Maize decreases by 19% with a 3.5 degrees temperature increase, when compared to current conditions, additionally increasing the water consumption up to 8%. Furthermore, cotton is predicted to have a positive impact due to climate change consequences, with an increase of 17% in production if there is a 2-degree rise in temperature. However, sugar cane faces a major drop in production up to 24% with an increase of 2.3% in water consumption.

[25] UNDP (2011). Egypt's National Strategy for Adaptation to Climate Change And Disaster Risk Reduction. www.climasouth.eu/docs/Adaptation011%20StrategyEgypt.pdf

2.4 Economic Impacts of Climate Change on Egypt's Water Sector

As previously stated, the Nile Delta plays an integral role in Egypt's agriculture, and its vulnerability to rising sea levels is undeniable. Agriculture requires water from the Nile for irrigation, which is subject to changes in precipitation and changes in temperature throughout the Nile basin, indicating the significant impact of climate change (El Raey et al., 1995)[26]. Egypt has already passed the internationally accepted threshold for water shortage and is very close to reaching "absolute water scarcity", with less than 500 cubic meters of water available annually per person, according to the UN (2024), stated by Goodman (2021)[27]. Egypt relies heavily on the Nile River for its agricultural needs, as was already noted. People in Egypt only use 6.8 % of the water available for daily needs. In order to address the water scarcity, the government is planning to introduce modern irrigation techniques like drip systems and sprinklers, as well as improve irrigation processes to use water more efficiently, particularly in newly developed agricultural areas. Better harvests that could be sold abroad would result from this.

According to the research conducted by Mostafa et. al. (2021)[28], the specific impact of climate change on Egypt's water resources, particularly focusing on irrigation water was studied. They highlighted the vulnerabilities of the country's water supply to the fluctuations caused by climate change, necessitating the significance of adaptive measures to protect this natural and essential resource. The study also revealed that the country's growing population and limited resources are further major challenges to be tackled for the proper management of water resources in Egypt. This was evaluated through a selected case study, covering Middle Egypt, consisting of Giza, Minya, Bani-Sweif, and Al-Fayoum, where general circulation models (GCMs) were used to analyze climate change and temperature increase on irrigation water, along with adequate methods for future adaptation to climate change. Furthermore, similar to the reports presented by the United Nations (2024), Gado & El-Agha (2021)[29] also emphasize the severe water scarcity faced by Egypt, which has increased due to the adverse effects of climate change. The total water demand

[26] El-Raey, M., Nasr, S., Frihy, O., Desouki, S., Dewidar, K. H. (1995). Potential impacts of accelerated sea level rise of Alexandria governorate, Egypt. Journal of Coastal Research. pp. 190–204. JSTOR, http://www.jstor.org/stable/25735708.

[27] Goodman, E. (2021). Dual threats: water scarcity and rising sea levels in Egypt. The Tahrir Institute for Middleast Policy. https://timep.org/2021/08/20/dual-threats-water-scarcity-and-rising-sea-levels-in-egypt/

[28] Mostafa, S. M., Waheed, O., El-Nashar, W. Y., El-Masrafawy, S. M., Zelenakova, M., Abd-Elhamid, H. F. (2021). Potential climate change impacts on water resources in Egypt. MDPI. 13(12), 1715; https://doi.org/10.3390/w13121715

[29] Gado, T. and El-Agha, D. E. (2021). Climate change impacts on water balance in Egypt and opportunities for adaptations. Agro-Environmental Sustainability in MENA Regions (pp.13-47) 10.1007/978-3-030-78574-1_2

has been consistently exceeding the available water supply, a crisis since the late 1970s, which poses a significant threat to the country's ability to manage sustainable water systems.

Furthermore, the study conducted by Omar et. al. (2021)[30], also provides detailed research on the adverse effects of climate change on water resources in Egypt. The study presents in-depth information on how water affects the agricultural sector in terms of food security and the socioeconomy of Egypt. The direct impact on water quantity, caused by climate change, is predicted to have "indirect effects on the Mediterranean saltwater intrusion to groundwater, which exposes agriculture to vulnerability" (Omar et. al., 2021). Water supply from the High Aswan Dam was predicted using hydrological simulations for flooding scenarios in Nasser Lake. The water salinity in the Nile Delta was assessed using one of the three mathematical models presented, and lastly, the results from the water supply model and the salinity model were used to identify the economy, food security, agriculture, and harvest patterns. Although the authors identify the potential of adaptation measures to promote food security without disrupting the economy, water supply and availability have a much higher and more significant impact on the economy and food security than the adaptation measures alone.

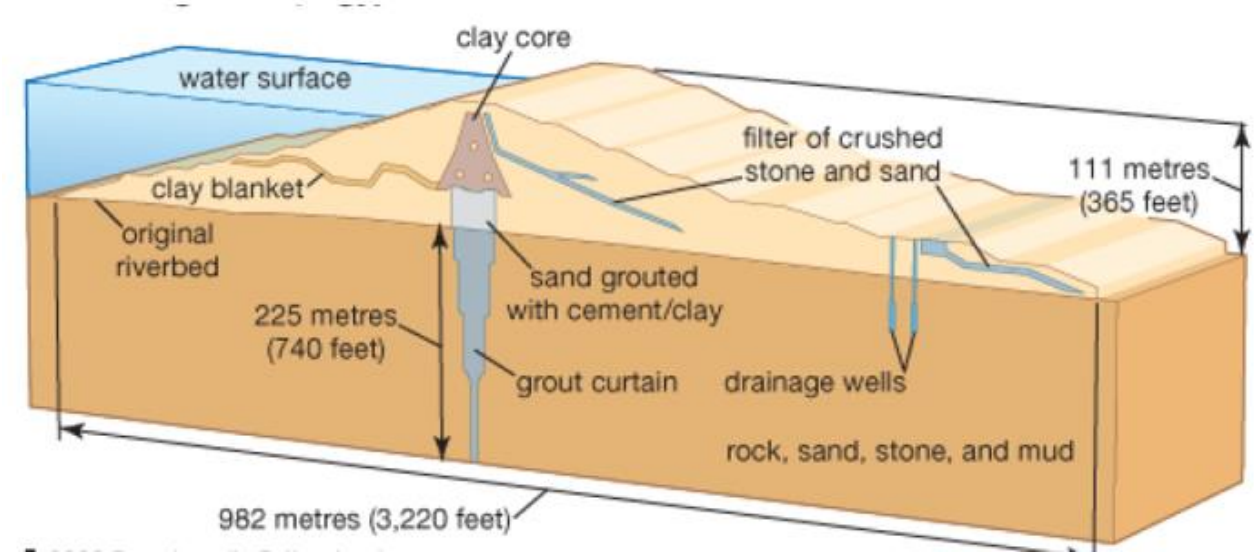
From 1993 to 2010, there was an increase in the sea level in the Mediterranean at a rate of 2.6 cm per decade. By the end of this century, it's estimated that the sea level can rise by as much as 22 cm (Al-Mailam et. al., 2023). It is emphasised that these estimates are calculated and approached with caution. Projections show that from 2030 and 2060 there will be a significant growth in Egypt's population within the Low Elevation Coastal Zone LECZ, due to sea level rise and the ongoing land subsidence and population. It is expected that by 2030 45 million Egyptians will face serious threats from rising sea levels, and by 2060 the population of LECZ can reach 63.5 million which is 249% over 60 years. The study by Al-Mailam et al. (2023) portrays the susceptibility and vulnerability of Egypt's Mediterranean coast and remarks as dangerously exposed to climate change. In the city of Alexandria, where 45% of its population lives in areas below sea level, the risk of flooding due to 0.5 meter of sea level rise, poses a serious threat. This situation would require a mass evacuation of 67% of the city's population, 65% of the industrial sector, and 75.9% of the service sector, impacting around 1.5 million people resulting in the loss of over 195,000 jobs. Furthermore, if there is a 1-meter rise in sea level, it would risk and expose

[30] Omar, M. E. M., Moussa, A. M. A., Hinkelman, R. (2021). Impacts of climate change on water quantity, water salinity, food security, and socioeconomic in Egypt. Water Science and Engineering https://doi.org/10.1016/j.wse.2020.08.001

64% of its beaches, 52% of its residential areas, 72% of its industrial, and 82% of the city’s service sector to face flooding.

The impacts of rising sea levels are critical to the coastal cities, as explained in the research by Al-Mailam et al. (2023), could affect the national economy. The coastal cities contain half of Egypt's industrial sector, 40% of agriculture, and Alexandria's shoreline contains 13.3% of Egypt's fish production. The government is aware and the estimation shows that by 2030 food production will decrease by a minimum of 30%. Additionally, the adverse effects of the rise in sea level will disrupt the national food supply chains. The Aswan high dam (see figure 14) is also part of this issue as it disrupted the flow of sand and dirt from the Nile River to the mediterranean sea which prevents the coastlines from retaining the required minerals to remain healthy. Furthermore, the excessive construction of buildings and the usage of sand worsens the situation, and these changes affect the land along the Nile delta's coast making it weaker. The salt level in the water is increased due to the erosion near Rosetta’s coast, harming the fresh water supply, making it unsafe for people to use and difficult for crops to grow.

Figure 14 - Aswan Dam



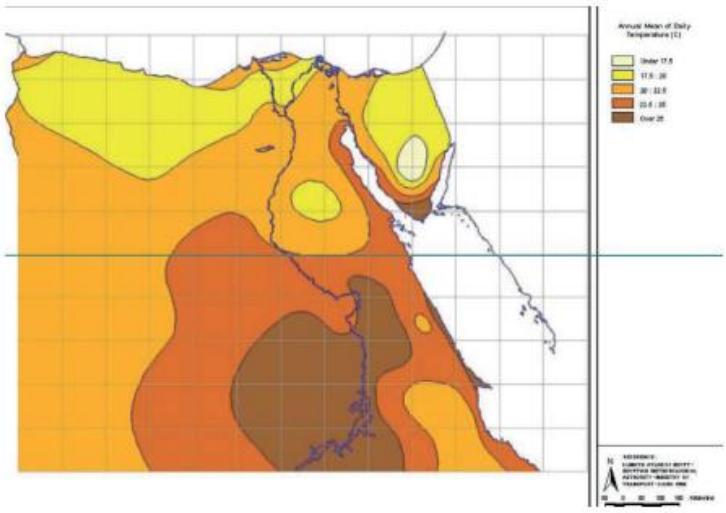
Source - Encyclopedia Britannica, Inc.

3. Practical Part

3.1 Climate Change Policies in Egypt

As previously established, Egypt is at significant risk due to the current and predicted adverse effects of climate change. As per the Paris Agreement COP21 in 2015, 196 countries agreed to contribute to assist in limiting the global warming temperatures up to 1.5 degrees Celsius, including Egypt (Abou-Ali, et. al. 2023). Egypt experiences hot and dry climate throughout the year, which leads to rainfall limitations. The average temperature in Egypt is between 17 and 20 degrees Celsius, as shown in figure 15 below. However, in upper Egypt, which is close to the Nile River, the temperature typically reaches 25 degrees Celsius or more (Smith, et. al., 2013). Given the previous literature, including the existing and forecasted negative impacts of climate change on the various economic sectors in Egypt, mainly agriculture, trade, and water, certain policies and strategies have been proposed and implemented, focusing on adaptation and improvements for the country.

Figure 15 - Average annual temperatures (C) in Egypt



Source - EEAA, 2010a.

Through the National Climate Change Strategy 2050 (NCCS) and the updated National Determined Contributions (NDC) in 2022, Egypt has provided an extensive plan and approach to addressing the issue and taking initiatives to become a regional leader in climate change (World Bank Group, 2022; Simões & Stanicek, 2022). As per the research conducted, even though Egypt has taken the necessary steps to overcome the challenges of climate change, they must be committed to the policies and regulations, and adhere to the proposed adaptation strategies presented in the updated NDC. Egypt's initiatives and efforts are highlighted in the most recent publication of NCCS, in May 2022, consisting of the actions against climate change, prioritizing mitigation and adaptation. Also, nationally declaring "Vision 2030", which is Egypt's Sustainable Strategy, with over 25 projects of 'high priority' with the aim of completion by the year 2030. The report by Simões and Stanicek (2022) and World Bank Group (2022), indicate the financial support from outside the country, in the amount of USD 196 billion and of USD 50 billion, for mitigation and adaptation respectively. With an emphasis on sustainability, Egypt plans to improve their 'transition to low carbon economy and their environmental credentials'. Considering the global COVID-19 outbreak, the economic measures and the high investments the country made, assisted comparatively well in their protection from the economic repercussions of the pandemic.

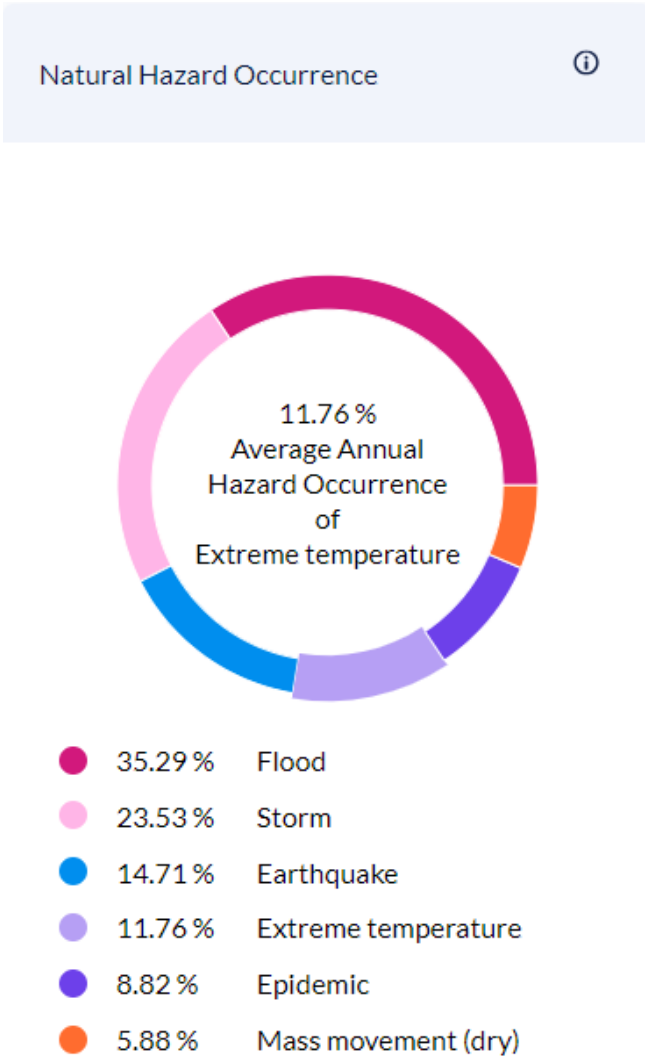
3.2 Policies and strategies concerning the water sector.

In the proposed 'Vision 2030' of sustainable developmental strategies by Egypt, the economic objectives highlighted are the strategies to reduce 10% of greenhouse gases compared to the levels from 2016 (IEA50, 2022; SDS Vision 2030), with 8 other projects proposed in the energy sector to gain positive outcomes by 2030. From the given data, it can be seen that the primary focus of Egypt's adaptation plans and strategies focus on preserving the water resources and coastal areas. The aforementioned goal of Egypt to reach and maintain a sustainable and green economy consists of strategies aimed at water availability, droughts, sea level rise, and other adverse effects of climate change given in the literature. Climate change induced challenges in the coastal zones include extreme natural disasters such as tsunamis, floods, cyclones, high tidal waves, etc, as noted by UNDP (2011) (see Figure 16). As per the IPCC 1992, in the same report, the recommended adaptation strategy to overcome issues with sea level rise are primarily focused on accommodation and protection in areas that are prone to extreme events such as hurricanes. The estimated costs of investing in the adaptation projects in coastal zones are predicted to reach 8.606 billion EGP,

followed by the costs of investing in water resources and irrigation to reach 3.350 billion EGP. The investment costs are divided between 4 five-year plans, that consist of four major projects of expenses, within which the costs are further divided according to each action taken under each project (see Figure 17). The investment costs cover activities and projects in the water and irrigation sector include raising awareness regarding the issues related to climate change, preparations of effective measures to address, monitor, and follow-up on the crisis and its impact on the water resources. Additionally, the largest project of overcoming the issue of uncertain challenges posed by climate change, consists of:

- Widening and deepening Tushka spillway, the main Nile stream, and large canals in case of high floods.
- Updating the operation of the High Dam during floods or drought.
- Constant rainfall monitoring and identifying trends and adaptation strategies. Implementation of early warning system when there are any changes in the Nile River flow that could be caused by climate change.
- Implementation of programs to maintain quality of water and reduce groundwater levels.
- Designing regional mathematical models to predict and simulate the adverse effects of climate change in the Nile Basin area. (see Figure 15, UNDP, 2011).

Figure 16 - Egypt's Natural Hazard Occurrence in % Annually



Source - https://www.climatewatchdata.org/countries/EGY?end_year=2020&start_year=1990#climate-enhancements

Figure 17 - Investment Cost Estimates of Adaptation Projects in the Water Resources and Irrigation Sector

Activity/Project	Investment cost estimates (in millions of Egyptian pounds)				Total (in million Egyptian pounds)
	1st Five - year plan	2nd Five - year plan	3rd Five - year plan	4th Five - year plan	
A- Building a culture of safety first, along with raising community awareness:					
- Raising awareness on climate change issues in association with consumption rationalization.	50	50	50	50	200
B- Considering adaptation to climate change and associated disaster risk reduction a primary national priority:					
- Preparing an effective institutional program to address crises resulting from climate change and its impact on water resources, monitoring and follow up on relevant programs.		50	50	50	150
C- Dealing scientifically with the issue of uncertainty:					
- Widening and deepening Tushka spillway to accommodate high flood run off, in addition to widening the main Nile stream and large canals.		100	200	200	500
- Updating the rules and regulations governing the operation of the High Dam in light of possible changes (drought or floods).	50	100	150		300
- Continued monitoring of rainfall and run off and their trends and adaptation strategies, and the creation of an early warning system on any change in the Nile River flow that may result from climate change.	100	100	200	200	600
- Studying the impact of sea water intrusion - in case of a sea level rise - into groundwater in the northern shore of the Delta and elaboration of programs to reduce groundwater level and maintain its quality.		200	200	200	600
- Pursuing scientific research to ascertain the results .	100	100	150	150	500
- Managing climate change risks and designing a regional mathematical model to simulate climate change in the Nile Basin region.	50	150			200
D- Researches and studies:					
- Studying predicted change in the Nile River flow, and adapting to it.		50	50	50	150
- Studying the development of unconventional water resources (water freshening).		50	50	50	150
Total investment cost estimates for the water resources and irrigation sector					**EGP 3.350 billion**

Source - UNDP (2011)

3.3 Policies and strategies concerning the agricultural sector.

Due to the extremely hot temperatures and dry climate, a vast area of Egypt remains unused, with only about less than 6% of land occupied by 95% of the Egyptian population (Hamzawy, et. al. 2023). Abou-Ali, et. al. (2023) state Egypt as an optimal location for the implementation of renewable and sustainable energy projects due to the high wind speeds, sunny weather, and the quantity of empty land. This provides the Egyptian government with the opportunity to overcome some of the economic impacts of climate change and promote a more sustainable pathway to the previously mentioned 'green transition'. It is advised in various research and studies, including the research conducted by Abou-Ali, et. al. (2023), that it is crucial for Egypt to use previous experience from other neighbouring countries that have and are tackling the adverse impacts of climate change, must reinforce policies, and start taking action towards the proposed adaptation

strategies. The negative effect of climate change on the water resources and irrigation sector will have a significant impact on the agricultural sector. Since majority of useable and consumable water comes from the Nile River, not only will it affect the health of the population, but also farming and agriculture-related activities. Temperature rise due to climate change, although at lower levels than the impact on water, still causes a major effect on agriculture, as some crops may be negatively affected, whereas other crops may benefit, which fluctuates the economic contribution of the sector (UNDP, 2011). Temperature, the rise in Mediterranean Sea levels, and drought are listed by the UNDP as indicators with the highest direct climatic impact. Through the proposed scenarios, highlighting the activities, projects, and strategies that cover thousands of feddans and water resources, certain predictions were made. The predictions involve the 'increase in crop water consumption and evaporation caused by rising temperatures, migration of labour from coastal zones due to the consequences of social and economic impacts, and lastly, the negative impact caused by sea level rise on agricultural land and groundwater reserves in the Delta' (UNDP, 2011).

In the agricultural sector, strategies developed for the adaptation to climate change are based on factors including the use of modern technology, the development of systems for various risks and challenges posed by climate change, following and strongly implementing the existing systems in rural areas which protect agricultural productivity from the negative effects of climate change, among a few more as per the study by UNDP (2011). According to Dr. Fouad's statement in her interview with the SCALA programme, the key priorities in agriculture and efficient usage of land highlighted in Egypt's NDC include the use of modern irrigation techniques, focusing on the agricultural sector and production, to increase the productivity of the current water consumption by the sector. She also emphasises the need for changes in crop species and quality of soil used for agriculture (*Egypt Scales up Climate Adaptation Actions of Its Agriculture, Water and Agrifood Sectors*, 2022).

The estimated cost of investments in the projects and activities for the agricultural sector against climate change are calculated to reach 7.93 billion EGP, as per the data collected by UNDP (2011). The costs of investments are categorized into 7 projects consisting of various activities. The investments in each activity over the given time period range from 5 million EGP up to 480 million EGP every five years per activity. The heavily invested activities include maintenance, development, utilization, exchanging, and classifying items of biodiversity, inventing new

variations and mutations of crops that have shorter growth seasons, also protecting and preserving the plants that are beneficial for the quality of the environment, as reported in the study. Additionally, investment costs in millions of EGP are made in activities such as building a structure for a new agricultural system that promotes sustainability, determining actions and programs that would allow farmers to adapt and raise awareness regarding the adverse effects and economic impact of climate change (see Figure 18).

Figure 18 - Estimated investment cost of adaptation projects in the agricultural sector

Activity/Project	Investment cost estimates (in millions of Egyptian pounds)				Total (in million Egyptian pounds)
	1st Five - year plan	2nd Five - year plan	3rd Five - year plan	4th Five - year plan	
A- Building an effective institutional system for managing crises and disasters resulting from climate change on the national and regional levels:					
- Monitoring and estimating vulnerability index and risk assessment for different agricultural data.	5	5			10
- Strengthening the monitoring, prediction, analysis capabilities, and their spread in current and future agricultural areas.	50	50	25	25	150
- Building an effective information exchange system on climate change at regional and international levels.		50	25	25	100
- Creating expert dynamic systems to provide information and analyses, and to make special recommendations.			50	50	100
B- Building genetic diversity on the level of plant varieties and species capable of realizing maximum productivity and neutralizing the change in climate indicators:					
- Estimating vulnerability index and risk assessment of biodiversity components exposure in different ecosystems.	5	5			10
- Estimating vulnerability index and risk assessment facing plant production.	5	5			10
- Strengthening the capability of the National Genes Bank and other genetic diversity banks in more vulnerable areas (the desert).	80	40			120
- Maintaining, developing, utilizing, exchanging, and classifying items of biodiversity.		100	100		200
- Feeding the national database with data on biodiversity in the most vulnerable ecosystems .			30	20	50
- Expanding protectorates systems .				200	200
- Focusing on programs of cultivation of new types of important field and horticultural crops capable of adapting to expected changes: temperature rise of up to 2 Degree Celsius, soil salinity, and relative dryness.	300	100	100	100	600
- Following up on plant pathogens and neutralizing their effect on the efficiency of production intake.		90	30	30	150
- Protecting plants in such a way as to preserve the positive biological balance that is beneficial to agricultural production.		90	30	30	150
- Devising new types of crops that have a short growth season			50		50
- Expanding the cultivation of crops with high capability of adaptation to climate change.				100	100
- Adjusting agricultural practices policies.				50	50
- Monitoring and assessing the vulnerability index and risks for animal production.	5	5			10

Activity/Project	Investment cost estimates (in millions of Egyptian pounds)				Total (in million Egyptian pounds)
	1st Five - year plan	2nd Five - year plan	3rd Five - year plan	4th Five - year plan	
C- Achieve specific and biological diversity of animal, fish and poultry production to protect them and to achieve food security for the community:					
- Maintaining Biodiversity and improving livestock production.	300	100	100		500
- Monitoring animal health, protection and vaccination.		150	50		200
- Developing vaccine and biological preparations production technology to combat zoonotic and expected diseases.		240	80	80	400
- Relying on biodiversity for the introduction of new feeds as a source of energy, fibers and protein.			70	30	100
- Joint management of scarce agricultural resources (land and water).	60	40			100
- Providing governmental support and insurance against climate change risks.		20	480		500
D- Developing new agricultural economic systems and structures to manage crops, aquaculture and animal production that are flexible enough to be implemented under climate change:					
- The economics of aquaculture and alternate use of wetlands north of the Delta.		50			50
- The economics of improving main crops and securing food, crop mix, industrialization, marketing and price forecasting.			15	10	25
- Agricultural industrialization and marketing, and price forecasting.			25		25
E- Increasing the efficiency of irrigation water use, maintenance of crop productivity and land protection against degradation.					
- Monitoring and assessing the vulnerability index and risks facing irrigation:	5	5			10
- Using new irrigation methodologies that rely on Precision Farming.		120	80		200
- Raising the efficiency of irrigation water use and improving field irrigation to 75%.			250	250	500
F- Reviewing policies of land use (new and old) and agricultural expansion programs according to land degradation trends in the Delta and elsewhere, resulting from the Mediterranean Sea level rise:					
- Monitoring and assessing the vulnerability index and risks of agricultural soil.	5	5			10
- Land improvement programs based on lowering salinity.	400	300	300		1000
- Creating information systems concerning land suitability for agricultural use (physical, chemical and biological fertility of the land).	200	100	100		400
- Protecting fish collections from new species that affect the biological and environmental balance of the fish wealth in Egypt.		200	100		300
- Conserving biodiversity and reducing the distinction of species.		150	100		250
- Building a structure for the aquaculture ecosystem.			200		200
- Protecting fish wealth from infections and diseases resulting from a change in environmental parameters (temperature, water quality, vegetation structure, nutritional sources(			150	50	200
- Conserving the density of fish growth (economically important types).				150	150
G- Develop systems, programs and policies to protect the rural community, support its capabilities to adapt to expected trends in climate change in association with: land use, plant and animal production, and internal migration resulting from climate indicators:					
- Studying, classifying and following up on the present condition of the rural community, traditional knowledge, and the ability to adapt (assessing vulnerability index and risks facing different rural communities).	40	30	30		100
- Identifying programs that would enable small farmers to adapt to climate change.		150			150
- Strengthening the capabilities of rural communities to manage their resources and output, and to participate in relevant decision-making.			200	100	300
- Empowering rural communities to participate in determining and implementing national policies of adaptation to and coping with disasters and crises.			120	80	200
Total investment cost estimates for the agricultural sector					**EGP 7.93 billion**

Source - UNDP (2011)

3.4 Implementation of Policies & Strategies in the Economic Sectors of Egypt

The different governmental sectors that contribute to the effective and efficient development of climate policies and strategies are within the Environmental Ministry, the Ministry of Electricity and Renewable Energy, Water Resources & Irrigation, Agriculture, Tourism, Utilities, Housing, etc. Additionally, the business, private, and public sectors are targeted by the Ministry of Trade and Industry. To overcome the challenges of climate change, policies in different economic sectors were reformed and implemented. In the updated NDC, launched by Egypt in 2022, the country emphasises and highlights their commitment to a future that is sustainable and 'green' economically, covering strategies and policies between the years 2015-2030 (Abdelaty, et al. 2023). For sustainable energy production in the oil and gas sectors, the energy policies were extensively reformed by Egypt. The MOPMR (Ministry of Petroleum and Mineral Resources) created the 'Higher Energy Committee and Energy Efficiency and Climate Department' and constructed organizational structures for efficiency in the petroleum sector. The data presents a reduction in the fossil fuel allowance from 6% to 0.3% of Egypt's GDP, between the years of 2012/13 to 2019/20 due to these established reforms. Further improvements to reduce the GHG emissions and improve the efficiency of fossil fuels, Egypt registered in the World Bank Zero Routine Flaring Initiative, following the requirements of ISO 50001. Consecutively, the investments in the supply of electricity from sustainable and renewable resources are encouraged to be increased by 20% in 2022 and 42% by 2035. Additionally, a 340% increase is seen in the same sector from the year 2015/16 to 2019/20, due to the implementation of the policies and strategies in the ISES 2035, according to the research by Abdelaty, et. al. (2023). The projects that are highlighted as the most significant for the renewable energy sector are 'the Benban Solar Park, Assiut Hydropower Plant, Kom Ombo Solar PV Plant, and the Gabal El-Zeit Wind Power Plant (Abdelaty et. Al., 2023).

To modernize and improve the agricultural sector, including food security, livestock production, cropping patterns, and all activities under the sector, Egypt has implemented various policies and strategies since the year 2009. The implementation plans included restrictions on water-intensive crops and projects associated with land reclamation while modernizing the irrigation systems. Since the impacts of climate change affecting the water sector has direct consequences within the agricultural sector, majority of the projects proposed and implemented go hand in hand for both

sectors. Some of the projects stated that primarily focus on agriculture are the ‘Sustainable and Agriculture Investments and Livelihoods Project (SHIP) between 2014-’23, Building Resilient Food Security Systems to Benefit the Southern Egypt Region between 2013-'18, and the Emergency Food Security and Resilience Support Project’ (Abdelaty et. Al., 2023). Projects such as ‘The Emergency Food Security and Resilience Support’ was developed by the Egyptian government to strengthen food security in the country by mitigating supply and drastically increasing costs to stimulate emergency aid, primarily implemented to balance the shortage in crop production, such as wheat, which were affected due the Russia-Ukraine war in 2021. Implementation of projects related to the water resources and the coastal zones sector include the ‘Integrated Coastal Zone Management’, which is managed by the government under the MWRI (Ministry of Water Resources and Management), followed by another project ‘Enhancing Climate Change Adaptation in the North Coast and Nile Delta Regions in Egypt’.

As stated by Dr. Yasmine Fouad, Minster of Environment of Egypt, in the interview with SCALA programme in 2022, discussed that the primary challenges faced by the country in adaptation, implementation, and mitigation goals are primarily inadequate financial resources and limited assistance from private entities and developed countries. Additionally, the insufficient data and the lack of accuracy in information, also contribute to the same (*Egypt Scales up Climate Adaptation Actions of Its Agriculture, Water and Agrifood Sectors, 2022*).

4. Results and Discussion

Egypt has realized that strong policies and plans are urgently needed to address the serious concerns that climate change poses. Projects like the National Climate Change Strategy 2025 and updated National Determined the contribution that Egypt is showing to become a regional leader in Climate Change mitigation and adaptation. With financial support totalling 196 Billion USD for mitigation and 50 Billion USD for adaptation emphasize international recognition of Egypt's vulnerability the importance of addressing climate change. Egypt also aligns with the goals of the Paris Agreement by highlighting sustainable and converting to low carbon economy.

Additionally, The Vision 2030 strategy for sustainable development targets to reduce greenhouse gas emissions by 10% by 2030. Its primary focus areas are sea-level rise mitigation, drought prevention, and water resource preservation. The protection of infrastructure and livelihoods from climate-related disasters relies strongly on investments made in adaptation projects, especially in coastal areas and water resources. Potential offers for Egypt's renewable energy to mitigate the economic impacts of climate change while supporting sustainable development. The agricultural sector prioritizes includes modernizing irrigation techniques and improving crop resilience to climate change, investments aim to improve the food security and mitigation from the negative impacts on the crop production. Cross governmental collaboration and engagement with the private sector are needed for effective climate policy implementation presenting Egypt's comprehensive strategy for mitigating and adapting to climate change as it progresses toward a sustainable future.

4.1 SWOT ANALYSIS

STRENGTHS	**WEAKNESSES**
• Launched comprehensive National Climate Change Strategy (NCCS, 2022). • Launched updated National Determined Contributions (NDC, 2022). • Assistance from global resources • Vision 2023 Sustainable Development Strategy (SDS, 2014). • An emphasis and commitment on moving toward a sustainable and low-carbon economy. • Extensive investment plans in green and renewable energy resources. • Commitment to implementing the proposed strategies and policies, in addition to upholding the Paris Agreement.	• Higher imports over exports leading to economic losses, deficit in food security, and inability to implement adaptation policies and future plans. • Lack of awareness and knowledge among the general population and farmers particularly of the extensive negative impacts of climate change. • Relying on external funding sources for adaptation and mitigation initiatives. • High investments costs for the proposed adaptation and mitigation projects. • Inefficient and limited usage of majority of Egypt's land.
OPPORTUNITIES	**THREATS**
• Gaining knowledge from the experiences of surrounding countries. • Increasing collaboration and support on a global level. • Ideal conditions for renewable and sustainable energy projects. • Potential increases in the country's economy through low carbon emissions and green transition strategies.	• The intensity of the adverse impacts of climate change on the major economic sectors such as, agriculture and water. • The disruption of agricultural productions such as reduction in crops • Unemployment in the agriculture sector, such as farming, fishing etc.

5. Conclusion

Egypt is facing a crucial moment in its struggle against the impacts of climate change. It is clear from thorough investigation and analysis conducted in the research that the nation confronts serious threats in several areas such as trade, agriculture, and water resources. Egypt has taken an active approach by enforcing policies like the National Climate Change Strategy 2050 and updated National Determined Contributions, as well as by aligning with international agreements like the Paris Agreement COP21.

Egypt seeks to reduce greenhouse gas emissions, slow the increase in sea level, avoid droughts, and protect its water resources. The 'Vision 2030' policy for sustainable development makes these objectives very clear. Financial commitments support from domestic and international sources are helping to strengthen these efforts, highlighting how the global community recognizes Egypt's vulnerability and its urgency to address climate change.

Furthermore, Egypt's commitment to update farming methods, investing in renewable energy projects, and switching to a low-carbon economy shows how committed it is to achieve sustainable growth. Effective policy implementation and building success in climate resilience need collaboration across governmental sectors and private sector.

As a conclusion, Egypt is making strong progress toward a sustainable future and has a well-thought-out plan in place for mitigating and adapting to climate change. By giving priority to adaptation measures, investing in strong infrastructure, and fostering innovation, Egypt is well-positioned to emerge as a leader in the area for mitigation and adaptation. In the battle against climate change, this will serve as a model for other nations to follow.

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